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Constructional and Conceptual Composition

by

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Abstract

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Goldberg's (1995) recognition that, in addition to various word-level constructions, sentences also instantiate meaningful argument structure constructions enables a non-polysemy-based analysis of various verb 'alternations' (Levin 1993). In such an analysis, meaning variations associated with the use of the same verb in different argument realization patterns are analyzed as resulting from composition of the same verb meaning with different meaningful argument structure constructions. This compositional analysis raises some important semantic questions: Which specific elements of verb and argument structure construction meanings motivate their composition? And what is the precise nature of the meaning that results from this composition? I argue that to answer these questions, it is essential that we look more closely at the underlying conceptual systems utilized by these constructions.

In this dissertation, I examine a set of simple single clause sentence examples which describe a variety of basic experiences involving motion, change of location, action, force, causation, and affectedness. One key assumption that the Neural Theory of Language (NTL) makes about language understanding concerns simulation semantics, the idea that the neural circuitry we use to understand descriptions of experiences is closely similar to that which is activated by the experiences themselves (Feldman 2006). Accordingly, I use linguistic, neuroscientific, and other forms of evidence to define a lattice of interconnected schemas that represent schematic structures and interrelations associated with the types of experiences described in these examples, and use these schemas in the meaning representations of the verb and argument structure constructions instantiated in these examples. In addition, the grammar described in this dissertation includes various word-level, phrasal and clause-level constructions, along with schemas to represent their meanings, all of which are represented using the Embodied Construction Grammar (ECG) formalism (Bergen and Chang 2005, Feldman et al. 2010). Significantly, use of this formalism has made it possible to utilize many of the schemas and constructions in this grammar in a computational implementation of a compositional constructional analysis of sentence meaning. This implementation, called the

Constructional Analyzer (Bryant 2008) determines the best-fitting interpretation of an utterance in context based on a consideration of syntactic, semantic, and contextually-specified constraints. The composed meanings of the constructions instantiated in this best fit interpretation serve as a semantic specification for the simulation of the event described by the utterance (simulation is not carried out as part of this implementation). Through simulation, the relatively schematic meanings specified by the constructions instantiated in a given utterance give rise to a much richer and fuller understanding of that utterance, via activation of additional conceptual structure related to an understander's experiences, beliefs, etc.

The schemas and constructions that comprise the grammar discussed in this dissertation have many complex interrelations. One important benefit of using the ECG formalism is that computational implementations facilitate the development of an internally consistent, wide-coverage, complex grammar. In this respect, it is similar to other unification grammars, such as HPSG (Pollard and Sag 1994) and LFG (Dalrymple 2001). However, unlike these other grammars, ECG has a deep commitment to embodied semantics, and is consistent with the NTL theoretical framework. Moreover, as the schemas and constructions presented in this dissertation illustrate, this formalism makes possible the integrated expression of several important cognitive linguistic insights, including those related to recurrent schematic conceptual structure such as: (1) image schemas (Johnson 1987, Lakoff 1987) and frames (Fillmore 1982); (2) basic patterns of cognitive organization such as prototypes (Rosch 1975, 1978) and radial categories of A-S constructions (Lakoff 1987, Goldberg 1995), and; (3) different attention-related phenomena such as perspective and profiling (Talmy 1996; Langacker 1987, 1991).

Together, the different elements described above enable the development of a grammar that supports compositional constructional analyses of a range of different sentence examples that instantiate various combinations of different verb and argument structure constructions. Significantly, these analyses capture the sometimes subtle similarities and differences in the event conceptualizations described by these examples. Moreover, this compositional account of sentence meaning also provides a compositional account of semantic roles that enable us to recognize a variety of cross-cutting generalizations that can be made about these roles.

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Preface

My choice of topics to examine in this dissertation, and the ways I have chosen to address them are both products of my own personal history. In this Preface I provide a brief backstory that may enable the reader to better understand the motivation behind these choices.

What does it mean?

I have long been fascinated by the notion of 'meaning'. As a rather grandiose life goal, I thought it would be very satisfying to be able to figure out the meaning of life, the universe, and everything. To me, this has always implied that we should somehow be able to take a bunch of external 'clues' about what we perceive of our surroundings, and somehow figure out what sort of larger, deeper, and hopefully coherent meaning underlies them.

The spatial world

Focusing on a somewhat more restricted domain of enquiry, I studied geography in college, learning how to recognize patterns in the landscape, and seeing how visible, external 'clues' help us better understand the nature of the physical world and the interacting processes that produced these patterns. This endeavor coincided with my childhood interest in analyzing and representing the spatial structure of my immediate environment by drawing house plans and making maps of my neighborhood. But as I learned more about maps and map-making, I started thinking more about how maps serve to represent and convey information. And how different maps convey different types of information.

Many of the structures represented in maps have a physical basis. But not all information they convey is necessarily directly perceivable (due to scale, 'bandwidth' or just the nature of the information, i.e. average temperature, population). Moreover, maps are inherently selective, showing some features but omitting others. As a simple example, a map might include all the roads in an area, but not indicate the types of vegetation. This is partially due to space limitations since to depict everything, we would basically have to recreate the thing depicted, at the same scale. But the selectivity actually serves a positive purpose, in that it allows us to focus on some key aspects of the situation being depicted, while backgrounding or omitting others. Moreover, representations in maps often reflect some particular conceptualization of the world rather than directly representing the world. For instance, forest and soil type boundaries are typically represented on maps as lines, even though they often exhibit a graded zone of change over some spatial extent. And due to scaling, bounded areas such as cities may be represented as single points. So a given map presents selected aspects of some particular conceptualization of 'reality'. The map thus conveys meaning, but the meaning is not the map itself. But neither is the meaning just the 'physical objective world' that the map is depicting.

Describing the spatial world: the language of spatial relations

Language is obviously another way we can communicate information about space and spatial relations. One significant difference between language and maps is that language has a temporal, linear structure that maps do not. Consequently, the user of the map determines much about what type of information he 'takes' from the map, and in what order. In contrast, a listener has to process the information in whatever order the speaker presents it. We might characterize this difference as similar to the one between touring an area on our own vs. following a guide along whatever path he has selected. Maps and language are similar in one very important respect, however: both allow the maker/speaker to use some combination of 'forms' to convey a particular conceptualization of the world (current or past, real or imagined) to another person. This underscores an important idea, namely that our conceptualization of space (spatial 'meaning') is to some significant extent independent of the means by which we represent and communicate it.

Consequently, we should not assume that spatial meaning somehow resides directly in language. Linguistic study does, however, provide an additional means to better understand how we conceptualize space, as well as other areas of experience. And this was one of my original motivations for turning my attention to the study of language.

A great deal of interesting and very insightful work has been done on space and spatial relations in language. I found works by Talmy (1983), Herskovits (1986), Lakoff (1987), Regier (1996) and Levinson (2003) particularly intriguing. Much of this work focuses on individual 'spatial relations terms', such as the various spatial prepositions used in English and other languages. Close examination of the meanings of individual terms reveals that each term can typically be used to describe several different types of spatial relations situations, which often leads to the conclusion that these terms may be quite polysemous. But, is this the only possible conclusion? After all, these descriptions of situations also usually include many other words. And, the meaning of the description as a whole presumably involves the composition of the meanings of all these different parts. For example, consider *The helicopter hovered over the car* vs. *The cat leaped over the car*. In the first example, one entity (the helicopter) has a static spatial relation to the car. While in the second example, the relation of the entity (the cat) to the car changes over time. But how do we know which relation is present in each of these sentences? In each case, the verb is supplying key information, indicating whether the entity with the spatial relation to the car is stationary or changing location. If it is stationary, the relation is presumably static. And if it is moving, the relation may be changing over time.

One way to analyze these sentences is to say that there are at least two different senses of *over*, one that describes a static spatial relation, and one that describes a dynamic, changing relation. To know which sense is applicable, though, we need to consider the meaning of the larger utterance (the semantic context) in which the preposition is being used. This raises an important question: to what extent might these differences in meaning be attributable to the larger context itself (e.g. a particular verb meaning in conjunction with this preposition), and not solely to the preposition? Clearly both the meaning of *over* and that of the verb are relevant to our understanding of the sentence, including our understanding of the spatial relation being described. But, do we want to say that in each case the meanings of each are somehow ‘added together’? Or that perhaps that they form a gestalt of some type, with the meaning of the whole related to -- but not necessarily strictly predictable from -- the meanings of each of these individual parts? If we follow this second approach, we don’t necessarily need to assume that a different sense of *over* is used in each sentence. But, we do need to explain how we can arrive at these two different ‘gestalt’ meanings, and also need to explain how the meaning of *over* is related to that of each of these different gestalts.

In either case, to fully understand which type of spatial relation each sentence describes, we need to look beyond the preposition and consider the words (especially verbs) that this preposition co-occurs with. More generally, to understand the meanings of each sentence, we can’t just determine the meaning of each word in isolation: we need to take into consideration the meanings of co-occurring words. In other words, we need to look beyond the meanings of separate, individual words, and think about the meaning of the combinations of words we find in phrases and sentences.

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Without the encouragement, inspiration and support provided by many different people (and a couple of dogs), I most probably would not have undertaken this project, and I most certainly would not have persevered to its finish.

I would first of all like to thank my parents, Fred and Corrine Kirsten, for raising me in an environment of intellectual curiosity, always supporting me in my endeavors, and only very infrequently asking "So why are you doing all this, anyway?"

I would also like to thank all those people whom I consider my intellectual mentors. This includes George Lakoff, Eve Sweetser, and Jerry Feldman. George sparked my initial interest in Cognitive Linguistics, and has opened my eyes to a different way of viewing meaning. Eve's clear teaching inspired me, and she provided the crucial impetus to enter the graduate program (18 years after getting my undergraduate degree). And Jerry's continuing support and willingness to give useful advice has kept me going.

In addition, I'd like to thank Len Talmy; it has been reassuring to know that someone with as many brilliant insights as he has had is also someone who loves details as much as I do. And Chuck Fillmore's curiosity about the different uses and meanings of *slap* (and other words) launched me on my rather obsessive investigation into a huge number of different sentences containing *slap*, *kick*, and an assortment of other rather violent verbs.

I've enjoyed the company of many outstanding colleagues. My original cohorts, Olya, Wes, Shweta, and Abby made the first years bearable and even quite fun at times. Other fellow students in linguistics and computer science have provided intellectual spark as well as friendship. In particular I'd like to acknowledge Johnny, Pat, Michael, Luca, Joshua, Eva, and Nancy. And I'd especially like to thank Johno Bryant, who has been a key collaborator in the development of the grammar described in this dissertation.

My long-time friends have also played a key part in this endeavor. Since I was a child, Regina has always had faith in me that has given me faith in myself. Rochelle drank many, many cups of coffee with me, while patiently listening to and providing useful comments on my ramblings about my work – thanks for being my sounding board. And thanks are also due to all my volleyball team-mates who helped keep me from turning into a complete desk-chair potato.

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I'd particularly like to thank my daughter, Alyssa, for her patience all these years. Although she is not quite sure how someone could possibly spend so much time analyzing sentences like *She kicked the ball*, she nonetheless shares my enthusiasm about sentences she herself has uttered, such as *That dog is panting hot stinky dog breath on me*. Maybe a future linguist? [Don't worry, Alyssa, there's no parental pressure going on here.]

Strange though it may seem, I'd also like to thank my past self (selves?), who persistently kept on working, even though she was not able to benefit from all of the invaluable advice my current self could have given her.

Lastly, and above all, I'd like to thank my husband Brian, for his patience and continuing support while I followed this long path, even (and especially) when it turned out even longer than either of us had initially anticipated.

Chapter 1

Compositionality

1.1 General Introduction

One of the amazing things about language is how, given even a relatively small number of words, we are able to combine them in different ways to convey a huge number of different, often novel meanings. For the language user, this compositional process is seemingly effortless, typically requiring little or no conscious thought. And, on the face of it, the basic process seems fairly simple and straightforward: words each have meaning, and when you put words together, you put their meanings together. Further, if you put a different set of words together, a different 'whole' meaning result.

Linguists have long realized that the story is more complex than this. A given language, for example, exhibits various patterns of word combinations, and provides various clues as to how word meanings should be assembled. Furthermore, as we look deeper at the meanings involved, various questions arise. For instance, in the case of verb 'alternations', recognition of more subtle differences in meaning leads to the question of how the 'same' words can be used to convey different meanings. And the story seems to grow still more complex when we ask even deeper questions, such as why is it that we are able to so effortlessly compose these meanings? And what is 'meaning', anyway?

A common attitude is that deeper questions such as these are not directly relevant to a particular linguistic analysis. And clearly, these questions are difficult to answer. But, I argue that by addressing these deeper questions, we can gain important insights that make the solution of more specific compositional issues tractable.

The approach to compositionality that I present in this dissertation relies on the use of two key tools. The first one is the Neural Theory of Language (NTL), which provides a theoretical framework that enables us to seriously address these deeper questions. The second is Embodied Construction Grammar (ECG), which provides a formalism for analyzing and writing construction grammars that are consistent with NTL principles. Together, these two tools have made it possible for me to develop a compositional, construction grammar analysis of a range of sentence examples, using a grammar that is both inspired and constrained by the 'deep' answers that NTL provides. Furthermore, much of the resultant grammar has been successfully implemented in the compositional interpretation of a variety of sentence examples (Bryant 2008; Feldman, Dodge and Bryant 2010).

In this dissertation I examine simple single clause sentences, focusing on sets of verb 'alternation' sentences: sentences that contain the same verb, but which exhibit different argument realization patterns. The specific examples examined in this dissertation are fairly limited in number, and at first (or even second) glance, may not seem particularly complex. However, a closer examination of these examples reveals that they present some significant challenges to a compositional analysis of their meaning. Significantly, these challenges are not unique to these particular examples; rather, they are indications of more general problems faced by compositional analyses. Consequently, the methodology I use to analyze these examples, and the insights gained through this analysis are applicable to a much broader range of data.

Some basic challenges to a compositional analysis of sentence meaning are apparent when we examine even a few examples at a relatively superficial level of meaning. For instance, in sentences like *Jack slapped Mary* and *Mary slapped Jack* how do we determine who is doing the slapping and who is being slapped? But as we increase both the breadth of data and the depth of our semantic analysis of this data, the picture grows increasingly complex. For instance, the same verb form (*slapped*) can be used to describe many different (but related) types of situations, as shown by examples such as the following:

(1) *She slapped the man*. She contacted the man with her hand, and likely caused him some degree of pain, though probably no lasting injury.
(2) *She slapped at the mosquitoes*. The mosquitoes are not necessarily affected by her actions, and she may in fact have not even contacted them. Thus, while she is an actor, her actions do not necessarily cause any effects.
(3) *She slapped the cup off the table*. Entails not only that she forcefully contacts the cup, but that the cup is affected by the action. However, unlike the first example (1), the effect is one of motion, not pain. Moreover, 'off the table' indicates something about the cup's change of location.
(4) *The slapped her hand on the table*. As with the previous example, this describes a mover that changes location with respect to a table. But, in this case, the mover is the instrument of the slapping action, not the target. And the motion is part of the slapping action itself, rather than being caused by forceful contact.

How can *slapped* be used to convey these significantly different meanings? How do we know which meaning this form is conveying in a particular situation? Which roles are being played by the different 'entities' described in these sentences? As these examples illustrate, the analysis of seemingly simple sentences can reveal underlying complexities of meaning, and raise important questions with respect to composition.

The heart of my work concerns the analysis and formal representation of meaning. In order to get the constructional analysis of sentences right, we need to get the meaning of the constructions and the sentences right. And to get these meanings right, there are several crucial steps we need to make. One step is to look beyond individual words, recognizing that the meaning of a given word typically includes concepts that are not unique to any one linguistic item. Another step is to recognize that meaning is not only associated with words, but also with the larger phrasal and clausal contexts these words occur in. This step increases the role of composition as a source of meaning variation, thus reducing the need to posit variations of individual word meanings (e.g. different verb senses). But it also brings up further issues about how a given language divides up meaning amongst individual constructions, and puts it back together again via unification of these constructions. In other words, we need to determine both the meanings of lexical and non-lexical units (e.g. phrases of various kinds) <u>and</u> how these meanings compose to create the meaning of particular utterances.

To address these issues, we need to expand our view of meaning and composition of meaning, not only looking beyond the meanings of individual linguistic items but, ultimately, looking beyond language itself. One critical assumption made by NTL is that meaning is not unique to language. Thus, constructional meaning taps into conceptual structure that is not unique to each construction, nor is it even necessarily unique to language. Therefore, one further crucial step is to analyze and represent the system of conceptual structure that constructions 'tap into'. Having taken this step, it becomes apparent that much of the complexity and inter-relatedness of constructional meanings comes from the complexity and interconnectivity of the underlying conceptual system.

Lastly, we need to consider the ways in which our full <u>understanding</u> of a given sentence may differ from the meaning directly specified by that sentence. The particular model of language understanding developed in NTL has, as I show, some important implications about what aspects of sentence understanding do – or don't – need to be specified by the constructions instantiated in a given sentence.

As I demonstrate in the following chapters, by addressing deep questions, and using tools provided by NTL and ECG, it is possible to overcome many challenges faced by a compositional analysis of sentence meaning. Furthermore, it is possible to develop grammars that support computationally implemented analyses of the deep embodied meanings of a variety of sentences, capturing sometimes subtle differences in the event conceptualizations that such sentences describe.

The story I tell in these chapters is, by necessity, quite complex and detailed. To help explain my motivations for choosing such an approach, and some of the choices I have made along the way, I first discuss my early encounters with some of the key data and issues examined in this dissertation. I also discuss some of the basic challenges the 'slap' sentences pose, along with a brief description of some approaches that have been taken to address these challenges. Goldberg's (1995) approach, in particular addresses some important problems, but faces some other considerable challenges. I therefore outline how these additional challenges can be addressed through the use of the NTL framework in conjunction with the ECG formalism. With this background information in place, in the second half of this chapter I provide an overview of the story told in the other chapters of this dissertation.

1.2 Background

1.2.1 First encounters with *slap* examples and some issues they raise

I first encountered the particular data that are the focus of this dissertation while working at the Berkeley FrameNet project (http://framenet.icsi.berkeley.edu). One step of the work in this project is to look at sets of sentences selected from a corpus, all of which contain the ‘same’ verb (lexical unit). Our objective was to try to analyze these sentences in terms of what different semantic frames they were evoking. Frames represent schematic representations of situations, with each frame including a set of participant and other conceptual roles that are the components of that situation. Because frames are not lexically-specific, the same frame can be evoked by many different words. Therefore, frames capture similarity of meaning across sentences containing different verbs. At the same time, frames capture a fairly deep level of sentence meaning. Consequently, they support recognition of relatively fine-grained differences in sentence meaning that are not always recognized and/or considered relevant to other linguistic analyses.

A large corpus such as the British National Corpus commonly contains a large number of different sentences that contain a given verb. Often, semantic analysis indicates that more than one frame is evoked by these sentences. In most cases, however, the sentences can, at least in theory, be categorized into a few different groups, each of which evokes a somewhat different frame.

For some verbs, this analysis results in the identification of several different categories. *Slap* is one such verb, in which semantic differences between sentences suggest there are several different frames being evoked. For instance, consider sentences such as the following:

(5) a. She slapped the man
b. She slapped the cup off the table
c. She slapped at the mosquitoes
d. She slapped her hand on the table
e. My backpack slapped against my back

Example (5) can be analyzed as evoking a ‘cause harm’ frame, in which an Agent brings about some harm to a Victim. The next example (6) is similar, but the result of the action differs from the first. This sentence can therefore be analyzed as evoking a ‘cause motion’ frame, in which a Causer causes a Theme to change location with respect to some location (e.g. Source or Goal). Example (7) can be viewed as a description of a situation in which an actor attempts to bring about some effect, but is not necessarily successful in this attempt. Thus, this might be analyzed as evoking an ‘attempted action’ frame, in which the Agent attempts to affect a Target. For (8), the Agent causes an Impactor to impact an Impactee (Cause Impact frame). And for (9), no Agent is present, and the appropriate frame therefore seems to be one of simple impact, in which an Impactor impacts an Impactee.

Thus, when the semantic analysis couples depth of meaning with breadth of data (e.g. a corpus), it becomes apparent that a given verb may exhibit considerable meaning variation across its different uses.

Use of frames in the compositional analysis of sentence meaning
The frames and frame roles of each of these sentences provide a way to relate the meanings of various 'parts' of each sentence to the larger meaning associated with the sentence as a whole. For instance:

(6) a. She slapped the man: 'She 'is Agent, 'the man' is Victim
b She slapped the cup off the table: 'She' is Causer, 'the cup' is Theme, 'the table' is Source
c. She slapped at the mosquitoes: 'She' is Agent, 'the cup' is Target
d. She slapped her hand on the table: 'She' is Agent, 'her hand' is Impactor, and 'the table' is Impactee
e. My backpack slapped against my back: 'My backpack' is Impactor, 'my back' is Impactee

Thus, given the assumption that the meaning of sentence as a whole is associated with a frame, we can identify which frame 'parts' (roles) are being expressed by the different sentence 'parts'.

Coupled with an analysis of the grammatical functions played by these different sentence 'parts', we can identify various <u>general</u> patterns of frame role expression. For instance, for (6a – b):

a. Subject is Agent, direct object is Victim
b Subject is Causer, direct object is Theme, indirect object is Source
c. Subject is Agent, indirect object is Target
d. Subject is Agent, direct object is Impactor, indirect object is Impactee
e. Subject is Impactor, direct object is Impactee

Because these patterns are not unique to any specific role fillers, we can recognize their presence in many other sentences. For instance, the first pattern is also present in *The boy slapped his little brother*, *Sandy slapped Bill*, etc. Thus, these are potentially productive patterns. Through such analyses, then, we can handle an important element of the compositional analysis of sentence meaning: the determination of general, productive patterns of 'role-filler' relations.

Compositional sentence analyses using frame-based roles have two very important advantages over ones which use isolated thematic-type roles. One advantage concerns depth of meaning. By using different frames and frame roles to represent the meanings of these sentences, we can capture finer-grained meanings than those typically associated with general thematic roles such as Agent and Patient. The other advantage concerns integration of meaning. Typically, thematic roles like Agent and Patient are defined as separate entities (e.g. as part of larger set of thematic roles, which don't necessarily have any defined relations between them). In contrast, by defining two roles such as Impactor and Impactee as part of the same frame, it is clear that the roles are directly related to one another. In addition, frames better indicate the overall meaning of the sentence as a whole.

So, at this point, we seem to have an approach that supports basic 'role-filler' compositional semantic analysis of a relatively broad range of data at a relatively deep level of meaning. But, there is a puzzle here. As shown by the examples above, sentences which contain the same verb can have significant differences in meaning. And we can analyze these differences using different semantic frames and roles. But, if the verbs are the same, and many of the other words are the same or closely similar, where are the meaning differences coming from?

If we make the lexicalist assumption that words are the only parts of the sentence that contribute meaning, we are forced to conclude that the words must mean different things in different situations. Given that we can also recognize similarities in meaning, we are likely to conclude that these different meanings are attributable to the use of different 'senses' of a given verb. But this assessment leads to what might be termed a 'sense identification' problem: How do we know which sense is being used in a given sentence?

The general answer is that we need to consider the larger context in which the verb occurs. This includes the semantic context (the other words in the sentence) as well as the larger context in which a given sentence is used. But what is particularly striking about the different senses of *slap* being discussed here is that these different senses are correlated with differences in argument realization patterns. Consequently, another key element in 'sense identification' is the 'syntactic' context it occurs in. 'Syntactic' is put in quotes because the argument realization patterns also include meaning elements. For instance, in addition to considering the 'grammatical function' of an NP, the type of entity described by this NP may also be relevant. The CauseHarm sense of *slap*, for example, is associated with transitive syntax (S V O). And, the direct object has to be animate. In sum, a given sense is commonly associated with a particular argument realization pattern. Therefore, to identify which sense is applicable, you need to identify this pattern.

One method for compositionally analyzing the different meanings of the *slap* sentences, then, is to define different senses of *slap,* and to determine the relevant argument realization pattern associated with each sense. And this same approach could be extended to the analysis of sentences containing other verbs. However, as we look at a range of sentences with semantically similar verbs, some more general patterns become apparent.

Many verbs are similar to *slap* both in meaning and use. For example, *tap, rap, kick,* and *hit* occur in sentences that evoke some of the same frames as the slap examples discussed above. Moreover, there are also many similarities in the patterns of role expression that these sentences exhibit. For instance:

(7) *She slapped/kicked /whacked /poked him* = cause harm frame, with subject expressing Causer, and direct object expressing Victim

(8) *She slapped/kicked /whacked /poked the cup off the table*: 'She' is Causer, 'the cup' is Theme, 'the table' is Source.

(9) *She slapped/kicked /whacked /poked at him* = attempted action, subject is Agent, indirect object is Target

It is possible to analyze these other sentences in a manner similar to that outlined above. That is, for each verb, we could identify several senses. And for each sense, we could identify the associated 'context'/argument realization pattern(s) it occurs with. But, the use of non-lexically-specific frames to analyze the meanings of these sentences enables us to recognize more general semantic and syntactic patterns that are <u>not</u> specific to *slap* or any one particular verb. And, recognition of these more general patterns is significant because they suggest an alternative, more general approach to the compositional analysis of sentences such as these.

1.2.2 A construction grammar analysis

The basics of an alternative, construction grammar approach were laid out by Goldberg (1995). One key way this approach differs from the one described above is that rather than focusing on lexically-specific relations between meaning and argument realization patterns, these relations are examined at a more general level. And, given this change in focus, it is possible to identify general argument realization patterns which recur across a range of different verbs, in which a particular frame is associated with some particular pattern of expression of frame roles.

Based on this and further evidence, Goldberg theorized that in addition to verbs, the grammar also includes various meaningful argument structure (A-S) constructions, each of which pairs some 'basic scene' with a particular pattern by which the roles associated with that scene are expressed. For example, the 'caused motion' A-S construction has the meaning of a basic scene in which a person causes something to move. This scene can be analyzed and represented as a Cause-Motion frame. The general argument realization pattern specified by this A-S construction is that the Causer is expressed by the subject, the Theme by the direct object, and Path by an oblique. In a specific use of this construction, it will unify with the verb in the sentence, and the verb's semantic roles will 'fuse' with the more general frame roles of the argument structure construction. So, for instance, in *She kicked the ball over the fence*, the kicker will 'fuse' with the Causer, the thing kicked (the ball) with the Theme, and the path of consequent motion of the kicked thing with the Path role. Because this A-S construction represents a general, rather than a lexically-specific pattern of argument realization, it can also unify with other, semantically similar verbs, such as *hit, whack, punch*, etc. Thus, as with all A-S constructions, this 'caused motion' construction captures some important generalizations, representing a general pattern of argument realization associated with some set of semantically similar verbs. Consequently, one benefit of positing A-S constructions such as these is that they address the 'sense identification' issue at a fairly general level.

One consequence of this construction-based approach, though, is that it increases the complexity of the compositional analysis of sentence meaning. Rather than just composing the verb meaning with that of its 'arguments', the verb meaning is composed with the argument structure meaning, and argument structure construction meaning is composed with the 'arguments'. In essence, then, the presence of a meaningful argument structure construction adds another compositional 'layer' into the analysis.

This additional layer is the key to developing an alternative, non-polysemy analysis of sentence meaning variation. But, this alternative analysis rests on one further, crucial assumption: that the meaning of the A-S construction may differ in significant ways from the meaning of the verb with which it unifies. Because this is a very important point, it bears some elaboration.

1.2.3 Semantic relations between verbs and A-S constructions

Prototypically, the semantic relation between the verb and the A-S construction is one of close similarity, in which the verb meaning is a more specific 'instance of' the general A-S construction meaning. For instance, the sentence *She threw the ball* can be analyzed as instantiating an A-S construction whose meaning is 'cause-motion'. And, we can consider the meaning of *throw* to be a more specific instance of this general 'cause-motion' meaning.

But given the existence of meaningful A-S constructions, there are strong motivations for recognizing the possibility that there may also be other types of semantic relations between a verb and a co-occurring A-S construction (e.g. see Goldberg 1995, Michaelis 2003). Thus, there may be significant differences between the meaning of the A-S construction and the meaning of the verb with which it unifies.

One very important consequence of these assumptions is that we don't necessarily have to posit different verb senses in order to analyze sentences that contain the same verb form but which describe different types of events. For example, we don't need to posit a 'caused motion' sense of *sneeze* in order to analyze *She sneezed oatmeal on the dog*. Instead, we can posit a 'core' sense of *sneeze* that applies to a wide range of sneezing descriptions, and which doesn't specify any particular effect on other entities. This verb construction can unify with a Caused Motion A-S construction that supplies the 'caused motion' element of the sentence meaning, including the Theme and Goal roles that are expressed in this example. The A-S construction and the verb still have some meaning in common. But, unlike the prototypical case, the A-S construction includes meaning not present in the verb.

Similarly, for *slap*, we don't necessarily need to posit different 'cause-effect', 'cause-motion', and 'attempted action' senses for, respectively, *She slapped the book*, *She slapped the book off the table*, and *She slapped at the book*. Instead, we can identify a 'core' meaning involving a person performing a slapping action and the thing they are (attempting to) forcefully contact. And the A-S construction can then provide additional information with respect to outcome of that action. Thus, rather than (solely) attributing meaning differences in these different slap examples to different senses of the verb, we can attribute it to differences in the meanings of the A-S constructions instantiated in these different sentences.

Given the existence of A-S constructions in a grammar, plus the further assumption that the meanings of these constructions may differ from those of the verb with which they unify, it is possible to analyze verb 'alternations' via constructional composition, without having to necessarily posit multiple verb senses. This approach is preferable to a lexicalist approach for several reasons. As Goldberg points out, it avoids the need to posit 'implausible' verb senses. Additionally, it recognizes important general patterns that language users learn and make use of to understand and produce sentences which contain (potentially novel) verbs and which are used to describe (potentially novel) situations.

The possible approaches to the analysis of verb 'alternation' sentences described here is similar in many important respects to the possible approaches for analyzing sentences containing spatial relations descriptions, discussed in the Preface. In both case, we can analyze meaning differences associated with different uses of a word as arising from the use of different 'senses' of that word. But, to know which sense is applicable, we typically have to consider the larger context in which that word is used. And, if we recognize that this larger context may itself be supplying meanings, then it is possible to analyze meaning variation compositionally, rather than as necessarily being a matter of lexical polysemy.

In both cases, then, to understand the meaning of a sentence, we need to do more than just consider the individual meaning of each word in that sentence. Thus, while the focus here is on verb and argument structure constructions, this work has much wider implications for the analysis of meaning variation, and the role meaningful non-lexical constructions of other kinds may play.

1.2.4 Additional challenges

Goldberg's construction grammar analysis of argument realization essentially introduces another 'layer' of constructional and semantic composition into analysis. And, it is this extra compositional 'layer' that enables an alternative to a polysemy account to sentence meaning variation. However, this additional layer also introduces some analytical and representational challenges. One particular challenge relates to the semantic relations between the verb and A-S construction that motivate their composition, and the results of such composition. For instance, why does the meaning of *slap* compose with that of different scenes, and when it does, what is the end result?

Goldberg views semantic composition of verb and A-S construction meanings primarily in terms of role 'fusion'. And, to fuse, roles must be semantically compatible. But this still requires that we determine what roles each of these constructions have and what makes these roles compatible. In some cases, the relevant semantic relations seem to be inherent in the way we categorize the meaning that is associated with the verb. For instance, independent of the analysis of any particular sentence, it seems reasonable to characterize the action described by *slap* as a more specific 'instance of' or subtype of a basic transitive scene, in which an Agent acts on and (potentially) affects a Patient. Accordingly, we can characterize the meaning of *slap* as including one semantic role (Slapper) that is a more specific instance of a fairly general Agent role, and another role (Slappee) that is an 'instance of' Patient. This kind of categorization of verb roles helps indicate the semantic motivation for the fusion that occurs in an example such as *She slapped the book*. The meaning of the transitive A-S construction instantiated in this sentence can be characterized as that of a basic transitive scene. Given the previous characterization of slap's roles, there is therefore clear semantic motivation for the verb's Slapper' role to fuse with the A-S construction's Agent role, and its Slappee role to fuse with the A-S construction's Patient role. Thus, in this particular case, the semantic 'compositional' relations mirror semantic 'categorization' relations.

In cases like these, where verb meaning is analyzed as a more specific instance of A-S construction meaning, the motivation for and results of their composition seem fairly obvious. And, because the meanings and semantic roles associated with the verb and argument structure construction are quite similar, there is no apparent need to delve further into the internal structure of either one.

However, the potential relations grow more complex as we look at a broader range of data. For instance, consider *She slapped the book off the table*. As noted before, the meaning of the A-S construction instantiated in this sentence can be characterized as a 'caused motion' scene or frame, with Causer, Theme, and Source roles. This scene involves a transitive component (e.g. Causer acting on Theme). But it also involves a motion and change of location element (e.g. Theme moves along some 'path', away from the Source). Assuming we don't want to posit a 'cause motion' sense of *slap*, we could still characterize its meaning as was done above, as an instance of the basic transitive scene. But given such an assumption, the verb meaning can't rightly be characterized as a more specific 'instance of' the A-S construction's meaning. Nor does it necessarily make sense to categorize Slapper as an instance of Causer, nor Slappee as an instance of Theme.

We might say that there is a 'means' relation: the slapping action is the 'means' by which the Theme's motion is caused. But what exactly does 'means' mean? And what does this indicate about the semantic compatibility of the verb and A-S construction semantic roles? Another way of looking at this relation is to say that the verb describes an action that is essentially part – but not all – of the scene associated with the A-S construction. That is, caused motion 'includes' a transitive action element as part of its meaning, but it also includes an spatial/motion component that is caused by this action. In this example, *slap* describes the transitive causal component, but not the consequent motion. Thus, we could say that there is essentially a 'part-whole' relation between the verb and A-S construction meaning.

The significant thing here is that in order to recognize this part-whole relation, we have to recognize the complex internal structure of the scene described by the A-S construction. This necessitates that we acknowledge that the relevant meaning of this A-S construction includes more than just a set of semantic participant roles. Moreover, this view also points to the complexity of the semantic roles themselves. For instance, in the 'caused motion' example above, the book is both something that is acted upon by a Causer/agent and something that moves in relation to some Source or Goal. And it is the first component of this complex meaning that seems to motivate the composition of this A-S construction role with the 'slappee' role.

Examination of additional examples indicates the need to recognize further complexity in constructional meanings and relations. For instance, consider *She slapped the book on the table* (with the reading that, while holding the book, she moved it and brought in into contact with the table, i.e. as a description of an event that might also be described by saying *She slapped the table with the book*). Various possible analyses of the meaning of the A-S construction in this sentence are possible. For instance, we could, as noted earlier, analyze it as a Cause Impact scene. Or, we could analyze it more generally as describing a Cause Motion scene. In either case, to figure out the appropriate semantic roles and relations, we need to know that slapping involves a 'slapper' moving an 'instrument' into forceful contact with a 'slappee'. Knowing this, there is motivation for the 'instrument' to fuse with the Impactor or the Theme role associated with the A-S construction. As above, this also requires that we recognize the complexity of this A-S construction role. If we analyze A-S construction meaning as CauseMotion, though, the motivation for fusion differs from above: in this example, fusion is motivated by the fact that the Theme role includes motion-related meaning, whereas in the previous example fusion was motivated by its patient-related aspect of meaning. So, as this and other examples indicate, a given verb may have several possible semantic relations to the A-S construction it unifies with. And detailed analysis of these relations requires that we recognize the internal complexity of both the A-S construction meanings (and associated semantic roles) and the verb meaning (and verb roles).

In sum, a compositional approach to the analysis of verb alternations has several strengths. It captures differences in sentence meanings without necessarily having to posit multiple senses for a given verb form. In addition, it captures generalizations over semantically similar verbs, and supports productive use of verbs to convey novel meanings. However, in order to understand the motivation for and results of many of these compositional patterns, we need to be able to recognize the internal complexity of the meanings of the verb and argument structure constructions.

Given this complexity, it would be very useful to have a consistent and precise formalism to represent constructions and their meanings. The use of frames and frame-based roles to represent meanings has many advantages over the use of isolated thematic-type roles. But, while individual frames (and associated roles) are sufficient to capture many fine-grained meaning distinctions, by themselves they are not adequate to capture the internal complexity and different semantic relations described above. At a minimum, in addition to defining individual frames, we would also need to recognize (and represent) relations between these frames. Moreover, as indicated above, a given frame may have relations to several different frames. In short, individual frames would need to be situated within a larger system of frames.

Ultimately, though, this is not a representational problem, but a conceptual one. That is, it requires a different way of viewing the meaning we're trying to represent.

1.3 Changing the game

Construction grammar approaches suggest that to understand the (compositional) meaning of a sentence, we need to consider more than just the meanings of the individual words in that sentence: we also need to consider the meanings of other constructions instantiated in that sentence. That is, language meaning involves more than just words. A frame-based analysis of meaning suggests that in many cases, at least some portion of a construction's meaning is not unique to that particular construction: it involves a more general, non-lexically specific conceptual frame. Consequently, when analyzing meaning in language, we need to look beyond the meanings of individual words and other constructions.

In addition to identifying the relevant meaningful 'parts' of a sentence, a compositional analysis of sentence meaning also requires that we determine how each of these parts relate to the meaning of the sentence as a whole. That is, how do the meanings compose? In the case of verb and A-S constructions, the key lies in their semantic 'compatibility'. Therefore, we also need to determine how meanings of constructions are related to one another. This too requires that we look beyond the meanings of individual 'meaningful' constructions, and consider the larger system of meaning itself: conceptual structures and their relations to one another.

For the verb and A-S constructions being examined here, the relevant conceptual structures (semantic domain) are events that involve action, motion, and other kinds of experiences which evolve over time. One way to go about analyzing and representing the structure of this domain is to follow a similar approach as cognitive linguists' analyses of spatial relations terms. Accordingly, we can examine processes and events to determine what types of recurrent schematic structures they evidence. And, we can try to analyze more complex meanings as composites of simpler, more 'primitive' meanings.

This approach, by itself, can yield valuable insights into the structure of this domain. Furthermore, it provides a way to ground the meaning of specific constructions in non-construction-specific conceptual structure. However, it does not address many deeper questions, such as: Why and how does language rely on the use of such structures and relations? How is this conceptual structure itself 'grounded? What is its basis? Why does it exist, and why does it take the form it does?

Seeking answers to these *why* questions is not just a matter of satisfying our intellectual curiosity. It is, as I demonstrate in this dissertation, a means by which we can get inspiration for and constraints on how to go about answering the *what* and *how* questions about complex semantic structure and its use in language.

1.3.1 Theoretical framework

The theoretical framework for this dissertation is provided by the Neural Theory of Language (NTL). NTL shares many of the core elements of various Cognitive Linguistic theories, viewing language as a cognitive process and considering meaning as an essential component of linguistic analysis. In addition it also seriously considers such questions as: How are language and meaning realized in the brain? How is language related to other types of cognition? And how does Linguistics fit onto the larger framework of Cognitive Science? Through answers to these questions, NTL provides a larger theoretical framework into which the somewhat diverse discoveries associated with Cognitive Linguistics can be integrated. I will discuss NTL in greater detail in the following chapter, but at this point it is important to note some of the important assumptions made by NTL, and to discuss their implications for the current work.

One key assumption is that 'meaningfulness' is not restricted to language; rather, it is continuous with other forms of thought. Another is that cognitive processes have a neural realization, and that the nature of this neural realization affects language (and linguistic analysis) (Lakoff and Johnson 1999, Dodge and Lakoff 2005).

A further, more specific assumption about language understanding involves *simulation* semantics (Narayanan, 1999, Feldman and Narayanan 2004, Gallese and Lakoff 2005), the idea that people understand utterances by (subconsciously) imagining or simulating the situations they describe. Crucially, this simulation involves activation of some of the same or similar neural structures as are active when performing, observing and/or imagining the events being described by a given utterance. Thus, the simulation of the situation described by the sentence *The girl ran* involves activation of some of the same or similar structure as is active when we run, see someone else run, plan to run, or imagine ourselves or someone else running. While not unequivocally established, simulation semantics is supported by a considerable amount of neuroscientific research, which has found evidence that neural networks active when performing actions are also active in other circumstances, including imagining and observing actions (for reviews, see Kosslyn et al. 2001, Rizzolati and Craighero 2004), as well as processing language about them (e.g. Hauk et al. 2004, Tettamanti et al. 2005). According to this theory, then, language understanding is associated with activation of neural structure that also serves other, non-language functions.

1.3.1.1 Grounding a semantic domain to neural structure

These assumptions have some important implications for how we approach the analysis of meaning in language. In particular, they suggest that it is fruitful to analyze meaning not only through the examination of language, but also through other non-linguistic means (e.g. neuroscience and cognitive psychology). More specifically, they indicate that our analyses of language and meaning are likely to be significantly enhanced by greater knowledge about their neural substrates. Thus, one means to discover more about the conceptual structures evoked by the *slap* sentences discussed above, is to consider non-linguistic evidence about the recurrent structures associated with various modes of experiencing the situations described by these sentences. For instance, what is the nature of the neural circuitry that is active when we observe, plan or imagine ourselves or someone else actually slapping someone or something? How might this circuitry differ in different situations? Is it different when we slap with the intention of causing harm vs. when our intent is to cause the slapped thing to change location? If so, how does it differ? Answers to these questions can provide insights into the internal structure of such actions, as well as giving insights into how our conceptualizations of different 'slapping' events might potentially differ from one another.

1.3.2 Embodied Construction Grammar

NTL is independent of any specific grammar formalism. But, Embodied Construction Grammar (ECG) is designed to be consistent with and further the exploration and application of the NTL approach to language. ECG is firmly in the Construction Grammar tradition (Croft 2001, Fillmore 1988, Fried and Boas 2005) but adds the centrality of embodied semantics (Johnson, 1987). Although the grammar I discuss in this dissertation is relatively small, it is rather detailed and complex in many ways. This level of detail and complexity is an essential component of the compositional account of meaning that I present. One important benefit of using the ECG formalism is that it provides a means for dealing with this complexity. Significantly, ECG serves as a computer specification for implemented computational applications. Especially relevant for the current work, this includes the ECG workbench (Bryant and Gilardi, to appear), a tool that enables us to interactively develop and view wide-coverage grammars, and which provides access to the Constructional Analyzer (Bryant 2008), a construction-based implemented system of language interpretation.

Two of the basic primitives used in ECG to specify grammars are constructions and schemas. Consistent with other construction grammar theories, ECG constructions pair form and meaning elements. In neural terms, we can view constructions as neural circuits that link form-related circuitry and meaning-related circuitry into a larger gestalt circuit. The nature of this circuitry is such that activation of the form component leads to the activation of the meaning component, and vice versa.

The meanings of ECG constructions are represented using 'schemas', a term meant to encompass both frames and image schemas. Consistent with other analyses, these schemas have internal structure which includes some relatively small number of roles, and which supports various kinds of inferences (Johnson 1987). Image schemas and frames are sometimes viewed as abstractions over experiences, with the implication being that we start with full, rich representations of experiences and then somehow "abstract out" or extract certain schematic structural elements that are common to all of these experiences. NTL provides a different view, one which explains how and why we perceive the particular schematic structural elements that we do. In this view, schemas are particular kinds of neural circuits that are active for a range of different experiences (Regier 1996, Dodge and Lakoff 2005). Significantly, such circuits are sensitive to only a few types of information relating to such experiences, being sensitive, for example, to the state of boundedness of an object, but not to its shape or color. Thus, such circuits are inherently 'schematic' in nature. In addition, these circuits are 'multi-modal', sensitive to information related to more than one particular modality of experience (e.g. visual, auditory, tactile, motor-control). Furthermore, because the brain areas corresponding to these circuits can be simultaneously active, these schemas can form various superpositions. Consequently, it is often possible to recognize the presence of more than one schema in a particular experience.

Significant for the current work, ECG schemas also include 'executing', or x-schemas. These schemas were inspired by research in biological motor control theory, and represent schematic structure that is associated with dynamic actions and events (Bailey 1997, Narayanan 1997, Feldman and Narayanan 2004, Bergen and Chang 2005). As we will see in later chapters, these x-schemas (also referred to as Process schemas) play a central role in the analysis of verb and argument structure construction meaning.

One important advantage of using schemas to represent constructional meaning is that they explicitly represent meaning elements that are key to grammar (and composition). The basic story is as follows. A specific, given experience is likely to include activation of both general/schematic structure and structure related to more specific information. For instance, an experience involving a specific cup will presumably activate schematic structure related to fact that the cup is a bounded object that can contain other objects, as well as activating structure relating to this cup's specific color, size, etc. Constructional meaning can potentially include both schematic and specific types of structure. However, in order to be able to use a construction to describe a range of situations, the conceptual structure it activates will almost inevitably have to be less specific than the structure activated during any one particular experience. We can also make the further assumption (consistent with Talmy 2000a) that the meanings associated with argument structure and other 'closed-class' constructions predominantly -- perhaps even exclusively -- consists of general, schematic conceptual structure, while the meanings of 'open-class' constructions, such as verbs, will typically include more specific structure.

These assumptions have very important implications for compositional constructional analyses of sentences. Ultimately, the goal of such analyses is one of conceptual composition: when the constructions in a sentence unify, their meanings should compose, and this composition should be consistent with our intuitions about the meaning of the sentence as a whole. But what motivates them to compose, and what is the result of this composition? As described more fully in later chapters, I make the further assumption that in the case of constructionally-specified compositional patterns, it is the general schematic structure that is common to (shared by) two constructions that guides their integration into a single coherent meaning, consistent with Lakoff's 'cog' theory (Gallese and Lakoff 2005).

The specific semantic relations between unifying constructions, and the conceptual structure they have in common, will differ for different types of constructions. In the case of role-filler relations (e.g. composition of an NP's meaning with a particular A-S construction event role), the motivating similarity might be quite general (e.g. role and filler are both some sort of 'entity'). For verb and A-S constructions, the relevant schematic commonalities are of a different type, involving structure related to processes, actions, and events. Given these assumptions, one key to successful compositional analysis is the recognition (and representation) of the commonalities of schematic conceptual structure of the unifying constructions. And once we figure out how (and why) the meanings of the parts compose with one another, then, given the parts, we can determine the meaning of the 'whole'.

One complication presented by the use of A-S construction in the analysis is that before we can put the parts together into a whole, we first have to determine how a 'whole' should be divided up into parts. Specifically, in an analysis in which A-S construction meaning can differ from that of the verb, one necessary step is to figure out how to 'decompose' meaning that in lexicalist approaches would be assigned solely to the verb. For instance, for the example *She slapped the cup off the table*, we need to differentiate between the 'means' by which the motion is caused (i.e. the slapping action) and the 'cause motion' event structure as whole. Then, whatever meanings we posit for the two constructions need to integrate with one another to result in an appropriate 'whole'. As I show in later chapters, to 'decompose' and compose these meanings, we need to be able to recognize complex internal conceptual structure associated with various processes, actions and events, and to define schemas that capture this structure.

1.3.3 How NTL helps

For slapping and other actions, we can take a similar approach as for the analysis of spatial relations terms, but apply this approach to a different semantic domain. In particular, we can pursue the general idea that complex conceptual structure/experiences can be analyzed as arising from different compositions of more ‘primitive’ elements.

Linguistic analysis is one means for pursuing this idea. But NTL provides an additional means for looking for structure. In the case of motor-control actions like slapping we can, as noted above, examine various kinds of evidence about the nature of neural circuitry/structure active during motor-control experiences. Then, using the information gathered from these different sources of evidence, we can define various schemas to represent the schematic structure of this semantic domain. When defining these schemas, one objective is to identify recurring general structures, with some limited number of roles. An additional objective, though, is to consider how complex structures may in some cases be analyzed as ‘composite’ schemas that incorporate the structure of other schemas. And, to recognize that a given ‘primitive’ may potentially be part of more than one composite.

As I will show, these different types of relations can be represented by defining individual schemas as part of a larger lattice of inter-related schemas. The end result may appear quite complex. But, it is important to keep in mind that the analysis and representation does not <u>introduce</u> this complexity. Rather, it reflects the complexity of the neural structure that it represents.

1.3.3.1 Language understanding model: one more piece of the puzzle

As outlined above, the ECG formalism can be used to create a grammar consisting of constructions and schemas. But, the grammar itself is only part of the story; we also have to have some ideas about how this grammar is actually used to communicate meaning. In turn, these ideas will affect the types of constructional meanings we posit for our grammar.

Building on the key idea that language understanding involves simulation, the NTL project has developed a simulation-based model of language understanding. This model involves two inter-related phases.

- The *analysis* phase takes an utterance in context and determines the best-fitting set of instantiated constructions and bindings. Each interpretation of the utterance is in the form of a semantic specification, or SemSpec, which consists of a set of schemas, bindings, and role value specifications. The Constructional Analyzer (Bryant 2008), mentioned above, is a computational implementation of this analysis process that takes into account semantic, syntactic, and contextually supplied information to determine a ‘best-fit’ interpretation of an utterance in a given context.

- the *enactment* phase involves the mental simulation -- or enactment – of the situation specified in the SemSpec. The SemSpec itself only includes what is actually specified in the utterance, along with information related to the context in which the utterance is made. But for each hearer, the content of the simulation will be richer than what is specified in the SemSpec. For one thing, the specified schematic structures will often allow the hearer to draw various further inferences about the situation being described. In addition, the specific simulation a hearer has will also be affected by the hearer's own particular experiences, beliefs, etc.

The different constructions instantiated in a given utterance thus serve to supply the semantic parameters for a simulation of the situation described by the sentence. So, one way to look at the meanings of these individual constructions is in terms of what sort of simulation parameters they each supply. But this in turn requires that we determine what sorts of parameters are relevant to event simulation

The basic single-clause sentences examined in the current work can be characterized as descriptions of some event: what is going on for some participant(s) at some place over some period of time. Some of the SemSpec parameters relate to the 'content' of the event. This includes specifications about the participant(s) and types of process(es) that are involved in the event, and the relations between participants and processes. Other parameters indicate something about the way this event should be simulated. For example, from which participant's perspective should the event be simulated, and on which elements of the event should attention be focused? Therefore, the constructions instantiated in a given sentence need to supply parameters that relate not just to the nature of the events themselves, but to how such events are experienced and conceptualized.

At the same time, constructions do not need to specify all of the rich 'meaning' that a language understander associates with a particular sentence. For one thing, additional information will be supplied by both the physical and discourse contexts the sentence is encountered in. For another, as noted above, the simulation process may give rise to various inferences. While the instantiated constructions will typically specify the conceptual structures (schemas) that give rise to these inferences, they don't necessarily need to specify the inferences themselves. Additionally, while simulations utilize rich world knowledge and experiential associations, the key simulation parameters supplied by constructions are assumed to be those relating to the conceptual structure shared by users of a given grammar. This is consistent with the idea that language provides only partial, schematic specifications of meaning. At the same time, it helps explain how the relatively underspecified meaning specified by a given sentence can give rise to various richer 'understandings' in the mind of the person hearing that sentence. Thus, while the constructions instantiated in a particular sentence are obviously a crucial, central factor in determining what a sentence means to someone, they are not the sole source of that 'meaning'.

1.4 Overview of chapters

1.4.1 Framework and general methodology

More detail about NTL and the ECG formalism is provided in Chapter 2. This includes a description of the ECG formal notation that illustrates how it can be used to represent spatial relations schemas and constructions, in a manner consistent with various cognitive linguistic insights and NTL. In addition, Chapter 2 provides a high-level overview of the various types of schemas and constructions an ECG grammar (of English) includes.

The actual process of creating a particular grammar involves consideration of a number of interacting constraints. And, by necessity, it is not a linear process. However, it is possible to describe the general approach I have taken. My general methodology is to: (1) analyze a semantic domain, using various kinds of evidence; (2) define schemas to represent recurrent structural elements; and (3) use these schemas to represent the meanings of constructions. For each domain, I first focus on verb constructions, and then examine argument structure constructions. Because the objective is to define constructions that support compositional semantic analysis of different sentences, it is crucial to define individual constructions within the context of a larger grammar. That is, as in any grammar, the way one construction is defined will depend in part on how other constructions in the grammar are defined.

To give an overall sense of the material covered, I first give a very brief overview of the other chapters in this work. Following this, I discuss the content of each chapter in somewhat more detail.

I start, in Chapter 3, by looking at motion-related events. In that chapter, I examine the conceptual structures involved, posit schemas to represent them, and then show how they can used to represent the meanings of various motion verbs. In Chapter 4, I examine some specific sentences that describe motion-related events, and show how these can be analyzed as the composition of several different constructions. The main focus here is on A-S constructions. But, it is crucial that A-S constructions be defined within an eye towards the other constructions in the grammar. The co-occurring verb constructions are particularly relevant, but we also need to consider the noun and prepositional phrases that are part of these sentence examples. Moreover, we need to determine the relation A-S constructions have to clause-level constructions as well. Once we have accounted for the set of constructions instantiated in a given sentence, it is then possible to analyze and determine a SemSpec for that sentence.

To analyze *slap* and many other sentence examples, we need more than just motion-related meaning, however. Accordingly, in Chapter 5, I examine meaning related to action, force, agency, causation, and affectedness. Based on this examination, I present schemas that capture many elements typically associated with Agent and Patient roles, but do so in a way that grounds these roles in richer embodied structures, rather than considering them linguistic primitives of some kind. I then show how these schemas can be used to represent the meanings of various 'agentive action' verbs, such as *slap*, *push*, and *cut*. In Chapters 6 through 8, I examine a range of sentences that *slap* and other related verbs are used in. To analyze such sentences, the grammar needs to include several additional A-S constructions. As I show, it is possible to recognize (and represent) various relations between these A-S constructions, some of which exhibit radial category structure (Lakoff 1987). In Chapter 6, I examine sentences with a transitive argument realization pattern, e.g. *She cut the bread*. In Chapter 7, I consider that nature of the 'conative' construction (e.g. *She slapped at his hand*.). And, in Chapter 8, I examine the various types of slap examples that express three event participant roles (e.g. *She slapped the cup off the table, She slapped her hand on the table, She slapped him on the hand*). In each case I show how the constructions instantiated in these examples support a compositional analysis of these sentences that captures both similarities and differences in their deep meaning (i.e. a meaning that indicates a specific conceptualization of some particular type of event).

Each of these chapters addresses some important issues. To better understand these, let us take a closer look at each of these chapters in turn.

1.4.2 Motion

Given the basic assumptions about conceptual structure stated above, and my objectives for meaning representation, how can we actually analyze and represent the structure of a particular semantic domain? I first address this question by looking at motion-related events. One of the key issues addressed in Chapter 3 is how to define schemas (and roles) that can be used to represent the meanings of various motion verbs (and their associated semantic roles). Achievement of this objective faces two challenges:

- Roles and inferences differ across different uses of these verbs, suggesting the presence of more than one schema. At the same time, there are also various cross-cutting similarities, suggesting various relations between these schemas. So, it is necessary to do more than identify one single 'motion' schema.
- Roles and inferences may differ for different uses of the same verb. Given the existence of meaningful A-S constructions in the grammar, we can assume that some differences may be attributable to the A-S construction rather than the verb. The main challenge here, then is to identify a 'core' meaning of the verb that is consistently present across a range of uses of that verb.

To get a better sense of these challenges and the means I use to address them, consider (10a-d), all of which describe motion-related events.

(10) a. The box spun.
     b. The box slid.
     c. The boy wriggled.

d. The boy walked.

There are some clear similarities across these examples. Each of them describes a motion-related event, with the subject describing the entity that is actually moving, while the verb describes something about the motion itself. But there are also some differences as to what further inferences we can make about this motion event. One such inference that differs concerns the mover's location over time. For both *The box slid* and *The boy walked* we infer that that the thing moving also changed its overall location. However, for the other two sentences (*The box spun* and *The boy wriggled*), this is not necessarily the case. Related to this, *spin* can be used for descriptions of 'motion in place', while *slid* cannot as in *The ball spun / ?? slid in place* (assuming this reading is not that of '<u>into</u> place'). Thus, motion descriptions may differ as to whether or not they specify that the mover changes its overall location.

Another inference concerns agency, control of the motion. For instance, compare:

(11) She slid / spun /rolled.
(12) She walked / sauntered / ran.

In the first set of examples (11), the mover may have been in control of her motion, but not necessarily so. (*She slid into home* vs. *She helplessly slid across the ice*). Whereas the examples in (12) entail that the mover was in control of at least some aspects of her motion, e.g. its initiation, maintenance, speed, and/or direction. Related to this difference, there are differences in the acceptability of inanimate fillers of the Mover role, as indicated by (13).

(13) The box slid / *sauntered.

Compounding this problem, these examples include different combinations of these elements. For instance (10c), *The boy wriggled*, describes motion that is controlled but not necessarily translational. And (10b), *The box slid,* describes motion is translational but not controlled. And for (10d), *The boy walked,* it is both, while for (10A), *The box spun,* it is neither. Furthermore, these additional elements are not necessarily restricted just to motion events. For instance, animate control of actions is not limited to actions that involve a change in the actor's location. This means that a 'walker', for example, is not only similar to other 'movers', but is also similar (albeit in different ways) to other 'actors'. So, the role played by the boy in *The boy walked* is similar in some respects to the one the box plays in *The box slid*, while it is similar in a different way to the role the boy plays in *The boy sang*. Thus, there are both significant similarities and differences in the schematic structure evidenced by these different motion-related descriptions. And the challenge is to represent constructional meanings so as to capture both the similarities and the differences.

The solution to this challenge lies first in looking beyond the meanings of individual constructions, and considering instead how to analyze and represent the underlying system of motion-related conceptual structure. The general methodology I use is to examine linguistic and neural data with the goal of gaining insights about the nature of this underlying conceptual structure. Based on this data, I identify various 'primitive' schematic structures, as well as schematic structures that can be analyzed as compositions of these primitives. Using the ECG formalism, I represent this complex conceptual structure as a lattice of inter-related schemas: a basic Motion schema plus more complex schemas that also integrate this basic motion structure with other types of structure. One of these complex schemas integrates motion structure with structure related to location change (represented using a Source-Path-Goal schema). And another integrates structure related to an actor's control of his body (represented using a MotorControl schema). These schemas can then be used to represent the meanings of verbs (and other constructions).

But this brings up another issue: how do we decide the number and meanings of constructions we need to posit for each verb? The problem is, the roles and inferences associated with a given verb may differ in different uses. For instance, consider the past tense verb *spun*. In some sentences this verb form is used to describe translational motion (*The top spun across the floor*). But in others it is not (*The wheel spun around and around*). Do we need to posit two different verb constructions, each with a different but related meaning? The answer to this clearly depends on what approach we take to analyzing meaning differences of verb 'alternations'. In the compositional approach I am taking, my objective is to identify a 'core' meaning that is present across a wide range of uses of a given verb form. For example, *spin* sentences all include a mover that is rotating, but vary as to whether the mover is or is not in control of this motion, and as to whether or not the mover is also changing location. Therefore, the construction for the 'core' meaning of this verb should include basic motion structure that is present in a wide range of uses. But it should not include structures related to location change or control of motion, which are present in only in some uses. These meaning variations will instead be handled through composition with A-S constructions having different meanings.

In the current grammar, the core meaning of each of these motion verbs is represented using one of the motion-related schemas in the schema lattice. For instance, the meaning of *spun* is represented using the basic Motion schema. The 'core' meanings of some motion verbs are more complex. E.g. for *slid,* sentence meanings consistently include both motion <u>and</u> change of location. Accordingly, I define a construction for *slid* which has the core meaning of translational motion, and represent this meaning using the more complex MotionAlongAPath schema.

One very important advantage of this representational method is that semantic relations between constructions are indicated by general non-construction-specific schematic relations. For instance, the various motion schemas all are related to and incorporate the structure of the basic Motion schema. Therefore, by using these schemas to represent the meanings of various motion verbs, it is clear that these verbs have some basic motion-related meaning in common. At the same time, these schemas help indicate finer-grained similarities and distinctions within this larger group of verbs. For instance, while MotionAlongAPath is related to Motion, it also contains structure that Motion does not.

Thus, verbs whose meaning is represented using MotionAlongAPath (e.g. *slide, skid, fall, rise*), can be seen as similar to one another, but different from other motion verbs (*spin, twist, roll*).

Another advantage is that schemas indicate the internal complexity associated with some of their semantic roles. For instance, each of the motion schemas described here includes a role for an entity that is moving. But, in the more complex schemas, this is actually a complex semantic role, one in which the basic motion 'mover' role is bound to other roles, such as 'trajector' and/or 'actor'. Consequently, the semantic roles associated with different motion verbs are both inter-related and, at times, internally complex. Furthermore, in some cases this will help indicate a role's similarity to other, non-motion-related semantic roles, such as the similarity between the actor/mover of *She walked* and the actor/non-mover of *She sang*.

1.4.3 Constructional composition

To understand a sentence like *The box slid/ spun across the floor*, we not only have to know something about the meaning of the verb, we also need to know something about the meanings of the other words in the sentence. But, our understanding of the sentence as a whole is more than just a collection of the meanings of these individual words. As already noted, this is true in at least two significant respects. Firstly, construction grammar theory makes the key assumption that individual words are not the only meaningful parts of a sentence. Therefore, to understand the meaning of the sentence, we also need to consider the meanings of non-lexical constructions instantiated in these sentences. This includes – but is not limited to -- argument structure constructions. Secondly, to understand the meaning of the 'whole', we also have to have some idea as to how the meanings of the various constructional parts fit together. That is, the meaning of a sentence is a structured whole, not just a collection of unconnected parts.

In accordance with the simulation-based model of language understanding, the relevant meaning of this 'whole' can be represented as a semantic specification (SemSpec) that specifies parameters for simulation of some sort of event. This places some important constraints on how we go about analyzing and representing constructions and their meanings. For one thing, the set of instantiated constructions that are posited for a given example need to supply the appropriate SemSpec parameters, i.e. ones that will support a simulation that is consistent with our intuitions about the type of event being described. Moreover, when these constructions unify, their individual meanings need to be integrated into a larger, coherent 'whole'.

In Chapter 4, I continue to examine sentences that describe motion-related events. Having discussed (in Chapter 3) the verb constructions instantiated in these examples, I shift the focus to an examination of the A-S constructions such examples instantiate. But, in order to support the compositional analysis of such sentences, we also need to identify other constructions that these sentences instantiate. Moreover, it is crucial that we also identify (and represent) the relations that the A-S construction has to these other constructions.

Goldberg's characterizations of argument structure constructions provide a good starting point. One key assumption Goldberg makes is that the meaning associated with a given A-S construction is that of some basic 'scene' or event.[1] For instance, the sentence *The box slid into the room* can be analyzed as instantiating an A-S construction whose meaning has the conceptual structure associated with basic motion events, which includes a participant role that we can refer to as Mover. Another assumption is that the A-S construction specifies how the participant roles of this event are expressed. For this particular example, the A-S construction indicates that the filler of the Mover role is expressed by the sentence's subject NP. In addition, it is assumed that when an A-S construction is instantiated in a sentence, its participant roles will 'fuse' with semantically compatible roles of the co-instantiated verb. For this specific sentence, the verb's 'sliding thing' role will fuse with the Mover role of the A-S construction. However, given the additional assumptions outlined above, we will need to determine and specify several other things related to these A-S constructions.

One central issue concerns the constructional and semantic relations between the A-S construction and the verb construction. What exactly is the nature of their semantic 'compatibility', and how are the two meanings integrated with one another? As stated earlier, I make the assumption that semantic compatibility is related to schematic commonalities of meaning. Using the current representational method, this can be captured via relations between the schemas used to represent constructional meaning. For the example above, I analyze the instantiated verb and A-S constructions as both identifying their meaning with a MotionAlongAPath schema. Consequently, the relevant relation here is essentially one of (schema) identity. Note, though, that this does not imply that the constructional meanings as a whole are identical: the verb may supply construction-specific meaning that is not part of the A-S construction meaning. For example, *slide* includes specification about the ongoing contact the mover has with some surface. Because the verb is an essential 'part' of this A-S construction, it is analyzed and represented as one of its constructional constituents.

One important benefit of characterizing and representing the relation in this way is that it is <u>not</u> verb specific. Several different verbs may incorporate the same schematic structure as a core part of their meaning. And, by representing the meanings of these verbs using the same schema, it is possible to essentially define a semantic 'class' of verbs. Significantly, relations involving this schema will apply to this whole 'class' of verbs. For instance, for the A-S construction being described here, any verb which identifies its meaning with the MotionAlongAPath schema can potentially serve as a constituent. This

[1] E.g see p. 40, Goldberg 1995: "Particular combinations of roles which designate humanly relevant scenes are associated with argument structure constructions, which themselves serve to carve up the world into discretely classified event types."

includes verbs such as *fall*, *skid*, *hurtle*, and *plummet*. Thus, each argument structure construction captures important generalizations about the 'argument realization' patterns associated with a group of semantically similar verbs.

To support the compositional analysis of sentences, we also need to identify (and represent) the A-S construction's relations to other constructions it typically co-occurs with. For *The box slid into the room*, this includes the prepositional phrase (PP) construction instantiated in *into the room*. As with the verb, this PP construction can be viewed as an essential 'part' of this argument structure construction, and therefore can be analyzed and represented as one of its constituents. And, as was the case with the verb, the A-S construction has to specify its semantic relation to this constituent. Again, I make the assumption that the relevant relation is one that involves shared schematic structure. In this case, though, the meaning of the constituent differs from that of the A-S construction. This is not a problem, however, because the A-S construction meaning is internally complex, as indicated by use of a MotionAlongAPath schema that incorporates both Motion and SPG structure. Consequently, it is possible to recognize that the schematic structure of the PP is the same as <u>part</u> of the A-S construction meaning. Moreover, this representational method also makes it possible to explicitly specify the relevant semantic relation between the A-S construction and its PP constituent in a non-lexically specific way. Consequently, this A-S construction can be used to analyze sentences in which the specific preposition differs (e.g. *The box slid into / across / through / past the room*). And, in each sentence, unification of the PP with the A-S construction will result in an integration of their meanings, with the PP constituent providing details about the 'path' element of the translational motion event.

In addition, we need to deal with the relation between the Mover and the subject NP. This raises two issues. First, is the subject NP a constituent of the A-S construction? In other words, are A-S constructions clause-level constructions? There are several problems with making such an assumption, one of which is that it would require us to posit different A-S constructions to analyze different clause types. For example, we would need different A-S constructions to analyze *The box slid into the room, Did the box slide into the room?* and *Slide the box into the room!* By defining separate clause constructions, we can instead analyze these sentences compositionally, as instantiating the same (phrasal) A-S construction, but different clause constructions. The second issue concerns the notion of 'subject'. Following Croft (2001), rather than considering this a grammatical primitive of some kind, 'subject' is defined as a constituent of certain clause-level constructions. These constructions specify constraints relating to agreement and ordering, as well as a semantic constraint that indicates that this constituent describes the 'focal' event participant (the 'profiledParticipant'). Each A-S construction indicates which specific event participant role is profiled. For instance in the current example, the A-S construction specifies that the Mover is the profiledParticipant. Thus, identification of the subject' NP constituent with a specific event role is handled compositionally, through the unification of the A-S construction with a clause construction.

For this example *The box slid into the room*, the verb and A-S construction meanings are closely similar, having what might be characterized as an 'instance of' relation (Goldberg 1995). But, Goldberg also makes the key assumption that other types of relations are also possible. And, it is this assumption that allows a compositional rather than a verb polysemy analysis of 'verb alternation' sentences.

Within Chapter 4, I show how sentences such as *The box spun into the room* can be analyzed in this compositional manner. This sentence describes a situation in which a Mover changes location. Therefore, we could analyze this verb as having a meaning of translational motion. However, in some sentences containing this same verb, such as *The box spun,* there is no entailment that the overall location of the Mover (the box) has changed. Consequently, we would not want to assume that the only meaning of this verb is one of translational motion. So, one possible analysis is to assume that there are two different senses of 'spin', both of which involve (rotational) motion, but only one of which involves a change in location. And, we could make a similar analysis of several other similar verbs, e.g. *roll*, *twist*, *wiggle*, etc. Thus, such an approach would lead to us positing multiple sense 'doublets' for a range of different verbs.

The alternative approach, followed here, is to posit a single 'core' sense of these verbs, which composes with different A-S constructions. For *The box spun into the room*, the relevant A-S construction is closely similar to the one instantiated in *The box slid into the room*, with both A-S constructions having a translational motion meaning. The crucial difference concerns this second A-S construction's relation to its verb constituent. Unlike the previous case, the meanings are not the same, but they do have some meaning in common: the verbs' motion meaning is the same as the 'Motion' portion of the A-S construction's MotionAlongAPath meaning. Thus, similar to the situation with the PP constituent, the A-S construction and its verb constituent share a portion of meaning. And again, by recognizing (and representing) the internal complexity of the translational motion event, we are able to explicitly identify the schematic commonality that motivates the composition of the A-S construction meaning with the meaning of its constituent, and to also specify precisely how they compose. Moreover, again, because the relevant meanings are not lexically specific, we are able to recognize general patterns that apply to a range of semantically similar verbs. Significantly, this compositional approach lets us capture the broader patterns of meaning variation associated with this 'semantic class' of verbs, rather than dealing with such patterns on a verb-by-verb basis.

Also important, in Chapter 4 I show how A-S constructions that are related in this way can be defined as radial categories. In the central case, the verb and A-S construction schematic meanings are closely similar (as in *The box slid into the room*). In extensions to this central case, the verb has some amount of schematic structure in common with the A-S construction, but the overlap is only partial (as in *The box slid into the room*). As I show in Chapter 4 and later chapters, radial categories can also be defined for many other types of A-S constructions.

1.4.4 An embodied view of force and causation

Up to this point, I have focused on motion and spatial relations. But in order to analyze a broader range of examples, including the many *slap* examples discussed earlier, the grammar needs additional schemas, as well as additional verb and A-S constructions. And to define these additional schemas, we need to examine the types of concepts described by these examples. In Chapter 5 I therefore examine conceptual structure related to action, agency, causation and effect. To do so, I follow an approach similar to the one I took for the analysis of motion-related conceptual structure. To start, I examine some sentences containing various 'action' verbs, with an eye towards what sort of schematic similarities and differences of meaning they exhibit. Examples (14a-c), for instance, all describe an action performed by some actor. And, for all of these we can make similar inferences as to the necessary expenditure of effort, control of action, etc.

(14) a. She walked past the box.
b. She pushed the box.
c. She cut the box.

However, the events described by (14b) and (14c) clearly differ in several important respects from (14a). One difference concerns the role played by the second entity (the box). In the first example, this entity primarily serves as a spatial landmark: the mover's location changing with respect to this entity, but the mover doesn't necessarily affect this entity in any way, and may not even come into contact with it. Whereas for the other two we might say that the actor is at least intending to 'act upon' this other entity (e.g. contact, apply force to). However, there are differences with respect to the 'effect' of this action. In (14c) there is a specification/entailment of affectedness, while in (14b) affectedness is a defeasible inference (e.g. we can say *She pushed the box but it was unaffected*). And in a sentence like *She pushed at/on the box*, the likely inference is that the box was <u>not</u> affected.

Examples such as these thus indicate the need to differentiate between actions that involve 'acting on' another entity, and those that don't. Furthermore, we need to dissociate the notion of being 'acted upon' by an actor from that of being affected in some way by that actor's actions. In other words, we want to distinguish 'patients' from other entities that may play a role in motor-control actions. But we will also want to distinguish between different 'patients', which implies, among other things, that 'patient' may actually be a more complex notion than a single role name might indicate.

Consistent with the NTL framework, I assume that these semantic differences are a reflection of differences in the conceptual structure active during various modes of experience of such actions. Therefore, as with the examination of motion-related events, I consider various kinds of evidence in order to determine more about the nature of this structure. Such evidence suggests that we can view many of these actions as being compositional in nature. Specifically, they all share the same central 'core' structure of basic motor control of the body. But, they include different additional elements that are related to the purposes that a given type of action is typically used to accomplish. For example, locomotion (e.g. walking) is typically used to get to some desired location. And to accomplish this goal, the actor needs to utilize location-related spatial information while executing the action. Similarly, actions whose goal is to interact in some way with another entity need to integrate 'interactional' information about that entity (e.g. shape, orientation). And when performing an action intended to cause some effect to another entity, the actor typically needs to attend to the ongoing state of this entity.

Based on such evidence, I posit a set of inter-related motor-control schemas. One is the basic motor-control schema introduced in Chapter 3. Another (ForceApplication) represents the structure of motor-control actions in which an actor contacts and applies force to another entity. And a third schema (CauseEffectAction) represents actions in which this force application is (intended to) affect the acted upon entity in some way. Importantly, the latter two schemas are both 'composites' which integrate structure related to contact, force, and – in the case of the third schema – causation and affectedness.

As I show, these schemas can then be used to represent the meanings of various action verbs. For instance, CauseEffectAction can be used to represent the meanings of verbs that specify that the actor's actions bring about some effect to the acted upon entity, e.g. *cut*, *crush*, etc. And the ForceApplication schema can be used to represent the meanings of verbs that describe forceful actions such as *push, pull, squeeze, slap*[2]*, punch, tap*, etc. As noted above, while this second set of actions are typically performed to bring about some effect, this is not always the case. And, even when there is an effect, it doesn't necessarily relate directly to the thing the actor applies force to (e.g. *He pushed off from the wall, He tapped on the glass*.). The ForceApplication schema enables us to capture the 'core' meaning that is invariant across a range of different uses of these verbs, without having to include 'affectedness' meaning that is not always present.

To understand how these verbs can be used to describe different (conceptualizations) of different kinds of events, we also need to consider the nature of the A-S constructions they co-occur with. Because these action verbs very commonly occur in transitive sentences, the first type of A-S constructions I examine are basic transitive ones.

1.4.5 Transitive A-S constructions

Transitivity in English is associated with a basic syntactic 'form' of S V O. But how can we characterize the meaning associated with this pattern? One challenge we face is that sentences of transitive 'form' can be used to describe many different kinds of events. Therefore, if we were to try to find the meaning common to all of these events, it would

[2] In a later chapter, though, I will argue that the meanings of slap, punch, and other 'agentive impact' verbs can better be represented using a somewhat more complex schema that integrates ForceApplication with additional structure.

necessarily be quite general. However, consistent with Goldberg's approach, we can make the assumption that, as with other types of A-S constructions, we can identify a prototypical, 'central sense' meaning that is a scene associated with some basic type of human experience. And, as Langacker (1991) argues, such prototypes can get extended in various ways. Accordingly, rather than trying to define one single transitive argument structure construction, we can define several, whose 'form' is similar, but whose meanings differ in various ways.

In chapter 6, I focus on the analysis of transitive sentences that describe what can be characterized as the 'prototypical' scene associated with transitivity. In such a scene, one participant (the 'agent') performs an action that results in another participant (the 'patient') undergoing a change in state or location. I make the assumption that the prototype for many types of basic scenes is one in which a human actor performs some kind of goal-directed action. Such purposeful actions are highly relevant to humans, as well as being quite experientially rich. Following this assumption, the prototypical 'Translational motion' scene is one in which the mover is an actor with the goal of changing his location. And the prototype for transitive scenes is grounded in actions where the actor's goal is to bring about some effect to another entity. Furthermore, these rich prototypes can serve as the basis for extensions which do not include all of the elements of the prototype. For example, the extensions may not include intentionality, and may not even involve an actor.

Consistent with simulation theory, for each of these prototypes we need to consider what sorts of embodied structures are active when people (successfully) perform that particular kind of goal-directed action. For all motor-control actions, this will presumably include basic motor-control structure associated with execution of some routine involving one or more body parts, which requires some amount of exertion. But, it will also typically involve structure related to the 'monitoring' of various elements related to another entity, such as that entity's location, orientation, and/or state. Additionally, it may include monitoring of the 'self' in relation to that entity (e.g. spatial relations, contact, force-related feedback, etc.). Because the CauseEffectAction schema (discussed previously) includes structure associated with prototypical transitive goal-directed actions, I use this schema to represent the meaning of these prototypical transitive A-S constructions.

Another well-known challenge presented to the analysis of transitivity is that verbs that exhibit a transitive argument realization pattern may also appear in sentences with other types of meanings and argument realization patterns (Fillmore 1970, Dixon 1991). Many verbs that can be used transitively can also appear in intransitive sentences, in which 'patient' is expressed as subject. For instance, the verb *slide* can be used in sentences such as *He slid the glass (across the table)* and *The glass slid (down the ramp)*. The intransitive example does not express a second agent participant; in fact, the scene described by this sentence may be conceptualized as only involving a single participant. And, as discussed earlier, other types of verbs, such as slap, can also appear in sentences that describe events which differ from those of the prototypical transitive scene (e.g. *She slapped at the mosquitoes* and *She slapped her hand on the table*).

As I show, these differences can be handled compositionally. For some verbs (e.g. *cut, crush*), we can identify a 'core' verb meaning that is essentially a more specific instance of the prototypical transitive scene. To analyze transitive sentences containing these verbs, we can define a transitive A-S construction whose verb constituent meaning has the same schematic structure as the A-S construction itself (indicated by the fact that both identify their meaning with the CauseEffectAction schema).

To analyze transitive sentences containing the other two types of verbs mentioned above, we can define extensions to this first, central case argument structure construction. As with the central case transitive A-S construction, the meanings of these extension is that of a prototypical transitive scene. However, these extensions differ as to the semantic relation between the A-S construction and its verb constituent. For one extension, the verb constituent meaning has the same schematic structure as the first subprocess of the CauseEffectAction (i.e. the force-application action that brings about some effect). This extension applies to verbs like *push* and *squeeze*, whose core meaning is one of force application. In these cases, the verb serves to elaborate the 'means' by which the effect is brought about. The other extension applies to verbs like *slide, spin*, etc., whose core meaning does not include agency or causal structure. In this case, the verb constituent serves to elaborate the effect that results from the causal action. Viewed from the perspective of the verb, we could say that in both cases the A-S construction serves to 'add' conceptual structure that is not necessarily present in the verb.

A similar approach can be used to analyze passives. The basic idea is to have passive A-S constructions use the same meaning schemas as their active counterparts. These passive constructions differ from active transitives, however, as to constructional details and as to 'perspective' (i.e. which event participant is profiled).

The set of A-S constructions described thus far support the compositional analysis of verb 'alternations' such as *The box slid*, *She slid the box*, *The box was slid by her*. Significantly, these analyses capture important differences in the event conceptualizations described by these sentences. Looking beyond language, we can make the broader observation that many processes can be conceptualized either as an autonomous process or as an externally-caused process. For externally-caused processes, while we typically focus on the causer, we can also potentially focus on the entity undergoing the caused process. And, as these sentences show, these different conceptualizations can each be expressed in English through the use of different argument structure constructions.

1.4.6 'Conative' A-S constructions

A sentence like *She slapped his arm* can be analyzed using a transitive A-S construction similar to the ones discussed above. But what about a sentence like *She slapped <u>at</u> his* *arm*? This second sentence can be seen as describing a situation which differs from the one described by the transitive example in terms of the 'affectedness'; his arm can be seen as being non-affected by the slapping action, and may not have even been contacted. Thus, the meaning differs from the prototypical transitive scene. Another obvious difference is that the non-agent participant is expressed as the object of a prepositional phrase, rather than as a direct object. In Chapter 7, I examine both of these types of slap examples.

Similar in many respects to Goldberg's analysis (1995: 63-64), I analyze the 'conative' A-S construction instantiated in examples such as *She slapped at his arm* as an extension to the central case A-S construction instantiated in examples such as *She reached for his arm*. Accordingly, I first examine the actions described by *reach* and by similar verbs such as *point* and *look*. Following the same methodology as before, I examine both linguistic and neural evidence related to the nature of the conceptual structure involved in the experience and description of such actions. Based on such evidence, I define a schema that represents the key schematic components of actions in which an actor moves an effector (a body part or instrument) in relation to some other entity (e.g. a 'target'), as in reaching actions. This 'effector motion' schema is internally complex, integrating motor-control and spatial structure. In addition I define constructions for *reach* and for the A-S construction instantiated in examples such as *She reached for his arm*. These constructions have schematic meaning in common, as indicated by the fact that both identify their meaning with the same 'effector motion' schema. This A-S construction serves as the central case from which the 'conative' A-S construction is extended.

What relations do *slap* and other similar verbs have to such an A-S construction? To answer this question, I also examine the nature of the actions described by verbs such as *slap*, *kick*, and *tap*. Crucially, such actions, in addition to having a 'force application' component, also have an 'effector motion' component. Specifically, the full action involves an actor moving an effector towards and then forcefully contacting some entity. As I show, the schematic structure associated with these actions can be represented by defining a composite motor-control schema that integrates 'force application' and 'effector motion' schemas. Thus, a portion of the verb meaning has the same schematic structure as the 'conative' A-S construction; specifically, they have 'effector motion' structure in common.

What is the meaning of 'conative' examples such as *She slapped at his arm*? I suggest that, based on an examination of a variety of sentences similar to this, that such sentences are used to describe situations in which the effects, if any, that the actor has on the other entity are attentionally backgrounded. Furthermore, as I show, the SemSpec produced by the analyses of such sentences supports a simulation which captures this meaning.

In central case A-S constructions, the schematic structure associated with the A-S construction is similar to that of its verb constituent. In examples instantiating such A-S constructions, the A-S construction may not seem to 'add' any meaning that is not already present in the verb. In some extensions, such as the transitive extensions described earlier, the A-S construction essentially 'adds' structure that is not present in all uses of the verb. For instance, in some cases it specifies that the verb-described process was caused by some 'agent'. Conative examples, however, involves a third, different kind of relation in which the schematic structure associated with the verb is actually richer than that of the A-S construction.

My contention is that in such situations, we focus our attention on the schematic elements specified by the A-S construction, while backgrounding (though not necessarily inhibiting) the schematic structures specified by the verb alone. Or, to put this in terms of simulation, we actively simulate the A-S construction-specified schematic structure, but do not necessarily simulate all the verb-specified schematic structure. Using the constructions defined here, the SemSpec produced by an analysis of *She slapped at his arm* specifies that the type of event being described is an 'effector motion' action (as specified by the A-S construction). This means that the SemSpec essentially supports a simulation that foregrounds the spatial and motion-related aspects of the verb-designated action, such as the motion of the agent's hand, and the fact that his arm is the spatial target of this motion. But it doesn't require simulation of forceful contact with this arm, or any consequent effects of such contact. This SemSpec and the simulation it supports are consistent with the description of a variety of situations, including one in which the actor misses his arm, but also including ones in which the actor hits his arm but the effects are minimal, and/or are not particularly relevant.

In sum, the key to the compositional analysis of many verb 'alternations' lies in the recognition and representation of the internal structure of constructional meanings. In the case of many transitive examples, such as *She pushed the cup*, the complexity of the A-S construction is especially relevant. But for other examples, such as *She slapped at the cup,* the complexity of the verb meaning is also relevant. Significantly, once we recognize (and represent) this complexity, it is possible not only to recognize the motivations for these different patterns of composition, but also to recognize the differences in conceptualization that accompany them

1.4.7 Further Complexity: slap examples with three expressed participants

In Chapter 8, I explore some additional uses of *slap* and other semantically-similar verbs, showing how the complexity of the actions described by these verbs motivates additional patterns of constructional and conceptual composition. Each type of example I examine expresses three participant roles, as in (15a-c).

(15) a. She slapped his hand off his leg.
b. She slapped her hand on his leg.
c. She slapped him on the leg.

Although these contain most of the ‘same’ words and even the same general argument realization pattern (same form), there are significant differences in the semantic roles they express, and in the type of situations they describe. These examples can be analyzed as instantiating the same verb construction but different A-S constructions. Composition of this verb construction with these different A-S constructions and the other constructions instantiated in a given example produces SemSpecs which capture both the similarities and differences as to the types of events these different examples describe, and as to the way in which the verb designated process is conceptualized in each case. In addition, these SemSpecs indicate that for each example the expressed participant roles are semantically complex, consisting of bindings between several different more ‘primitive’ roles. By analyzing and representing these roles in this manner, it is possible to recognize commonalities and differences in the roles associated with different examples.

As Chapter 8 underscores, to understand why verbs can be used in different types of event descriptions, and to understand why and how the semantic roles associated with the verb are integrated with those of the A-S constructions instantiated in these different examples, it is crucial to look beyond the constructions themselves, and to more deeply consider the nature of the actions and events these constructions are used to describe.

1.5 General remarks

One central requirement for the compositional semantic analysis of various ‘verb alternation’ sentences is a characterization of the meanings of both the verb and the A-S constructions instantiated in such sentences. Crucially, we need to identify the semantic structures and relations that motivate the composition of the meanings of these constructions. Moreover, we also need to characterize (and represent) the results of such composition. Complicating this task, there are often many different ways that constructional meanings can compose with one another.

NTL assumptions change the way we view and represent constructions and constructional meaning. One key assumption is that the internal complexity and schematic structure of constructional meaning, as well as the various relations between the meanings of various constructions are both reflections of the complexity and interconnections of underlying schematic conceptual structure. Therefore, when attempting to define the meanings of individual constructions, we need to look beyond these constructions, and even beyond language and consider the nature of the underlying conceptual system.

The compositional constructional account of sentence meaning that I present in this dissertation shows that ultimately, the key to addressing some of the basic issues about compositionality that were raised in this chapter lies in recognizing the multi-faceted, interconnected nature of the meanings conveyed by various constructions. Given this, we can analyze how different patterns of constructional composition can be used to convey different patterns of conceptual composition.

Chapter Two

Framework and Methodology

2.1 Overview

One of the specific objectives of my work has been to create a set of ECG constructions (a grammar) that supports compositional analysis of sentence meaning. Moreover, this analysis is intended to capture the sometimes subtle differences in meaning exhibited by sentences that involve verb 'alternations'. My particular focus is on verb and argument structure constructions and the schemas used to represent their meanings. The analysis of full sentences, though, requires that the grammar also include additional constructions and schemas.

The success of such a compositional analysis rests, I argue, on a close examination of the complexity, richness and structure of the meanings involved. The meaning representations used in this dissertation were developed by building upon a methodology common in cognitive linguistics, in which a particular semantic domain is examined with respect to the types of recurrent conceptual structures exhibited by descriptions of this domain. Crucially, such examinations look beyond the meanings associated with individual words and constructions, and attempt to determine the nature of the larger underlying conceptual system.

The larger theoretical framework provided by NTL, in conjunction with the ECG formalism, provides a means to formally integrate the sometimes diverse insights which arise from such investigations. Moreover, NTL seriously addresses the question of how language and meaning are processed in the brain, thereby providing reasoned answers as to why such systems may exhibit the structures they do, and how they may be manipulated and communicated through language use. In turn, this both inspires and constrains the analysis and representation of meaning and language. The ECG formalism also provides a means to precisely and consistently represent these meanings, as well as supplying a way to develop and represent a structured inventory of constructions. What is more, this formalism has enabled computational implementation of the analysis process.

2.1.1 Chapter Road Map

In this chapter, I present an overview of the methodology used in this dissertation. I start with a brief review of some important cognitive linguistic insights and a description of how these are viewed within the NTL framework. Then, I discuss NTL, the simulation-based model of language understanding, and some implications these have for writing grammars that will support a compositional analysis of sentence meaning. In the second half of the chapter, I describe the ECG formalism, demonstrating how it can be used to represent constructions and schemas that are consistent with NTL principles.

2.2 Cognitive Linguistic Insights

In cognitive linguistics, meaning is central. Not surprisingly, then, many of the key insights made by cognitive linguists relate to the nature of language meaning. One important area of investigation has identified a number of conceptual primitives that recur in the meanings of many different words both within and across languages. Cross-linguistic analysis of terms used to describe spatial relations, for instance, indicates the existence of various 'universal primitives', such as bounded region, contact, and path. Furthermore, the meaning of individual terms can in many cases be analyzed (at least partially) as various compositions of a relatively limited number of these conceptual primitives (e.g. Talmy 1972; 1983; Langacker 1976; 1987). Moreover, in addition to spatial relations concepts, there are many other types of primitives that can potentially be integrated into terms used to describe motion and other types of events. So, rather than viewing the meaning of individual constructions (including words) as unanalyzable primitives, it is better to analyze them as incorporating one or more non-word-specific conceptual primitives.

Cognitive linguists have also identified various kinds of conceptual gestalts, including image schemas (Johnson 1987; Lakoff 1987), and frames (Fillmore 1982). These conceptual structures recur within language, but are not necessarily unique to language. Image schemas for the most part have been analyzed as recurrent structures related to basic experiences, e.g. motion into and out of a container, or moving along a path to a destination. They are characterized as gestalt-like wholes with a limited number of internal parts. The structure is schematic, not specific (e.g. it includes roles whose specific values or fillers can vary from situation to situation). Moreover, the structure is such that it can support various kinds of inferences. Frames share many of these same characteristics, but have generally been defined in terms of more specific cultural experiences, such as commercial events. As with image schemas, they include a relatively limited number of internal parts, or roles. Actions and roles associated with a particular word (such as 'buy' or 'buyer') can be defined in relation to this conceptual frame. Hence, both image schemas and frames encode recurrent conceptual structures that are utilized in language, but which are not unique to any specific linguistic term.

Cognitive linguistic examinations of the nature of language meaning thus suggest that the meanings of individual words (and other constructions) are in many cases grounded in concepts that are to a large extent independent of these words. Moreover, many of these concepts themselves have identifiable internal structure, including various roles. This in turn suggests that non-word-specific semantic roles (such as 'patient' or 'mover') should be viewed in relation to larger conceptual structures rather than as stand-alone concepts.

Several key cognitive linguistic insights are related to the recognition that the description of a particular situation is not just a statement about the 'objective facts' of that situation. Rather, each description also indicates a particular conceptualization or construal of this situation, with this conceptualization potentially differing along several dimensions. One such dimension involves the perspective taken on that scene (Talmy 1978, 2000a; Langacker 1987, 1991). Another involves the distribution of the conceptualizer's attention. Some important cognitive linguistic concepts that are related to attention include Figure-ground organization (Talmy 1972, 2000), trajector-landmark asymmetries, and the relative prominence of an element that is 'profiled' with respect to some conceptual 'base' (Langacker 1987, 1991). When representing language meaning, we therefore not only need to indicate 'content', but also how this content is conceptualized in a particular situation.

However, while these insights and associated theories all fall under the broad umbrella of cognitive linguistics, it is not entirely clear how they are inter-related, nor how they might be integrated with one another. This uncertainty is compounded by the lack of consistent formalization. Verbal descriptions and/or various graphical representations may suffice for expressing specific insights, but the lack of uniformity and consistency make it difficult to put them all together into a larger coherent framework.

2.3 Neural Theory of Language (NTL)

NTL assumptions have important implications as to how we view these insights, and as to how we can extend the methodology described above.

As mentioned in the previous chapter, one of the key assumptions made by NTL is that, 'meaningfulness' is not restricted to language. Another is that as with other cognitive processes, language-related processes have a neural realization, and that, moreover, the nature of this neural realization affects language (and linguistic analysis) (Lakoff and Johnson 1999, Dodge and Lakoff 2005). In turn, this assumption entails a commitment to parallel *spreading activation* as opposed to serial processing. In addition, as with other cognitive processing, language understanding is assumed to involve a *best-fit* evaluation of competing possibilities, utilizing information from multiple domains.

A further, more specific assumption about language understanding involves *simulation* semantics (Narayanan 1999, Feldman and Narayanan 2004, Gallese and Lakoff 2005, Feldman 2006), the idea that people understand utterances by (subconsciously) imagining or simulating the situations they describe. And, crucially, this simulation involves activation of some of the same or similar neural structures as are active for other 'modes' of experience, such as when performing, observing and/or imagining the events being described by a given utterance.

Examination of neural circuitry helps provide explanations as to *why* certain types of conceptual structures are recurrently evidenced in language and other experiences. For instance, the 'schematicity' of image schemas is likely related to the relatively limited types of information to which the underlying neural circuits respond. And the fact that image schemas structure different sensory-motor modalities of experience (e.g. visual, tactile auditory experiences of a container) is likely related to the 'cross-modal' nature of these circuits (Lakoff and Johnson 1999). Furthermore, many neural circuits are typically active during a given experience, and different combinations may be active during different experiences. This suggests that the composition that takes place in language is a specific example of a more general phenomenon of 'conceptual' composition, a process present in a wide variety of human experiences.

One very important implication of these assumptions, then, is that it is possible to gain insights into the structure of a given semantic domain not only by looking at linguistic evidence, but also by looking at evidence produced by other types of research on experiences related to that domain, including psychological, physiological and neuroscientific research. Regier's (1996) work on spatial relations terms and Bailey's(1997) work on motor-control verbs both demonstrate the value of such an approach.

Accordingly, the methodology I follow in the current work is to examine various sources of evidence about the conceptual structure present in some basic semantic domains, looking for:

- Recurrent schematic structures
- 'Primitive' conceptual structures that are utilized in different combinations in more complex conceptual structures.

Putting these two parts together, then, one of my central objectives is to define 'primitive' schematic structures that compose in various ways to form more complex, richer 'composite' schematic structures, of the kind evidenced in basic human experiences.

Another important objective is to use these schemas as a key element in a compositional analysis of sentence meaning. This requires more than just an analysis of conceptual structure; it requires analysis of how these structures are evoked and manipulated by language.

The strategy followed by NTL is to break down analysis into different inter-related levels. One level of investigation is associated with experimental neuroscience, and concerns the specific neural structures and processes involved in language and other cognitive activities. At another level, hypotheses are made about the types of circuitry and computational processes involved in the performance of these brain functions. For the current work, the relevant level is one that is concerned with a formal representation of language and meaning. Representation at this level is intended to map to structures identified within other levels, though it can't express all the findings made at these other levels. In addition these formal representations are also informed by and consistent with linguistic analyses (Dodge and Lakoff, 2005).

As mentioned in the previous chapter, NTL is independent of any specific grammar formalism. But, Embodied Construction Grammar (ECG) is designed to be consistent with and further the exploration and application of the NTL approach to language (Bergen and Chang 2005; Feldman 2006; Feldman, Dodge and Bryant 2010). While ECG is designed to be consistent with NTL, the ECG formalism does not explicitly represent the neural mechanisms involved in thought and language, such as spreading activation, connection strength, and mutual inhibition.[1] ECG is firmly in the Construction Grammar tradition (Croft, 2001; Fillmore, 1988; Fried & Boas, 2005; Goldberg 2006) but adds the centrality of embodied semantics (Johnson, 1987). The ECG formalism is designed to simultaneously fill several functions. For the current work, this formalism primarily serves as a technical too for linguistic analysis. In addition, though, this formalism also serves as a computer specification for several other implemented applications. These include a construction-based system of language interpretation that utilizes a best-fit heuristic (Bryant 2008; Bryant and Gilardi, to appear) and computational models of language acquisition (Mok 2008, Chang 2008). And, as discussed in Feldman and Gilardi (to appear), there are also extensions to deal with metaphor and mental spaces.

To better understand the ECG formalism and the types of grammars it is used to represent, it is important to know how ECG fits into the larger theoretical framework of NTL.

2.3.1 Grammar

A key NTL idea is that much of the richness and complexity of language meaning is related to the 'conceptual structures' that we, as agents, use to interact with the world. Because of commonalities in brain function and in basic types of experiences, people presumably share much of this conceptual structure. Thus, although each individual's conceptual systems will also be shaped by personal histories, cultural experiences, etc., we can assume that they share a basic 'skeleton' of conceptual structure.

[1] Consequently, to the extent that a given linguistic phenomena is dependent on one of these mechanisms, it may be difficult to adequately analyze it using this formalism.

The grammatically-relevant elements of this shared conceptual structure can be analyzed and represented as ECG 'schemas', a term meant to encompass both image schemas and frames, as well as schemas that represent the structure of various types of processes. Consistent with the tenets of NTL, any schemas posited for a given ECG grammar should be motivated by and consistent with cognitive as well as linguistic evidence. The ECG formalism supports representation of various relations between schemas, thus enabling individual schemas to be defined as parts of larger, more complex lattices of inter-related schemas. In this way, it is possible to capture some of the complexity and interconnectivity of conceptual structure, consistent with the massive interconnectivity of the neural substrate.

People within the same language-using community are assumed to have a shared grammar: a set of constructions and schemas that are shared by most members of this community. Consistent with Cognitive Grammar and other construction grammars (e.g. Langacker 1987; Fillmore 1988; Goldberg 1995; Kay and Fillmore 1999; Croft 2001; Michaelis 2003), ECG grammars include both lexical and non-lexical constructions. Furthermore, the constructions within a given grammar are structured both by (part-whole) constituency relations, and by the relevant generalizations over form, meaning, and distribution that the language learner is likely to learn (and for which there is evidence that people actual do learn).

When analyzing and representing a particular ECG grammar, the goal is to identify constructions at various levels of abstraction, not to only define maximally general constructions. In this respect, ECG grammars following the lead of other usage-based grammars, and might be better described as maximalist instead of minimalist (e.g. Langacker 1991, Tomasello 2003, Goldberg 2006). This is consistent with a data-driven learning story, in which there are many small sub-regularities upon which generalizations are built (see also Chang 2001, 2008; Mok 2008). Accordingly, the grammar described in this dissertation includes both relatively specific constructions that capture local generalizations as well as more general constructions that capture more global generalizations. While many of these generalizations are represented in the current grammar through the use of 'subcase' relations, it remains an issue for further work as to how the neural circuitry involved in the learning of these generalizations can best be analyzed and represented. In addition, constructions may exhibit various patterns of 'cognitive categorization', including prototypes (Rosch 1975; 1978) and radial category structure (Lakoff 1987). Especially relevant for the current grammar, this includes radial categories of argument structure constructions.

2.3.2 How ECG grammars are used to analyze sentences

As with other construction grammars, the basic story is that a typical sentence instantiates several different constructions from a grammar (for optimal communication, this should be a grammar shared by speaker and hearer). The forms and meanings associated with each of these constructions are ‘unified’, giving rise to the form and meaning associated with the sentence as a whole.

The primary focus of the current work is on sentence understanding, rather than production. In the process of understanding, the hearer/understander starts with the ‘form’ of the sentence as a whole, and has the objective of determining its meaning. To do this, the understander needs to determine which constructions this sentence instantiates, and how they unify with one another.

A key assumption in NTL is that this process of understanding involves simulation. To understand a sentence that describes a person slapping an object, for example, the understander will activate some of the same or similar neural circuitry as when he himself performs or plans such an action, observes someone else performing it, or imagines himself or someone else performing this slapping action. Another important NTL assumption is that, as with other cognitive processing, language understanding involves a *best-fit* evaluation of competing possibilities, utilizing information from multiple domains. The NTL project has developed a simulation-based model of language understanding that is consistent with both of these assumptions (Feldman 2006).

This simulation-based model involves two phases: an analysis phase and an enactment phase. In the analysis phase, a given grammar is used to analyze an utterance in context. The goal of this analysis is to determine the ‘best-fitting’ set of instantiated constructions, along with the bindings that indicate the relations between these different constructions. In many cases there will be multiple, competing interpretations; the determination of the best-fitting set of constructions will be based on a consideration of syntactic, semantic, and contextually-specified constraints. Significantly, Bryant (2008) has developed an implemented system for this analysis process, called the Constructional Analyzer which has been used to analyze many of the sentence examples presented in later chapters.

The best-fitting interpretation of the utterance is in the form of a semantic specification, or SemSpec, which consists of a set of schemas, bindings, and role value specifications. The ‘output’ of the analysis phase, then, is a (partial) specification of the particular event conceptualization that the utterance describes.

The second phase of the model is the enactment phase, which involves the mental simulation – or enactment – of the situation specified in the SemSpec. As with the analysis phase, there are some systems which implement this simulation phase (see, e.g., Mok, Feldman and Gilardi, to appear). The content of this simulation can potentially be much richer than the SemSpec which prompts it. This is because specific simulations will typically involve additional structure related to the understander’s specific experiences, state of mind, relation to speaker, etc. Moreover, the simulation of the situation specified by the Semspec may give rise to various inferences. Thus, while analysis of the utterance in context indicates certain (schematic) parameters of meaning, fuller understanding of that utterance occurs during the enactment phase.

2.3.3 Implications

Given this simulation-based model of language understanding, the rich meaning that is associated with a given simulation does not necessarily need to be completely specified within the constructions themselves. In part this is true because the process of simulation may give rise to various inferences. While the instantiated constructions will typically specify the conceptual structures (schemas) that give rise to these inferences, they don't necessarily need to specify the inferences themselves. In addition, the key simulation parameters supplied by constructions are assumed to be those relating to the schematic conceptual structure shared by users of a given grammar. In addition to schematic structure, the simulation itself may utilize rich world knowledge and idiosyncratic experiential associations possessed by the understander.

To capture 'deep' sentence semantics, the constructions <u>do</u> need to provide information about the 'content' of the event these sentences describe, as well as providing 'attentional' and/or 'profiling' information that indicates how this content is conceptualized in a particular description. Additionally, to get a coherent SemSpec, the meanings of the instantiated constructions need to be composed with one another. That is, the end result should be an integrated whole, not a collection of disjoint, unconnected elements. As we will see, the key to this integration lies in the identification of the commonalities of schematic meaning associated with the different constructions instantiated in an utterance.

The best-fit analysis of utterance meaning has two important implications for how the constructions in a grammar should be defined. One is that constructions do <u>not</u> have to be mutually exclusive in order to determine the most appropriate analysis of an utterance. The other is that the constructions <u>do</u> need to specify in sufficient detail the factors that are relevant to the assessment of best fit.

To support compositional analysis of a range of sentences, the grammar needs to include a variety of constructions (and a variety of schemas to represent their meanings). The focus of most of the dissertation is on verb and A-S constructions and associated schemas. But, in the following section, I describe some of the other constructions that form part of a more complete grammar.

2.4 Embodied Construction Grammar (ECG)

The ECG formalism was designed to create grammars that are consistent with NTL principles. The ECG formalism doesn't define any one specific grammar. In fact, an important benefit of using this formalism is that it allows one to write and test many different grammars. These grammars can be quite complex, but the ECG Workbench tool (Bryant and Gilard, to appear) can significantly aid the writing, testing, and visualization of a given grammar. Moreover, this tool also provides access to a computational implementation of construction-based language interpretation, using the Constructional Analyzer (Bryant dissertation).

The notation used in this formalism is described below using examples from the English grammar utilized in this dissertation. While the schemas in this grammar are, in general, intended to capture cross-linguistic generalizations, the constructions define form-meaning pairings that are specific to English.

2.4.1 ECG notation and primitives

Two of the basic primitives used in ECG to specify grammars are **constructions** and **schemas**. Constructions are paired form constraints and meaning constraints. ECG is different from other construction grammar formalisms because the meaning constraints are defined in terms of embodied semantic schemas. ECG also contains two additional primitives (**situations** and **maps**) that are not utilized in the current work (but see Feldman & Gilardi, to appear).

There are four ways to specify relations between these ECG primitives: roles, sub-typing (through the **subcase of** keyword), evoking a structure (through the **evokes** keyword), and constraints (co-indexation and typing). A **role** names a part of a structure, and the **subcase of** keyword relates the construction/schema to its type lattice, allowing for structure sharing through (partial) inheritance.

Evoking a structure makes it locally available without imposing a part-of or subtype relation between the evoking structure and the evoked structure. Using Langacker's standard example, the concept hypotenuse only makes sense in reference to a right triangle, but a hypotenuse is not a kind of a right triangle, nor is the right triangle a role of the hypotenuse. The **evokes** operator is used to state the relationship the hypotenuse has to its right triangle conceptual base.

Like other unification-based formalisms, such as HPSG (Pollard and Sag 2004) and LFG (Bresnan 2001, Dalrymple 2001), ECG also supports constraints on roles (features). The double-headed arrow operator (↔) is used to indicate bindings between roles. In computational implementations, this binding is treated as role co-indexation. Roles can be assigned an atomic value using the assignment operator (⟵). A type constraint (specified with a colon) constrains a role to only be filled by a certain type of filler. Comments, where present, are preceded by double slash marks (//).

2.4.2 Schemas

Schemas are used to represent a variety of conceptual structures, including image schemas, and frames (Fillmore 1982). Consistent with other analyses of such structures, schemas are defined as gestalt-like wholes with a limited number of internal parts, which are represented as **roles**. Crucially, rather than defining them as isolated, stand-alone structures, these schemas are defined as part of a larger lattice of schemas, with each schema having various types of specified relations to other schemas in the lattice. This reflects the complexity and interconnectivity of the conceptual network these schemas are being used to (partially) represent.

Various 'primitive' schemas form a critical part of this lattice. These hypothesized primitives reflect recurrent schematic commonalities in basic experiences. Such experiences are presumably shared by people, all of whom process them using some of the same basic functional networks in the brain. Therefore, these schemas are likely to be universally-available to speakers of all languages, though they may of course be utilized in different ways by different languages. A fully defined grammar will also include schemas that represent recurrent commonalities in more culturally-specific experiences. These schemas, akin to FrameNet[2] frames, will also specify relations to other schemas in the lattice.

As an introduction to ECG schema representations, let me discuss how we can represent the structure prototypically associated with the 'Container' schema. Many different objects, such as rooms, boxes, forests, lakes and trees are commonly conceptualized as containers. While there are many important differences in terms of the size, shape, substance, etc. associated with these different objects, they share some common spatially-defined elements. Of particular importance is the 'boundary' of the container, which divides space into two regions: the interior (the space enclosed by the boundary); and the exterior (the surrounding area – the space not enclosed by the boundary). For actual containment of another object, various force-dynamic properties are also often relevant. For instance, the boundary must be strong enough that it can keep the contents inside the container. And there must typically be a 'portal', an opening in the boundary that allows motion between the Interior and the Exterior. Not all instances of "bounded spatial regions" include these force-related containment elements, however. For example, we are likely to view an open field as a bounded region, though the boundaries of this region do not prevent motion into or out of this region.

The spatial structure shared by these different 'bounded regions' is represented in the current grammar as a BoundedRegion schema (Figure 2.1). The name of an ECG schema (specified on its first line) serves as a unique identifier, and usually indicates something about its meaning. In this case, using the name "BoundedRegion" rather than "Container" indicates that this schema specifies the spatial, but not the force-dynamic structure described above. The **roles** section of the schema lists the basic structural elements of this schema. For this schema, the roles are interior (a region of space enclosed by a boundary), boundary (the boundary which encloses this interior region), and exterior (the region outside the closed boundary). Roles in a schema may have type

[2] See http://framenet.icsi.berkeley.edu for further details.

constraints, which are specified after the role name (separated by a colon). In BoundedRegion, the interior and exterior roles are both specified to be of type 'region'.

The BoundedRegion schema represents the key structural elements of a particular schematic conceptualization of some expanse of space. This same schematic structure is also a key element in our conceptualization of bounded objects, such as containers. Such objects can be conceptualized as having two parts: a boundary and an interior region. The schematic structure of such objects can be represented as a BoundedObject schema.

BoundedObject is defined as a **subcase** of BoundedRegion. Subcases contain all the structure of their 'parent' schema, but also specify additional structure[3]. In addition to the roles it inherits from BoundedRegion, the BoundedObject schema has another role, that of the entire bounded object: the whole. Crucially, BoundedObject differs from BoundedRegion in that it also includes part-whole structure. This is indicated by specifying that BoundedObject **evokes** a PartWhole schema (not shown).

Unlike the subcase relation, the 'evokes' relation does not imply that the evoked schema is a 'parent' of the schema which evokes it. Thus, BoundedObject is not considered a subcase of PartWhole. However, 'evokes' does indicate that the PartWhole schema structure is 'accessible' to BoundedObject. And, as indicated by other constraints, the structure of PartWhole is incorporated into that of BoundedObject. While all of the evoked roles and constraints are 'accessible' to the schema being defined, there is no requirement that all (or even any) of them actually be incorporated into this schema's structure.

BoundedObject specifies that its interior and boundary are both parts of the larger whole. This is specified via relations between BoundedObject roles and those of the evoked PartWhole schema. These meaning constraints utilize slot chain notation. The evoked PartWhole schema was given a local name (pw). The term 'pw.part1' refers to the 'part1' role of this evoked schema. Bindings between roles are specified using a double headed arrow (↔). Thus, the constraint 'interior ↔ pw.part' specifies that BoundedObject's interior role is bound to the part1 role of PartWhole. In this way, this schema illustrates how two roles can be bound together to form a more complex role.

[3] The '**subcase of**' keyword is used here to indicate that one schema incorporates all the structure of another schema. One way to describe this relation is in terms of inheritance: we can say that a subcase 'inherits' the roles and constraints of its 'parent'. Note, though, that this metaphor has some inferences that may not be quite appropriate since it implies that there is an actual transfer of structure, whereas the relation may be better conceptualized as a sharing of structure.

```
schema BoundedRegion
   roles
      interior: region
      exterior: region
      boundary
```

```
schema BoundedObject
   subcase of BoundedRegion
   evokes PartWhole1 as pw
      roles
         whole : @entity
      constraints
         interior ↔ pw.part1
         boundary ↔ pw.part2
         whole ↔ pw.whole
```

Figure 2.1 The BoundedRegion and BoundedObject schemas.

These schematic structures are a core part of many descriptions of an object's location. For instance, in object location descriptions such as *The cup is in the box*, the cup is conceptualized as a bounded object. Such descriptions also include another important schematic element, concerning the relation between the entity being located and this schematically-conceptualized region. Moreover, in descriptions such as this one, the relation is asymmetric: it involves the cup's relation to the box, not the symmetric relation between the cup and the box (as in, for example, *The cup and the box are adjacent*). This asymmetric relation is not limited to situations involving bounded regions; it also applies, for example, to regions that are structured with respect to verticality (*The cup is above the box*) or contact and support (*The cup is on the box*).[4] The key structural elements of this kind of asymmetric spatial relation are represented by a 'trajector-landmark' schema, named the TL schema (Figure 2.2). Specifically, this schema represents a situation in which one entity (the trajector) is located in some attentionally-profiled region of space (the profiledArea) that is defined in relation to a reference entity (the landmark).

```
schema TL
   roles
      trajector
      landmark
      profiled Area
```

```
schema SPG
   subcase of TL
   roles
      trajector
      landmark
      source
      path
      goal
```

Figure 2.2 The TL (trajector-landmark) and SPG (Source-Path-Goal) schemas.

An additional 'Source-Path-Goal' schema, here named SPG (Figure 2.2), represents situations in which the trajector's location changes over time. This schema is defined as a **subcase of** TL, and, consequently, inherits all of its structure. In addition to its inherited trajector and landmark roles[5], SPG has roles for describing an ordered series of locations: source, path, and goal (each of which can, in turn, serve as the

[4] Talmy (2000a) analyzes such relations in terms of Figure and Ground.
[5] The inherited roles are shown here in gray.

profiledArea). In the chapter following this one, I will discuss some additional elements that are commonly associated with the notion of Source-Path-Goal, and will show how they too can be represented using schemas.

The conceptual structure that is represented by the schemas described here is assumed to exist independent of any specific linguistic construction. These schemas can be used in various combinations to represent the meanings of various constructions in the grammar. For example, as will be shown below, the meaning of the lexical construction for *in* can be represented using the TL and the BoundedObject schemas. But, BoundedObject can also be used in the meaning representations of many other constructions, such as *inside*, *inner*, *out*, *outside, enter* and *exit*. And TL is also used in the meaning representations of other prepositional constructions, such as *out*, *at*, *on*, and *above*. Thus, the meaning of a given construction may be represented using more than one schema. And the same schema may be used to represent the meaning of more than one construction. This is consistent with two related cognitive linguistic insights concerning spatial relations terms. The first is that such terms can be analyzed as combinations of more primitive elements. And the second is that the same primitive may be used by more than one spatial relations term.

2.4.3 Constructions

An examination of some lexical and phrasal constructions whose meanings can be represented using the schemas described above will help illustrate how constructions are represented using the ECG formalism. In this section I first present constructions for specific lexical items (e.g. *in*, *out*, and *into*). Then, I show how more general constructions can be used to capture important generalizations over various 'classes' of lexical items. Following that, I will discuss phrasal constructions (specifically, prepositional phrases). With this background in place, I will then discuss some of the additional schemas and constructions that are included in the current grammar.

To start, let us examine an ECG construction for the central sense of *in* (Figure 2.3).
As with schemas, ECG constructions each have a unique name. This name can be considered to be an identifier of this particular constructional gestalt. A common convention for lexical constructions is to have the main part of the name be the same as the orthographic form of the construction. Typically, a number is added after the name, since the same form is often linked to more than one meaning (i.e. a word may have more than one meaning or sense). Accordingly, the current construction is named IN1.

Constructions are pairings of form and meaning. In ECG, this pairing is represented by a form block (defined by the **form** keyword) and a **meaning** block. Both the form pole and meaning pole of a construction can be typed. For simple lexical constructions such as IN1, the form pole is simply constrained to be a word, which is specified using the WordForm schema (not shown). Form blocks can also have form constraints, which provide more details about the typical form associated with a given construction. For IN1, the orthographic form of the construction as a whole is specified by setting an appropriate value for the orth role (self.f.orth ← "in"). Because this specification may appear a bit cryptic, let me explain it in a bit more detail. The 'self' part of this constraint is used to refer to the construction a whole. The ".f" notation is used to refer more specifically to the form elements of that construction. The ".orth" element indicates that we are referring more specifically to the orthographic form. Thus, "self.f.orth" refers to the orthographic form of the construction as a whole. The single headed arrow (←) is used to specify a value constraint. And, in this particular case, this value is that of a particular orthographic string: "in". [6]

Like schemas, constructions are arranged into a subcase lattice (with each subcase potentially having more than one parent). The IN1 construction is a subcase of a general LocativePreposition construction, a construction that captures commonalities in the meaning and use of various spatial lexical constructions (prepositions). This general construction will be described at further length later in this section.

The construction's meaning is specified in the **meaning** block, using schemas. To create a formal meaning representation, we of course first have to some idea of what we're trying to represent. The IN1 construction is intended to represent a central sense of *in*, analyzed here as including two key elements:

- *In* is used to specify a location, with this location being defined in relation to some landmark entity. This construction's meaning is, in this respect, similar to other spatial preposition constructions such as those for *at* and *on*.
- For *in* (but not necessarily for other prepositions), this landmark entity is conceptualized as a bounded object (container), and the relevant location is the interior region of this object.

This meaning is represented as a composition of two schemas: the TL (trajectory landmark) schema and the BoundedObject schema.

To capture the first of the two elements listed above, the meaning of the construction as a whole is identified with the TL schema. This is specified as a type constraint on the meaning block of this construction (meaning: TL). To capture the second element, the construction specifies relations between the TL schema and the BoundedObject schema. This requires several steps. First, the construction evokes the BoundedObject schema (**evokes** BoundedObject as bo). Then, relations between these two schemas are specified in the 'constraints' section of the meaning block. The landmark role of the TL schema is bound to the whole role of the BoundedObject schema, indicating that the landmark is conceptualized as a bounded object. And the profiledArea role of the TL is bound to the

[6] Neurally speaking, a constructional form is more than just the 'form' itself (e.g. a particular sound, hand shape, or written symbol); it is the neural structure that is active when a person produces and/or perceives that particular 'form'.

interior role of BoundedObject: this indicates that the relevant location is in the interior of the landmark.

Again, these meaning constraints utilize slot chain notation. Self.m, for example, refers to the meaning of the construction as a whole, which in this construction is identified with the TL schema. The landmark and profiledArea roles of this schema are therefore specified as self.m.landmark and self.m.profiledArea, respectively. The evoked BoundedObject schema was given local name 'bo'. The whole and interior roles are therefore specified as bo.whole and bo.interior, respectively.

Thus, the meaning block indicates that the meaning of this construction is a complex gestalt, one that integrates the structure of two different conceptual primitives. It is important to keep in mind, though, that these textual representations are not themselves the meaning of the construction. Rather, they operate as a kind of shorthand, indicating the linguistically-relevant parameters of the neural structures which are actually active in the mind of the language user.

```
construction IN1
   subcase of LocativePreposition
   form
     constraints
       self.f.orth ← "in"
   meaning: TL
     evokes BoundedObject as bo
     constraints
       self.m.landmark↔ bo.whole
       self.m.profiledArea ↔ bo.interior
```

```
construction OUT1
   subcase of LocativePreposition
   form
     constraints
       self.f.orth ← "out"
   meaning: TL
     evokes BoundedObject as bo
     constraints
       self.m.landmark↔ bo.whole
       self.m.profiledArea ↔ bo.exterior
```

Figure 2.3 Lexical constructions for central senses of "in" and "out".

These same schemas can be used to represent the meaning of other constructions as well. For example, consider *out.* This word has a central sense that is similar in many respects to that of *in*. As with *in*, it is used to specify a location in relation to a landmark that is conceptualized as a bounded object. But, there is a key difference: the relevant location is the region around (outside) the object, <u>not</u> the object's interior region. The OUT1 construction is therefore very similar to IN1. It does of course have a different orthographic form: "out", rather than "in". The only other difference, though, concerns one of the meaning constraints. Instead of binding the profiledArea role to the interior role of the boundedObject schema, it is bound to the exterior role (self.m.profiledArea ↔ bo.exterior). Thus, both terms make use of the same schematic structures, but combine them in different ways.

The meaning of other spatial relations terms can also be represented as compositions of schemas. But, there will be other schemas involved besides the two presented above. For instance, terms that specify <u>changes</u> in location will use a SourcePathGoal (SPG) schema, which represents a series of locations, instead of the TL schema, which represents a single static location. And SPG can combine with schemas that indicate how the landmark is schematically conceptualized. For instance, for *into*, as with *in* and *out*, the landmark is conceptualized as a container. But, unlike *in* and *out*, the profiled location for *into* changes over time.

```
construction INTO1
  subcase of PathPreposition
  form
    constraints
          self.f.orth ← "into"
 meaning: SPG
   evokes BoundedObject as bo
   constraints
          self.m.landmark↔ bo.whole
          self.m.goal ↔ bo.interior
         //  self.m.path ↔ bo.boundary
         //  self.m.source ↔ bo.exterior
```

Figure 2.4 The INTO1 construction.

The INTO1 cxn (Figure 2.4) is both similar to and different from the IN1 construction. As with IN1, the landmark is conceptualized as a bounded object. And location is defined in relation to this bounded object. But, unlike IN1, the meaning of INTO1 involves a <u>change</u> of location over time. To represent this change of location, INTO1 identifies its meaning with the SPG rather than the TL schema. As with IN1, it also evokes the BoundedObject schema, and binds the whole object to its landmark role (self.m.landmark↔ bo.whole). The series of locations can then be represented as bindings between the roles of SPG and those of the BoundedObject schema (self.m.source ↔ bo.exterior ; self.m.path ↔ bo.boundary: self.f.m.goal ↔ bo.interior). n this way, this construction specifies that initially, the trajector is located somewhere outside of the bounded object, then it crosses the boundary of this object, and finally it is located inside the object.

To summarize, the ECG formalism provides a way to represent constructions as relations between constructional form (in this case, a word form) and schematic conceptual structure. Moreover, as shown here, some of the same schemas can be used to represent the meanings of different constructions. In this way, it is possible to formally represent the insight that similar schematic structures may recur in the meanings of a number of different words (and other constructions). At the same time, each construction can also include specifications of construction-specific meaning. As illustrated in this section, this can include specification of a particular pattern of composition of two (or more) schemas. Hence, in at least some cases, constructional meaning is a 'gestalt' which incorporates some number of more 'primitive' elements. ECG constructional representations such as those shown here thus serve to indicate various schematic commonalities in the meanings of the different constructions, while at the same time indicating significant differences in meaning as well.

2.4.3.1 General constructions

As with schemas, constructions in the grammar are arranged into a subcase lattice (with each subcase potentially having more than one parent). Each lexical construction, such as those discussed above, is therefore defined as a subcase of one or more general constructions. IN1 and OUT1, for instance are each defined as subcases of the more general LocativePreposition construction, and INTO1 is defined as a subcase of PathPreposition. In this section I discuss these two general constructions and the important role they and other general constructions play in the grammar.

In a subcase relation, the structure of the 'parent' construction is 'inherited' by all of its subcases. [7] This relation is therefore well-suited for representing generalizations over groups of more specific constructions. If, for example, several constructions have some form and/or meaning structure in common, we can define a more general construction that represents this commonality. And, the more specific constructions can be defined as subcases of the general one. Each subcase inherits the structure of this parent, and then specifies additional unique information that distinguishes it from other subcases. Thus, general 'parent' constructions represent form and/or meaning generalizations over a set of more specific constructions.

But, this raises two important questions:

- Which types of similarities are relevant? That is, for which similarities do we want to define general constructions?
- At what granularity do we want to recognize and represent these generalizations? Should we focus on very local generalizations? Broader generalizations? Both?

We can examine these questions by looking at the lexical constructions IN1 and OUT1. These constructions are similar in several respects. In terms of form, the similarity is a fairly coarse-grained one: they are both words. In terms of meaning, though, the similarity is much finer-grained: both of these constructions are used to 'profile' some spatial region, and in both cases this region is defined in relation to a landmark that is conceptualized as a container. This semantic similarity is indicated within the constructional representations by the fact that both constructions identify their meaning with TL and also evoke and incorporate the structure of BoundedObject. We could define a general construction that specifies these particular similarities, though this construction would only have a couple of subcases. These constructions also have semantic similarities with many other constructions. For instance, *inner* and *outer* also include BoundedObject structure. And *at*, *on*, *above*, etc. also are used to profile some

[7] Use of the terms 'parent' and 'inherit' are not meant to imply any particular developmental order for the relation between the parent and its subcase(s). Developmentally speaking, it may in fact be the case that the children give rise to the parent, rather than the reverse (Tomasello 2003).

spatial region that is defined in relation to a landmark. So, we could also potentially define general constructions that are based on either of these similarities.

Which of these sorts of generalizations are relevant for the grammar? Or, to put the question somewhat differently, what sort of general constructions does a grammar need to include? To answer these questions, we need to consider another very important motivation for positing general constructions. In addition to capturing similarities in the form and/or meaning of specific constructions, general constructions can also serve to indicate similarities in terms of how these specific constructions are actually <u>utilized</u> in utterances. That is, general constructions should ideally capture form and/or meaning commonalities that are associated with groups of constructions that have similar usage patterns.

For instance, the usage patterns for *in* and *out* are similar to those of *at, on,* and *above* in that all can be used as the first word in a prepositional phrase. Their usage differs, however, from words such as *inner* and *outer*. Therefore, based on these commonalities of meaning <u>and</u> usage, IN1 and OUT1 are defined as subcases of a general construction that also has subcase constructions for *at, on*, etc. (but not for *inner* or *outer*).

How general should general constructions be? One important thing to note at this point is that it is possible to use general constructions to capture more than one type and/or granularity of generalization. So, for instance, constructions that capture more local generalizations can be defined as subcases of constructions that capture broader generalizations. Consequently, recognition of local generalizations doesn't come at the price of ignoring broader ones, nor vice versa.

We can capture very broad generalizations about usage by defining general constructions that are essentially equivalent to 'part of speech' constructions. For example, the grammar can include a general Preposition construction that includes all prepositions as subcases.

It is also useful to define constructions that capture more local generalizations over the meaning and use subgroups of prepositions. For instance, prepositions used to describe agents (*I was bitten by a cobra*) are similar in some respects to those used to describe instruments (*I hit the cobra with my umbrella*). But these both differ from spatial prepositions used to describe locations (*I sat in my room*) and paths (*I crawled into my room*). By defining a general SpatialPreposition construction, we can distinguish prepositions used to describe spatial relations from those used for other purposes. At the same time, though, there are some distinct differences in meaning and use within this group of spatial prepositions. Some can be used to describe changes in location (*He walked in/ to/ into /through the room; The cat jumped on /onto /over the table*). But only a more restricted subset can be used to describe unchanging locations (e.g. *They stayed in/*to /*into /*through the room; He stood at / on /*onto the table*.). Based on these distinctions, we can further divide spatial prepositions into two groups: those that can be used to describe static locations (constructions whose meaning is TL), and those that cannot (constructions whose meaning is SPG). Thus, we can define separate general construction for different prepositional 'subgroups '.

The current grammar includes two general constructions that capture generalizations over these two subgroups of spatial prepositions. One general construction is LocativePreposition (Figure 2.5), whose subcases include IN1, OUT1, and constructions for *at* and *on*. These lexical constructions all identify their meaning with TL, indicating that they are used to specify a location that is defined in relation to some landmark entity. These lexical constructions differ as to what additional schemas they evoke and what constraints are placed on the landmark entity. LocativePreposition identifies its meaning with TL and does not have any additional meaning constraints. Thus, the general construction represents the structure shared by all of its subcases, while the subcases themselves include meaning specifications that set them apart from one another.

The other general construction, PathPreposition (Figure 2.5), has subcases that include INTO1 as well as constructions for *to*, *through*, *across*, etc. Each of these subcase constructions identifies its meaning with SPG but, as with the previous group, they differ as to what additional schemas they evoke, if any. By identifying its meaning with SPG, PathPreposition specifies the semantic structure that is shared by all of its subcases.

Both of these general constructions are defined as subcases of a more general SpatialPreposition construction (not shown).[8] From SpatialPreposition, they inherit the constraint that their form is of type WordForm, a form constraint that is shared by all of their subcases. That is, though lexical subcases vary as to their specific orthography, they are all words.

general construction LocativePreposition
  subcase of SpatialPrepositio
  form: WordForm
  meaning: TL

general construction PathPreposition
  subcase of SpatialPreposition
  form: WordForm
  meaning: SPG

Figure 2.5 The LocativePreposition and PathPreposition constructions.

In sum, this section illustrates how the ECG formalism can be used to represent grammatically-relevant generalizations over groups of constructions. The formalism itself doesn't determine which specific general constructions a grammar has to include, however. Therefore this section also serves to illustrate some of the principles and thought processes that motivate the particular general constructions and subcase hierarchy that structure the current grammar.

[8] The subcases would presumably inherit their form constraints from this more general construction. It is not clear what meaning constraints, if any, this more general construction would have.

Another important point to be made here concerns the benefits of representing the meaning in the way described above. In particular, when the meanings of several (semantically-related) constructions are represented using some of the same schemas, it is a fairly straightforward matter not only to recognize commonalities of meaning, but also to define general constructions that actually specify these commonalities.

2.4.3.2. Constructions with Constituents

Constructions such as IN1 can be characterized as 'word-level' constructions: constructions that pair a specific word form with a specific meaning. But, in addition to constructions for individual words, the grammar also needs to include constructions that specify different ways that words can be combined with one another to form various types of larger 'wholes', such as phrases and sentences. Or, to put it another way, the grammar needs to include constructions that specify various patterns of constructional composition. Crucially, these constructions need to indicate the meanings that are associated with these different patterns.

To perform this function, the grammar includes many different non-lexical constructions. The non-lexical constructions in the current grammar include the argument structure constructions that are at the heart of this work, as well as other various phrasal constructions and clause-level constructions. Significantly, like lexical constructions, these non-lexical constructions are presumed to be meaningful.

In this section, I show how the ECG notation is used to represent such constructions by discussing an analysis of the phrase 'in the room' (with the 'static location' meaning it has in sentences such as *He stood in the room*). This phrase is analyzed as instantiating three lexical constructions (for 'in', 'the' and 'room'). It also instantiates two non-lexical constructions: the Locative-PP phrasal construction, as well as a noun phrase construction.

Phrasal constructions share many properties with *lexical* constructions. Like lexical constructions, they include form and meaning blocks. However, unlike lexical constructions, phrasal constructions have components that are themselves constructions. Consequently, in addition to form and meaning blocks, phrasal constructions also include a **constructional** block, in which these constructional components are defined as **constituents**.

Locative-PP (Figure 2.6) includes two constituents: prep and np. Each of these constituents has a specified constructional type. The prep constituent is constrained to be a construction of type LocativePreposition, and the np constituent is constrained to be of type NP.[9] To serve as a constituent, a construction instance (i.e. a 'construct') must be

[9] In the ECG construction, the constructional type constraint is specified after the name of the constituent, separated by a colon. E.g. prep: SpatialPreposition; and np: NP.

compatible with its type constraint, being either an instance of the named construction or of a subcase of it. Instances of IN1, as well as of other subcases of the general LocativePreposition construction will therefore meet the type constraints on the prep constituent. And, constructs which are of type NP will meet the type constraint on the np constituent. The NP construction has several different nominal and pronominal construction subcases, and will be described more fully in a later section of this chapter. Use of general type constraints such as these avoids the need to list each possible individual lexical construction instance that might serve as a constituent. Most importantly, it supports productive composition of many different constructions with this phrasal construction. Consequently, this phrasal construction can be used to analyze a range of prepositional phrases, e.g. *in a lake*, *on him*, *at my sister's house*, etc.

The form block specifies constraints on the ordering of these two constituents, indicating that the prep constituent form precedes that of the np constituent (prep.f before np.f).[10]

```
construction Locative-PP
  subcase of Spatial-PP
   constructional
    constituents
      prep: LocativePreposition
      np: NP
   form
     constraints
       prep.f before np.f
  meaning: TL
    constraints
      self.m  <--> prep.m
      self.m.landmark <--> np.m
```

Figure 2.6 The Locative-PP construction.

Crucially, Locative-PP also includes specifications relating to the <u>meaning</u> of this type of prepositional phrase. As with spatial prepositions, spatial prepositional phrases such as 'in the room' are used to describe locations in relation to some schematically conceptualized landmark. In this respect, the meaning of the phrase is similar to that of its prepositional constituent. Accordingly, the meaning of Locative-PP is identified with the TL schema (**meaning:** TL).

For any given instance of this phrasal construction, the specific schematic location will depend on the specific preposition that serves as the prep constituent. Therefore, this construction also needs to indicate that the particular spatial relation will be determined by the co-instantiated preposition construction. This is done by specifying a binding between the meaning of the phrasal construction as a whole, and that of it preposition constituent (self.m ↔ prep.m). In essence, this indicates that – in this particular case -- the

[10] The keyword before is one of several terms used in the ECG formalism to specify ordering.

preposition is the semantic head of this phrasal construction. But, as we will see, this is not always the case.

In addition, this phrasal construction indicates how the conceptual structure associated with each of the constituent constructions is composed into a conceptual whole. Locative preposition constructions describe a location with respect to some schematic landmark. Prepositional phrase constructions differ from prepositions in that they 'ground' the spatial description by linking the landmark role to some particular referent entity: specifically, the one described by the np constituent construction. To specify that the 'noun phrase' constituent provides the filler of the landmark role, the meaning of this constituent is bound to the phrasal construction's landmark role (self.m.landmark ↔ np.m.referent). Due to the binding between the phrasal construction and its prep constituent, this is the same landmark role as the one associated with the preposition. Thus, the two constituents each provide form and meaning-related structure. The phrasal construction specifies how these forms and meanings are composed with one another to create form and meaning 'wholes'.

The phrase 'in the room' can therefore be analyzed as instantiating several different constructions. Within this phrase, the word 'in' is analyzed as an instance of the IN1 construction, and 'the room' is analyzed as an instantiating an NP construction. The phrase as a whole is analyzed as instantiating the Locative-PP construction, with the IN1 construction serving as the prep constituent, and the NP serving as the np constituent. When these constructions unify, their meanings will compose with one another to form a single coherent meaning. The end result is that 'the room' is conceptualized as a bounded object that serves as a landmark. The interior part of this object is 'profiled', indicating that this is the location being described by the phrase. The phrase itself does not indicate what is located in this region.

Because the constraints on the constituents are defined at a general level, phrases instantiating other prepositions (e.g. those for *on*, *at*, *above*) and other noun phrases can also be analyzed as instantiating this same Locative-PP construction. In each case, the noun phrase will serve to describe the entity that fills the landmark role. And the preposition will indicate how to schematically conceptualize this landmark. Phrasal constructions such as these, with general, rather than lexically-specific constraints on their constituents, are therefore critical elements in the grammar, enabling a compositional analysis of a range of different, sometimes novel, combinations of words.

<u>Additional prepositional phrase constructions</u>

Many phrases that describe static locations can be analyzed as instantiating the Locative-PP construction. But, as already discussed, some prepositional phrases describe situations in which an entity's location <u>changes</u> over time. To analyze such phrases, the grammar includes additional prepositional phrase constructions, which are similar in general constituency and form constraints to Locative-PP, but which differ in meaning.

First, consider the phrase *into the room*, as in *She ran into the room*. This phrase can be analyzed as instantiating the Path-PP (Figure 2.7). This construction differs from Locative-PP in two important ways. Firstly, reflecting the fact that it is used to describe changing rather than static spatial relations, it identifies its meaning with SPG rather than TL. Secondly, it constrains its prep constituent to be of type PathPreposition rather than type LocativePreposition. Thus, prepositions such as *into, across, over*, etc. may serve as constituents in this phrasal construction.

In all other respects, though, Path-PP is the same as Locative-PP. These commonalities can be captured by defining these two constructions as subcases of a more general Spatial-PP construction (Figure 2.7). Subcases of this general construction may:

- have more specific type constraints on prep constituent
- have different, but related, meaning (e.g. SPG rather than TL)
- have additional meaning constraints (e.g. Path-PP has PathPreposition)

```
general construction Spatial-PP
  constructional
    constituents
      prep: SpatialPreposition
      np: NP
  form
    constraints
      prep.f  before np.f
  meaning: TL
    constraints
      self.m ↔ prep.m
      self.m.landmark  ↔ np.m.referent
```

```
construction Path-PP  // central case
  subcase of Spatial-PP
  constructional
    constituents
      prep: PathPreposition // e.g. into, to, from
      np: NP
  form
    constraints
      prep.f. before np.f
  meaning: SPG
    constraints
      self.m ↔ prep.m
      self.m.landmark  ↔ np.m.referent
```

Figure 2.7 The Path-PP and the general Spatial-PP constructions.

<u>Semantic relations between a phrase and its 'head' constituent</u>

For both of these spatial PP constructions, the schematic meaning specified for the phrasal construction as a whole is the same as the type constraint on its prepositional constituent. Therefore, while the phrasal construction serves to specify how prepositional meaning should be composed with that provided by the NP constituent, it does not 'contribute' any schematic structure that is not already present in its prepositional constituent.

Very importantly, however, ECG also allows the specification of other types of relations. As we will see, this is crucial for the analysis and representation of A-S constructions, where the meaning of the A-S construction can potentially differ in significant ways from the meaning of its verb constituent. This also has implications for the analysis of other types of constructions, including prepositions and prepositional phrases.

Specifically, if we assume that the meaning of a phrasal construction can differ from that of its constituents, it is possible to analyze some variations in phrasal meaning via composition, rather than necessarily positing multiple lexical constructions for different 'senses' of a given word.

To illustrate, let us return to the phrase *in the room*. In the discussion above, this phrase was analyzed in terms of its 'static' meaning. For instance, in the example *He stood in the room*, the phrase is used to describe a static spatial situation, in which the interior of the room is the ongoing location of the standing person. However, as noted earlier, this same phrase can also be used to describe scenes in which a moving entity is changing location, as in *He ran in the room*.[11] In cases such as these, the phrase is used to describe a dynamic situation, in which a person's location changes over time and the interior of the room is that person's final location.

One possible way to account for these meaning differences is to posit two senses of the word *in*: one which is used to describe a particular location, and another which describes a 'path' of motion. Accordingly, in addition to the IN1 construction (which identifies its meaning with a TL schema), we could also posit a separate IN2 construction which identifies its meaning with SPG.

However, if we assume that the meaning of the prepositional phrase construction can differ from that of its preposition constituent, then an alternative approach is possible. In this alternative, compositional approach, the different phrasal meanings are analyzed using a single preposition construction, but two different prepositional phrase constructions. Briefly, the idea is as follows. For the static situations, such as *He stood in the room*, the phrase is analyzed as instantiating a Locative-PP construction, as discussed above. Because the meaning of Locative-PP is identified with TL, this analysis indicates that the phrase as a whole describes a static spatial relation. However, when the phrase is used to describe situations involving motion and change of location, as in '*He ran in the room*', it is analyzed as instantiating a different prepositional phrase construction, the Path-PP2 construction. This second construction is defined as a subcase of the Path-PP construction described above, and inherits its constraint that the phrasal construction's meaning is identified with an SPG schema. Thus, both of these constructions indicate that the prepositional phrase as a whole is used to describe a more dynamic situation, in which the spatial relation changes over time.

Path-PP2 differs from Path-PP in some significant respects, though. For one thing, its preposition constituent is constrained to be a 'locative' spatial preposition (such as *in*) rather than a 'path' preposition (such as *into*). This means that the 'SPG' meaning of

[11] With the reading of his entering the room, as in *I walked in the room and closed the door behind me.*

Path-PP2 differs from the 'TL' meaning of its prep constituent. Therefore, Path-PP2 has to specify that the inherited constraint that the meanings are the same should be ignored (specified using the keyword **ignore**).[12] In place of this ignored relation, Path-PP2 specifies a different relation, using three constraints. One constraint is that the trajector roles associated with each construction's meaning should be identified with one another, and a second is that the landmark roles should be as well. The third constraint is that the goal role of the phrasal construction's SPG schema is identified with the profiledArea of the prep constituent's TL schema. Together, these constraints indicate that the profiled area specified by the preposition is the <u>final</u> location of some entity that is changing location. Thus, even though its prep constituent specifies a single spatial relation, the Path-PP2 phrasal construction can be used to describe <u>changes</u> in spatial relations.

```
construction Path-PP2  // extension for locative preps
   subcase of Path-PP
   constituents:
         prep: LocativePreposition // e.g. in, inside, on, under
          np: NP // inherited from Spatial-PP
   form:
      constraints
         prep.f. before np.f   // inherited from Spatial-PP
   meaning: SPG
      constraints
         ignore self.m ↔ prep.m
         self.m.tr ↔ prep.m.trajector
         self.m.landmark ↔ prep.m.landmark
         self.m.goal ↔ prep.m.profiledArea
         self.m.landmark  ↔ np.m // inherited from Spatial-PP
```

Figure 2.8 The Path-PP2 construction.

As I discussed in the prior chapter, when we analyze the same form as potentially having the two or more different meanings, it raises what I termed the 'context identification' problem. That is, if we analyze a particular form (e.g. 'in') as being associated with two different meanings, how do we know which meaning is appropriate in a given situation? The compositional approach presented here does not require us to posit different lexical senses. But, it still faces this same problem of context identification, since the phrasal forms themselves are the same in both cases. The solution to this problem lies in looking to the larger contexts in which these prepositional phrases occur. As will be discussed at greater length in later chapters, A-S constructions help in many cases to supply this relevant contextual information. A-S constructions which include prepositional phrases as constituents include specific type constraints on these constituents. Thus, they help to specify particular contexts in which specific types of PP constructions do – or don't -- occur.

[12] This constraint indicates that this construction utilizes all the roles and structure that is specified in the parent structure with the exception of this one role binding.

To summarize, here are some key points about phrasal constructions:

- Phrases are analyzed as constructions with constituent 'parts' that are themselves constructions. Furthermore, these constituent parts may themselves have parts. For example, the phrase 'in the room' can (in some contexts) be analyzed as instantiating a Locative-PP, one of whose constituents (np) may in turn have two constituent parts. Thus a particular string of words may be analyzed as instantiating a set of 'nested' constructions.
- The phrasal constructions specify their parts at an intermediate level of generalization. For instance, the prep constituent of Locative-PP is constrained to be LocativePreposition; this is not as specific as IN1, nor as general as Preposition.
- The phrasal construction is 'meaningful'.
    - In ECG constructions, the **meaning** block's type constraint indicates the meaning of the whole phrase
    - Additional meaning constraints specify how the meanings of constituents are integrated into this whole.
    - The meaning of the whole may differ from that of its parts
- In many cases, we will want to define several specific phrasal constructions that have the same general constituency and form constraints, but which have important differences in meaning. As shown above, for example, even though many prepositional phrases have the same basic constituents and form (a preposition followed by an NP), they have significant difference in meaning. Therefore, the current grammar includes several different PP constructions.
- At same time, we will want to recognize relations between these more specific constructions. These can be captured via:
    - General constructions generalization (e.g. define specific PP constructions as subcases of more 'general' PP constructions)
    - radial categories (e.g. define a specific central case PP and one or more subcase extensions)

2.4.4. Additional Constructions and Schemas

To analyze the particular sentence examples examined in this dissertation, the grammar obviously needs to include more than just preposition and prepositional phrase constructions. And, along with additional constructions, the grammar needs to include additional schemas to represent their meanings. In the remainder of this chapter, I provide an overview of the additional elements needed.

We can divide these additional grammar elements into two basic groups, based on the primary linguistic functions constructions in each group are typically used to perform. The first group includes nouns, NPs ('referring expressions'), and the schemas to represent their meanings. The second group includes verbs, Argument Structure and 'subject-predicate' constructions, along with the schemas used to represent their meanings.

For this dissertation, the primary focus is on the schemas and constructions in this second group. The first group is important as well, however, because these constructions serve as constituents in both A-S and 'subject-predicate' constructions (as well as serving as constituents in the spatial-PP constructions described above). Moreover, compositional analyses of the sentence examples examined in this work requires that the meanings of both types of constructions be integrated with one another in order to determine the meaning of the sentence as a whole.

2.4.4.1. NP and noun constructions and schemas

One way to characterize constructions is by the particular linguistic function(s) they are used to perform. One such function is to direct the language understander's attention to specific entities. This is a very basic function of language: that of reference. To perform this function, constructions need to supply various types of information about a particular referent (see Bergen and Chang 2005, Bryant 2008). Given this information, an understander can usually then determine the most likely referent within a given context.

Certain linguistically-specified parameters are regularly used in the description of referents. These include such elements as the basic 'category' of the referent (e.g. what kind of thing is it), its number (e.g. singular, plural), its 'givenness' or 'accessibility' (e.g. whether it is already present in the physical and/or discourse context), and its grammatical gender (relevant in English in the pronominal system). In ECG, these elements are represented as roles in a ReferentDescriptor schema (Figure 2.9).[13]

In the analysis of specific utterances, ReferentDescriptor (RD) serves to gather together the constructionally-specified constraints concerning some particular referent. These constraints are then used in a separate reference resolution process to determine the most likely referent in a given context.

```
schema ReferentDescriptor
  roles
    ontological-category
    givenness
    number
    grammatical-gender
    referent
```

Figure 2.9 The ReferentDescriptor schema

[13] While it is conventional among the ECG community to use such a schema, not all of the details have been fully worked out and agreed upon. Consequently, the exact schema used varies to some extent from analyst to analyst (e.g. Bergen and Chang 2005, Bryant 2008, Mok 2008). For the current work, I will use the RD schema shown in Figure 2.9.

General NP construction and subcases

Several different types of constructions can be used as 'referring expressions'. These constructions include pronouns (*he, she, it*), proper nouns (*Jack*), determiner-noun and other various complex phrases (*the box, a penguin*). These constructions can typically serve as constituents in a range of other constructions in the grammar. For instance, determiner-noun phrases can be constituents in prepositional phrases (*in the box*), verb phrases (*slid the box*), and 'subject-predicate' clauses (*the box slid*). Significantly, this pattern is similar for the various different types of 'referring expression' constructions. For instance: prepositional phrases (*in it /Jack / a penguin)*; 'verb phrases' (*slid it / Jack / a penguin*); and 'subject-predicate' clauses *(It / Jack / A penguin slid*.).

Clearly these various constructions differ to some extent in both form and specific meaning. However, it is also clear that at a more general level these constructions are similar to one another. Firstly, as already pointed out, they can all be used to describe a referent. Secondly, it is also possible to identify broad similarities in the patterns of distribution associated with these different constructions. As discussed earlier in this chapter, similarities in the meaning and usage patterns of a group of constructions can be formally represented through the use of general constructions. To capture the broad similarities discussed here, the current grammar includes a general NP construction (Figure 2.10), whose meaning is identified with ReferentDescriptor. Constructions for pronouns, determiner-noun phrases, proper names, etc. are defined as subcases of this general NP construction. Together, NP and its subcases effectively define a 'category' of constructions that are similar in meaning and use.

```
general construction NP
  subcase of RootType, HasNominalFeatures
  meaning: ReferentDescriptor
```

Figure 2.10 The NP general construction.

One benefit of defining a general NP construction is that it can serve as a general type constraint on constituents of other constructions. For instance, in the Locative-PP construction (Figure 2.6), discussed earlier, the construction's np constituent is constrained to be of type NP. All construction instances that are subcases of NP therefore meet the general constructional type constraint on this constituent. Similarly, other constructions – including A-S constructions – can also include constituents that have this same type constraint.

Subcases of NP inherit the constraint that the meaning of the construction as a whole is identified with ReferentDescriptor. In addition, specific subcases include one or more constructional constituents, one of which is typically a noun of some kind.[14] The

[14] While many NP subcases are multi-word phrases that include a noun, this is not always the case. Thus, use of the term 'noun phrase' to characterize the entire group of constructions is somewhat misleading.

subcase's constituents supply various kinds of information about the referent which that subcase construction is used to describe. The semantic relation between each constituent and the construction as a whole is specified as a meaning constraint.

It is far outside the scope of the present work to conduct a full analysis of referring expressions. For this reason, and because only a relatively small number of NPs are instantiated in the examples examined in this dissertation, this portion of the current grammar is fairly simple.[15] However, since NPs are a necessary part of my examples, it will be useful to have some idea of how they are analyzed using the current grammar. To this end, in the section below, I present an analysis of the phrase 'the box'.

Analysis of 'the box'

Using the current grammar, the phrase 'the box' is analyzed as instantiating three constructions: a DeterminerNoun construction, and two lexical constructions (for 'the' and 'box'). The DeterminerNoun construction (Figure 2.11) has two constituents: a determiner (det) and a noun (n) constituent. As specified in the form block of the construction, the determiner precedes the noun. As with all subcases of NP, the meaning of the construction as a whole is identified with ReferentDescriptor. In addition, DeterminerNoun has two meaning constraints that specify the semantic relation the construction as a whole has to each of its constituents. To understand the specific constraints used here, it is helpful to first know a bit more about the meanings associated with the two lexical constructions instantiated in 'the box'.

The first lexical construction is called the THE construction (Figure 2.11). This construction is a subcase of the more general Determiner construction (not shown), and inherits its constraint that the meaning of the construction as a whole is identified with an RD schema. In addition, THE indicates that the value of the ReferentDescriptor's givenness role is "uniquely identifiable". That is, the particular referent being described is either physically present, has already been introduced in discourse, and/or is otherwise already known to the speaker and hearer.

The second lexical construction is the BOX1 construction. Analyzing and representing the meanings of common nouns such as this is a bit tricky. We know a great deal about objects like boxes: how they are shaped, what they are used for, what materials they are commonly made from, and so on. But, while it may at times be necessary to access one or more facets of box-related knowledge to understand a particular utterance, we don't necessarily want to represent everything we know about boxes within the BOX1 construction. For one thing, such knowledge exists independent of any one particular

[15] It is possible to define ECG grammars which include a much richer set of referring expression constructions. For instance, in some grammars with a more complex NP lattice, Determiner-Noun, described below, is defined as a subcase to a more general 'specifier-NP' construction. Plus, in addition to simple nouns (e.g. *box*), the 'noun' (kernel) constituent is defined such that it can also include modified and compound nouns (*big box*; *book box; boxes and cartons*).

lexical construction (and can be referred to in different ways, e.g. by pointing, or using phrases like 'that square thing'). We could therefore define a separate 'box' schema. But this is problematic as well, since schemas are – as their name suggests – primarily intended to represent grammatically-relevant schematic structure, not detailed specific knowledge about the world. An alternative approach is to represent the rich, specific details in a separate (but accessible) knowledge base, or external ontology. ECG schemas and constructions can then specify some detailed aspects of meaning by referring to structures within this ontology. It is important to keep in mind, however, that even though the representation of this knowledge is handled in a separate system, in terms of neural circuitry the conceptual structures associated with a given noun are all presumed to be interconnected.

BOX1 and the other noun constructions in the current grammar assume the existence of such an ontology. Ontology items are distinguished from ECG schemas by the presence of an '@' sign preceding their name. For the BOX1 construction, the meaning pole of the construction is identified with the 'box' element within such an ontology, which is specified as '@box'.

Each of these two lexical constructions meets the constraints for one of DeterminerNoun's constituents. As a subcase of the more general Determiner construction (not shown), THE meets the constraints on the DeterminerNoun's determiner constituent (det). And because BOX1 is a subcase of the more general Noun construction (not shown), it meets the type constraints for the noun constituent (n).

When these constructions unify, their meanings will be integrated with one another. The phrase as a whole is a description of a particular referent, and the constituents of the phrase each supply information about that referent. In this particular example, the determiner indicates the givenness of the referent, and the noun indicates its ontological category. Together, these two constraints will help the understander to determine what the most likely referent is in the given context.

This pattern of meaning integration is specified in DeterminerNoun's meaning constraint section. The first constraint specifies a binding between the meanings of DeterminerNoun and its det constituent. Both constructions identify their meaning with a ReferentDescriptor schema: this binding indicates that they identify their meaning with the same ReferentDescriptor. The second constraint specifies that the meaning of the noun constituent is bound to the ontological-category role of DeterminerNoun's ReferentDescriptor. When the instantiated constructions unify, these constraints serve to gather the constructional meaning specifications into a single ReferentDescriptor whose ontological-category is @box and whose givenness value is "uniquely-identifiable".

```
construction DeterminerNoun
   subcase of NP
   constructional
      constituents
         det : Determiner
         n : CommonNoun
   form
      constraints
         det.f before n.f
   meaning // RD, inherited from NP
      constraints
         self.m <--> det.m
         self.m.ontological-category <--> n.m
```

```
construction THE
   subcase of determiner // subcase of Word
   form
      constraints
         self.f.orth ← "the"
   meaning // RD, inherited from Determiner
      constraints
         self.m.givenness ←  "uniquely-identifiable"
```

```
construction BOX1
   subcase of Noun   // subcase of Word
   form
      constraints
         self.f.orth ← "box"
   meaning: @box
```

Figure 2.11   Constructions instantiated in the phrase ‘the box’.

To summarize, here are some of the most important points about NP and its subcases:

- The general NP construction and its many different subcases define a category of constructions which exhibit broad similarities in meaning and use.
- These constructions are used to describe ‘referents’ of various kinds.
- To indicate this function, the meanings of these constructions are identified with a ReferentDescriptor schema.
- NP subcases have one or more constituents which supply various kinds of information about the referent that a given instance of NP is being used to describe.

2.4.4.2 Verbs, A-S constructions, and associated schemas

Basic, single clause sentences such as the ones examined in this dissertation are often used to describe events: what is going on for some participant(s) over some period of time. In addition to providing information about the ‘participants’ in the event (e.g. the referents filling the different event roles), the constructions instantiated in such sentences also specify information about the 'content' of the event, e.g. the particular type of action or process that is unfolding over this period of time. Moreover, utterances also indicate a particular conceptualization or construal of this event. For instance, they indicate from which participant's perspective the event is described, and on which elements of the event attention is focused.

The schemas that represent these meanings, and the constructions whose meanings are defined using these schemas are the major focus of the rest of this dissertation. The following section provides a brief, high-level overview of some of these schemas and constructions. Fuller descriptions of more specific schemas and constructions are provided in the chapters which follow.

<u>Processes: x-schemas, x-nets, process schemas</u>

In addition to the spatial 'image schemas' discussed earlier in this chapter, and linguistic schemas such as the ReferentDescriptor schema, ECG grammars also include schemas that represent schematic structures associated with actions and events. The current grammar includes a linguistic EventDescriptor schema (described in the following section), along with many different 'process' schemas.

Process schemas represent the schematic structures associated with a wide range of processes which 'unfold' over time, including motor-control actions, motion, and various changes in state and location.[16] The structures common to this wide variety of processes are represented using the very basic Process and ComplexProcess schemas (Figure 2.12). Subcases of these basic schemas are used to represent the more specific structures associated with specific types of processes. Together, these general schemas and their subcases form a lattice of inter-related schemas.

The Process schema includes two roles. The protagonist is the core participant of the Process. And the x-net role represents the structure of the process itself. X-nets (originally X-schemas, for executing schemas) were inspired by research in biological motor control theory, and have been computationally implemented to model dynamic actions and events (Bailey 1997; Narayanan 1997; Chang, Gildea & Narayanan, 1998). Within the NTL simulation model, x-nets are used to model the flow of activation within a simulation network (see Feldman and Narayanan, 2004; Bergen and Chang, 2005). One important thing to note about x-net structure is that it includes states and transitions that can be used to indicate specific stages of a dynamic process. A general process x-net includes temporally ordered stages such as: Initial, Start, Ongoing, Finish, and Done. As with entities, detailed information about specific x-nets is handled using a separate x-net

[16] This particular term was inspired by Langacker's use of *process* to refer to 'a relationship that evolves through time' (Langacker 1999, p.10).

ontology. For this reason, constraints on x-net roles are preceded with an '@' symbol. For Process, the x-net role is given the very general type constraint '@x-net'.[17]

ComplexProcess is a structure-building schema, defined independent of any specific process, which specifies how two processes can be composed to form a single more complex process. It has two subprocess roles, called process1 and process2. Its x-net role is specified to be a 'complexxnet' that integrates the x-nets of each of these subprocesses. The ComplexProcess's primary protagonist role (inherited from Process) is co-indexed (using ↔) with the protagonist role of process1, and the secondary protagonist2 role is bound to the protagonist of process2.

```
schema ComplexProcess
   subcase of Process
   roles
    protatgonist  // inherited
     protagonist2
     x-net: @complexxnet
     process1: Process
     process2: Process
  constraints
     protagonist ↔ process1.protagonist
     protagonist2 ↔ process2.protagonist
```

```
schema Process
  roles
    protatgonist
    x-net: @xnet
```

Figure 2.12 The Process and ComplexProcess schemas.

The grammar includes many different subcases of Process and ComplexProcess, some of which integrate the schematic structure represented by other types of spatial schemas. The complexity and interconnectivity of this complex lattice of various 'process' schemas is intended to reflect the complexity and interconnectivity of the structure active during various modes of experience of a variety of processes. Specific processes will be examined in much greater detail in later chapters. In Chapter 3, I describe some of the motion-related schemas in this lattice. Chapters 5 and 7 focus on schemas related to motor-control actions.

Verbs

To capture very broad generalizations about verbs, we can define a general Verb construction, whose meaning is identified with the very general Process schema. Specific verbs are represented as subcases of this general construction, and will have more specific form and meaning constraints. For example, the 'motion' sense of the verb *move* can be represented using the Move1 construction, which specifies that its orthographic form is "move" and its meaning is identified with a Motion schema

[17] In terms of the computational implementation of the simulation process, specific values for the x-net role associated with a given processes will serve to identify the particular x-net that can be used to model that process.

(discussed in following chapter). In addition, Move1 specifies that the relevant x-net is @move. Both the Verb and Move1 constructions are shown in Figure 2.13.

```
general construction Verb
   form:  WordForm
   meaning: Process
```

```
construction  Move1
   subcase of Verb
   form
      constraints
         self.f.orth ← "move"
   meaning: Motion
      constraints
         self.m.x-net ← @move
```

Figure 2.13 The Move1 and general Verb constructions.

Tense and aspect

All of the sentence examples examined in this dissertation contain past tense verbs, e.g. *slapped*, *slid*, *pushed*, etc. Because these examples do not differ as to tense and aspect, the verb constructions in the current grammar have only simplified specifications relating to these meaning elements.

However, the current grammar is designed to be compatible (with some modification) with other ECG grammars that provide a more complete and nuanced analysis of tense and aspect. This compatibility rests on the reasonable assumption that the 'process-related' meaning of verbs being examined here is to some extent orthogonal to the particular time that this process occurs and/or to a particular conceptualization of the aspectual structure of this process. Working from this assumption, we can analyze and represent tense and aspect independent of specific verb forms. The full meaning of a given verb form can then be analyzed as a composition of verb-specific 'process' meaning and non-verb-specific tense and aspect meaning. Aiding the integration of the meanings of these different types of constructions, Chang et al. (1998) have shown how aspect can be handled via x-net-related specifications. One way to represent the meanings of specific verb forms, in a manner consistent with the above assumptions, would be to define them as subcases of a basic verb 'lexeme' and a particular Tense/Aspect construction.

The current grammar, however, employs a somewhat simpler approach. To capture facts about tense and aspect, past tense verb constructions are defined as subcases of a more general PastTense construction. But, rather than inheriting its process-related meaning specifications from a 'lexeme' or 'root' construction, these are specified directly within the construction for a particular past tense verb form. This is illustrated in the MovePast construction in Figure 2.14.

```
construction  MovePast
   subcase of PastTense
   form
      constraints
         self.f.orth ← “moved”
    meaning:  Move
         self.m.x-net ← @move
```

Figure 2.14   The MovePast construction.

<u>A-S constructions and the EventDescriptor schema</u>

Argument structure (A-S) constructions are examined much more fully in Chapter 4 and the chapters which follow it. In this section, I highlight a few important points about how A-S constructions in the current grammar are analyzed and represented using the ECG formalism.

A-S constructions are defined as phrasal constructions. In all cases, they include a verb constituent, though they vary as to what additional constituents they include, if any. As with verbs, the overall meaning of each A-S construction is identified with a process schema (i.e. Process, or a subcase thereof). As we will see in later chapters, this enables recognition and precise specification of a variety of semantic relations between A-S constructions and their verb constituents.

A-S constructions also include structure and constraints related to one additional schema: the EventDescriptor schema (Figure 2.15). The EventDescriptor schema has roles that correspond to various constructionally-specified parameters about the content and conceptualization of events.[18] For a given utterance, these roles will be bound to schemas and/or roles associated with the verb, argument structure, and other constructions instantiated in the utterance. The EventDescriptor roles include:

- eventType. This role indicates the overall “event structure” of the event being described. The filler of this role is supplied by the A-S construction, and will typically be linked to a “basic experience” schema (related, for example, to translational motion or cause-effect actions). While there seems to be wide-spread agreement that languages are sensitive to distinctions between different types of events, there is less agreement as to which elements of event structure are most relevant. Among the leading candidates are: (1) the distinction between simple vs. complex events; (2) the presence or absence of causal relations; and/or (3) the presence or absence of motion (for overview see Levin and Rappaport Hovav 2005). As will become more apparent in later chapters, due to the nature of the schemas used to represent A-S construction meaning, the eventType role has the potential to reflect all of these distinctions. For example, CauseEffect schemas have complex

[18] As with RD, while it is conventional among the ECG community to represent roles such as these in one or more linguistic schemas, specific grammars vary as to the details.

event structure that includes causal relations, Motion schemas can supply motion information, and CauseMotion schemas contain both types of information. This yields a richer, more complex set of event categories than encompassed by most individual theories.

- profiledProcess: a process or subprocess of the event that receives focal attention. The filler of this role is supplied by the verb.
- profiledParticipant: the focal participant in the scene. Simulation of the scene will focus on elements that are relevant to this participant. This role can be thought of as the semantic correlate of subject.
- profiledStage: indicates which aspectual stage(s) of the event is profiled. This role is not utilized in the analysis presented in this dissertation, but would presumably be supplied via the Tense/Aspect constructions associated with a given verb form. Tense and aspect marking may in turn refer to particular stages in the relevant x-net, indicating for instance that the progressive profiles the ongoing stage of a process (Narayanan 1997, Chang et al. 1998).

```
schema EventDescriptor
   roles
      eventType: Process
      profiledProcess: Process
      profiledParticipant: @entity
      profiledStage
```

Figure 2.15 The EventDescriptor schema.

2.5 ECG Grammars: a summary

This chapter has shown how the ECG notation can be used to formally represent a construction-based grammar that is consistent with the larger theoretical framework of NTL. Use of this formalism was illustrated using constructions and schemas from the grammar used throughout the rest of this dissertation. It is important to keep in mind, however, that the ECG formalism itself does not determine which specific constructions and schemas a grammar should contain. In fact one significant advantage of using this formalism is that it allows one to define and test different grammars, a process that is greatly facilitated by the ECG workbench tool (see Bryant and Gilardi, to appear; http://ecgweb.pbwiki.com/). This computational tool provides a means to write and visualize grammars, to test them through access to the Constructional Analyzer (Bryant 2008), and to interactively explore the SemSpecs that are produced by sentence analyses.

The current grammar is designed to meet several different inter-related objectives. One important objective concerns the compositional analysis of the meanings of a range of different sentence examples. To analyze these sentences, the grammar needs to include several different kinds of constructions and schemas. In this chapter I discussed some of the preposition and prepositional phrase constructions included in the current grammar, and the image schemas used to represent their meaning. In addition, I provided a high-level overview of some of the other types of constructions and schemas in the grammar. To fruitfully analyze a range of sentence examples, the grammar needs to include several additional types of constructions, along with schemas to represent their meanings. In the following chapters, I discuss many different verb and A-S constructions, along with a variety of schemas used to represent their meanings.

In order to support the analysis of any specific utterance, the constructions in the grammar need to include syntactic and semantic information that aids determination of the 'best-fitting' set of constructions instantiated by that utterance. In addition, they need to include specifications that indicate how the instantiated constructions unify with one another.

Unification of the constructions instantiated in a particular utterance results in a composition of their meanings. This composed meaning is represented as a SemSpec, which consists of a set of schemas, bindings, and role specifications. Consistent with NTL assumptions about simulation-based language understanding, this SempSpec provides important semantic parameters which guide the simulation of the situation described by the utterance. The constructions instantiated in a given utterance should produce a SemSpec that is an integrated, coherent 'whole', rather than a collection of unconnected elements. Moreover, the simulation supported by the SemSpec for a given utterance should be consistent with our intuitions about that utterance's meaning, and should support relevant inferences that we are likely to make concerning that utterance.

In order to support the compositional analysis of a range of different utterances, the constructions need to combine with one another in different ways. Moreover, the SemSpecs that result from the analyses of different examples should indicate both how their meanings are similar to one another, as well as how they differ.

Given the assumption that constructions within a grammar exhibit various cognitive relations and patterns of organization, an additional objective is to recognize and formally represent some of these patterns. In this chapter, I discussed three important types of constructional relations that can be represented using the ECG formalism:

- Constituency relations. Some constructions are analyzed as having one or more constructional 'parts' whose structures are integrated into the construction as a whole. For example, the Path-PP prepositional phrase construction has a 'prep' and an 'np' constituent.
- Generalizations over more specific constructions. The current grammar includes many 'general constructions', each of which specifies similarities in the form, meaning, and/or distribution of its more specific subcases. For instance, the general SpatialPrepostion construction serves to indicate important commonalities of its more specific PathPreposition and LocativePreposition subcases.
- Radial category structure. Some constructions serve as a central member of a radial category construction. Subcase 'extensions' of this central case inherit the parent's

rich structure, but 'ignore' some portion of it. Moreover, extensions have some unique specifications of their own. In this chapter, the Path-PP2 construction was defined as a radial category extension to the central Path-PP construction. As we will see, many of the A-S constructions in the current grammar are analyzed and represented as being members of radial categories.

Schemas in the current grammar are used to represent highly interconnected, often complex schematic conceptual structures. Consequently, rather being defined as 'stand-alone' isolated structures, each ECG schema is defined as part of a larger lattice of schemas. The lattice of schemas in the current grammar is designed with a particular eye towards identifying and representing various relations between relatively 'primitive' schematic structures and 'composite' schemas of varying degrees of complexity. In other words, where warranted, the aim is to analyze complex schematic structure as the integration of more 'primitive' structures. Thus, the schema lattice includes both fairly simple 'primitive' schemas as well as more complex 'composite' schemas. Schemas in this lattice are also linked by 'evokes' relations and binding constraints.

Due to these various factors, then, the definition of any individual schema or construction is always constrained by whatever other schemas and constructions are posited in the grammar. This is true to some extent of any grammar, but the semantic analysis and representation is much deeper in ECG. Moreover, these schemas and constructions are also constrained by the larger theoretical framework of NTL, as well as being constrained and inspired by the linguistic and cognitive data that is being analyzed.

2.6 Overview of examples and grammar used in this dissertation

The specific set of schemas and constructions discussed in this dissertation form an ECG grammar that is sufficient to support a compositional constructional analysis of a range of different sentence examples that describe various kinds of basic experiences. While the general objective of this dissertation is to provide a compositional account of sentence meaning, the analytical focus is primarily on the verb and A-S constructions instantiated in the sentence examples examined in this dissertation. Accordingly, verb and A-S constructions, along with the schemas used to represent their meanings, constitute the richest, most fully developed portion of this grammar. To actually analyze full sentences, several additional types of constructions and schemas are also utilized, many of which have been described in this chapter.

Most of the constructions and schemas (or closely similar variants thereof) discussed in this dissertation have been individually tested using the analyzer, and have been used in the analysis of the different types of examples examined in this dissertation. Furthermore, many of these constructions and schemas have been computationally tested as parts of other grammars, most notably as part of the grammar used in Bryant's (2008) computational implementation of a construction-based system for language interpretation, and as part of the EJ1 grammar described in Feldman, Dodge and Bryant (2010). And, in fact, some of the nominal and clause-level constructions used in the current grammar were designed, largely by Bryant, as parts of these other grammars. However, a grammar consisting only of the specific schemas and constructions discussed in this dissertation has not been fully tested; nor would there be much point in doing so, since it is by nature only a partial grammar that is designed to support the analysis of a substantial but limited number of different types of sentence examples.

Because the scope of this dissertation is necessarily limited, the current grammar does not provide a full account of all of the linguistic functions associated with all of the different types of constructions in the current grammar. Most notably, the verb constructions provide only a rudimentary handling of tense and aspect. Additionally, the grammar includes only a very simple set of nominal constructions, and the number of preposition constructions and schemas used to represent their meaning is also limited. Moreover, because spatial relations are not the primary focus of this dissertation, analysis and specification of the details of how various image schemas (such as Source-Path-Goal) are grounded in neural circuitry remains a topic for future work.

A fuller account of language clearly needs to include much more. In addition to the elements mentioned above, it also needs to include, for instance, a treatment of metaphor, negation, speech acts, and mental spaces, to name just a few key things. To the extent that these aspects of language are orthogonal to the linguistic phenomena dealt with in this dissertation, it is likely that they too can be handled via constructions that will compose with those in the current grammar. However, given the interconnectedness of the concepts that language is used to convey, it is inevitable that as the schemas and constructions in the current grammar are integrated into more comprehensive grammars that deal with these additional phenomena, they will require various modifications both large and small. Moreover, the analysis and representation of some linguistic phenomena may well require that we amend the formalism itself.

The use of the ECG formalism to represent the grammar presented in this dissertation provides some significant benefits for the current work. As we will see, there are complex inter-relations between the schemas and the constructions needed to support a compositional analysis of the examples examined here. One benefit of using ECG is that, as described earlier in this chapter, it has computational implementations which enable the development of an internally consistent wide-coverage, complex grammar. In this respect, it is similar to other unification grammars, such as HPSG (Pollard and Sag 1994) and LFG (Dalrymple 2001). However, unlike these other grammars, ECG has a deep commitment to embodied semantics, and is consistent with the NTL theoretical framework used in this dissertation. Moreover, as the schemas and constructions presented in the following chapters illustrate, this formalism facilitates the integration and expression of several important cognitive linguistic insights, representing recurrent schematic conceptual structure (e.g. image schemas, frames), basic cognitive patterns of cognitive organization (e.g. prototypes and radial categories of A-S constructions), and different attention-related conceptualization patterns (e.g. perspective and profiling). Together, these elements enable the development of a grammar that supports compositional analyses of a range of different sentence examples that capture the similarities and difference in the event conceptualizations these examples describe.

Chapter Three

Motion-related Conceptual Structure and Motion Verbs

3.1 Chapter Overview

Motion and the changes in location that commonly accompany it are pervasive, salient parts of many of our common everyday experiences. Moreover, these are commonly recognized as basic conceptual elements that are relevant to various patterns of linguistic expression (e.g. Anderson 1971; Talmy 1975, 1985, 2000b; Langacker 1999; Jackendoff 1990; Croft 1991). In this chapter I show how the methodology sketched out in the previous chapter can be applied to the analysis and representation of the conceptual structure associated with motion-related events. Based on the recurring schematic structures evidenced by motion-related descriptions and experiences, I define a set of inter-related motion schemas. In addition, I show how these schemas can be used to represent the meanings of various 'motion' verbs.

English has a large number of verbs in English that can be used to describe motion-related events, including *move, roll, spin, fall, slide, exit, walk, saunter*, and *jog*, to name just a few. We can make the broad generalization that these verbs all describe the motion of some 'mover', and that their meanings are therefore similar in some important respects. At the same time, there are some clear differences as to the nature of the motion and, additionally, differences as to the specific role that this 'mover' plays in the event being described.

As was the case with the preposition and PP constructions in the previous chapter, the verb constructions I define in this chapter simultaneously serve several important functions:

- Capture the meaning elements that are relevant to a given construction's semantic composition with other constructions.
- Capture similarities and differences between the semantic roles of different constructions.
- Indicate construction-specific meaning
- Support generalizations of various types and granularities over various 'classes' of semantically-similar constructions.
- Support inferences /entailments associated with that construction.

The key to achieving these different functions lies not just in how we represent constructional meanings, but in how we view the meaning we are trying to represent. One important assumption here is that the semantic relations between different individual constructions arise primarily from relations inherent in the conceptual system. Given this and other NTL assumptions about the nature of language and meaning, it is clear that we need to look beyond the meaning of individual constructions, and to try to determine the nature of the motion-related conceptual structures they are 'tapping into'. These conceptual structures can then be represented using the ECG formalism in a way that captures the schematic structures and interconnections evidenced both in motion-related experiences and in descriptions of such experiences.

As discussed in later chapters, the schemas described in this chapter are also used in the representations of various argument structure (A-S) constructions, as well as being part of other verb construction meanings. As we will see, the way these motion-related schemas are defined and used to represent constructional meanings plays a very important part in the constructional compositional analyses of sentence examples examined in Chapter 4 and later chapters.

Chapter road map

In the following section, I examine some specific motion verbs and discuss some of the difficulties they present to an analysis and representation of their meaning that serves the functions listed above. Following this, I outline the methodology used to analyze and represent motion-related conceptual structure, and then present a more detailed discussion of specific meaning elements and their representation using ECG schemas. Then, I show how these schemas can be used to represent the meanings of several different motion verb constructions. In conclusion, I discuss the advantages of this approach.

3.2 Challenges

As indicated above, meaning representations should ideally serve several different functions. Of particular importance for compositionality are the components of meaning that are relevant to a given construction's composition with other constructions instantiated in a particular utterance. For example, as discussed in the previous chapter, the meanings of spatial prepositions and prepositional phrases can both be analyzed as involving similar schematic structure, and, accordingly, can be represented using the same or closely related schemas (TL and SPG). As a result, these constructions have a similar set of roles (e.g. trajector and landmark). Consequently, when instances of these constructions unify with one another, the semantic motivation for the 'fusion' of their semantic roles is clear. Additionally, the referent described by the NP construction instantiated in a given prepositional phrase will bind with the 'fused' landmark role. In this way, the NP serves to indicate more about the particular filler of this spatial role.

Similarly, when a verb construction serves as a constituent of an A-S construction, its meaning will be integrated with that of the A-S construction. This integration of meaning will include the 'fusion' of the semantic roles associated with each of these constructions. Therefore, it is important that the meanings of these roles be analyzed and represented such that the semantic motivation for their fusion (and the results of this fusion) is readily apparent. Moreover, these roles will typically bind with referents described by co-instantiated NP constructions, such as 'subject' and 'direct object' noun phrases.

However, in order for verb-related schemas and roles to serve <u>all</u> of the functions listed above, there are several challenges that need to be addressed. To illustrate the nature of these challenges, let us consider the verbs in the following examples:

(1) The box rotted.
(2) The box spun.
(3) The box slid.
(4) The boy sighed.
(5) The boy wriggled.
(6) The boy walked.

If we were to focus solely on <u>differences</u> in verb meaning, we could analyze and represent the meanings of these different verbs using lexically-specific schemas. For instance, we could have a 'rotting' schema with a Rotter role, a 'spinning' schema with a Spinner role, etc. Such a representation would clearly indicate that the meanings of each of these verbs differ from one another. Additionally, they could be used to identify lexically-specific argument realization patterns (e.g. Rotter role is filled by 'subject' NP, Spinner role is filled by 'subject' NP, etc.). But without further information, such an analysis fails to identify any similarities in verb meanings. Nor does it provide any basis for drawing broader generalizations about these argument realization patterns. For instance, what meaning do Rotter and Spinner have in common that motivates their binding with the meaning of the subject NP in both cases?

On the other hand, if we focus solely on <u>similarities</u> in the meanings of all these verbs, we can make the very broad generalization that these verbs all describe some kind 'process' that occurs over some period of time. Accordingly, we could represent the meaning and schematic roles associated with each of these verbs using a single very general Process schema.

Thus, lexically-specific schemas can serve to capture very fine-grained distinctions in verb meaning. And a very general 'process' schema can represent a very coarse-grained similarity between the meanings of these and other verbs. Furthermore, by defining lexically-specific schemas as subcases of the more general process schema, these two methods can be combined. In such an approach, each lexically-specific semantic role would be bound to the much more general Protagonist role of the Process schema. This would indicate that Rotter, Spinner, Sigher, etc are similar in that they are all Protagonists of some sort of process. And, in terms of argument realization, we could make the generalization that in each of the examples above, the Protagonist is bound to the meaning of the subject NP. Thus, by essentially having two 'layers' of semantic representation, we can simultaneously capture very coarse-grained similarities and very fine-grained differences in the meanings of verbs such as these.

However, such an approach fails to indicate several important intermediate-grained generalizations and distinctions that can be made about different subsets of verbs. One basic distinction concerns motion: spinning, sliding, wiggling and walking, for example, all entail that the protagonist <u>moves</u>, whereas sighing and rotting don't. Consistent with these differences in meaning, it is felicitous to use spatial modifiers like 'around' with motion verbs, as in *The box spun / slid around*, and *The boy wriggled / walked around*. But their use is infelicitous with non-motion verbs like *sigh* and *rot* (e.g. ??*The box rotted around;* ??*The boy sighed around*).

Another basic distinction concerns action: for sighing, wriggling, and walking we can infer that the protagonist performs some sort of action (typically involving volition and some expenditure of effort), whereas this is not true for rotting, nor is it necessarily the case for spinning or sliding. Correspondingly, while the filler of the protagonist role for actions typically needs to be an animate entity, as in (4), (5) and (6), this is not the case for the other processes, as indicated by (1) (2) and (3).

In sum, there are significant differences as to the types of motion- and action-related entailments and inferences associated with different verbs. Significantly, these differences affect how the verb will (or won't) compose with some types of constructions. However, if each specific verb meaning is simply analyzed and represented as a direct subcase of the very general Process schema, the meaning representations will not directly indicate the motion- and/or action-related meaning that is shared by some, but not all verbs.

Moreover, there is an additional, cross-cutting distinction amongst motion verbs concerning entailments about changes in the protagonist's location. Many motion verbs support an inference of locational change even in utterances in which no particular path of motion is specified. E.g. *The box slid/fell* entails that the box moved from one place to another. Consequently, it doesn't make sense to specify a <u>lack</u> of locational change, as in ?? *The box slid/fell but stayed in place.* For these verbs, then, their meaning necessarily includes both motion <u>and</u> locational change.

However, many other motion-related verbs can be used to describe situations in which the mover does <u>not</u> necessarily change its overall location. For example, *The boy wriggled* entails that the boy's body moved, but does not necessarily mean that he changed his location with respect to his surrounding environment. And some uses of these verbs actually specify a <u>lack</u> of locational change, as in *The boy wriggled but stayed in his seat*. Similarly, the verb *wiggle* (whose protagonist is not necessarily an animate actor), can be used to describe motion that does not result in a change in location, as indicated by (7).

(7) "When Willeford arched over the bar on her third and final attempt at 5 foot, 4 inches, the bar wiggled but didn't budge…" [1]

Examples such as these suggest that the concept of 'motion' is potentially dissociable from that of 'change of location'.

Consequently, motion schemas and roles should ideally serve to indicate that:

- Motion is both similar to and different than other processes (movers are similar to other protagonists, but not all protagonists are movers).
- Some, but not all motion involves the mover's control of that motion (i.e. some but not all movers are actors).
- Some, but not all motion involves a change in location (i.e. some but not all movers change their overall location).

Further complicating matters, these different 'meaning elements' may be combined in different ways by different motion-related verbs and event descriptions. For instance:

(8) *The boy wriggled* -- describes a situation in which the protagonist is in control of the motion (mover is an actor), but there is not necessarily any change in the mover's location.

(9) *The box slid* -- describes a situation where the mover changes location, but is not in control of its motion (mover is not an actor).

(10) *The boy walked* -- all of these elements are present (mover is an actor who changes location).

(11) *The box spun* -- only 'bare' motion is present (the mover is not an actor and does not necessarily change location).

This suggests that we can compare and contrast these verbs (and associated semantic roles) along different 'dimensions' of comparison. We can, for instance, compare them on the basis of whether they involve motion, whether they involve an animate actor, and/or whether they involve a change in the protagonist's overall location.

What sorts of schemas are needed to represent these different meanings, so as to fill the various functions listed at the beginning of this chapter? As discussed above, positing lexically-specific schemas and roles (e.g. a Slide schema with a Slider role), would help indicate differences in constructional meaning. But, by themselves, these do not indicate commonalities of meaning (nor do they really tell us much about what meaning a given construction has). By positing a very general process schema with a protagonist role, we can represent structure that is common to all verb constructions. But such a schema does not indicate any intermediate level generalizations of the type typically associated with different 'semantic classes' of verbs.

[1] Source: www.stripes.com/article.asp?section=123&article=62870

Simple schemas such as Motion and Action (with Mover and Actor roles, respectively) could explicate some mid-level similarities and differences, and would allow us to distinguish between 'motion verbs' (in which the protagonist is a Mover) and 'action verbs' (in which the protagonist is an Actor). But, neither schema by itself is adequate for representing finer-grained distinctions within these general groups, such as distinctions between motion verbs relating to animacy (motion controlled by an actor) and location change (motion that results in a change in the overall location of the mover).

As I show in the remainder of this chapter, the key to solving this representational challenge lies in the analysis (and representation) of a larger <u>system</u> of motion-related conceptual structure. This in turn involves an examination of both linguistic and non-linguistic evidence about how our experiences of motion-related events are structured.

3.3 Overview of methodology, assumptions

The basic methodology I use is similar to the one used to analyze and represent the meanings of spatial relations terms: (1) Examine the types of recurring conceptual structures that are present in the experience and description of basic motion events; (2) Define an inter-related set of primitive and composite schemas to represent the recurrent schematic structures, and; (3) Use these schemas to represent the meanings of verbs that are used to describe motion events. Crucially, this approach requires us to look beyond the meanings of individual motion-related verbs, to the larger system of motion-related conceptual structure to which they refer.

One important lesson that can be learned from the examination of spatial relations terms is that it is possible to identify general schematic structures that recur across a range of different specific types of experiences. For instance, we can recognize the presence of schematic "container structure" in many different types of entities (e.g. boxes, caves, mouths, etc.), experienced via different sensory-motor modalities (e.g. seeing, hearing, manipulating). And in each case, the schematic conceptualization involves a similar limited number of parts (boundary, interior, exterior, portal), and we can draw similar inferences (e.g. if something is in the interior, it needs to cross the boundary to get to the exterior). Moreover, we can in essence 'decouple' this schematic structure from the specific entities involved in any given situation. That is, there is a recurrent similarity in the roles that these entities play, even though the specific entities that play these roles differ from situation to situation.

Another crucial point is that while these schematic structures are a key element of constructional meaning, they do <u>not</u> have a one-to-one correspondence with the meanings of constructions. As seen above for prepositions, the same schema may be utilized by more than one preposition (e.g. *in, into, out*, etc. all utilize 'container' schema structure). And, the meaning of a given preposition can often be analyzed as a composition of more ‘primitive’ schemas (e.g. *into* as a composition of BoundedObject and SPG). In such cases, the semantic roles associated with the preposition may be complex (e.g. the landmark role of both *in* and *into* is conceptualized as a bounded object). And, while these prepositional meanings include only a schematic specification of these roles, composition with other instantiated constructions can provide further information about the fillers of one or more of these roles (e.g. the NP object of the prepositional phrase may specify information about the entity filling the landmark role).

Similarly, the experiences and descriptions of various motion-related events differ in their details. But, consistent with ‘schema structure’ assumptions, it is possible to identify recurrent similarities in the number and type of participants involved, the nature of the processes themselves, and the inferences we can make about these processes. Furthermore, as with spatial relations, I presume that the schematic structures evidenced in language about motion-related events are closely related to the neural circuitry used in processing other types of experiences of motion events (e.g. performing, seeing, and imagining them). Consequently, in addition to linguistic evidence, I also consider sources of evidence that indicate something about the neural circuitry used to process these other types of experiences.

In the sections which follow, I start by looking at motion in general, and its relation to other kinds of processes. Next, I look at distinctions within the motion domain. First I examine the close relation between motion and changes in location. Then, I look at motion that is associated with motor-control actions, in which an actor controls his motion and any accompanying changes in location. As part of this examination, I show how motion-related conceptual structure can be represented as a set of inter-related schemas. I define separate Motion, SPG and MotorControl schemas. And, I show how more complex schemas (MotionAlongAPath, AnimateMotion, and Locomotion) can be defined as compositions of these more primitive schemas. In addition, I show how these schemas can be used to represent the meanings of various motion-related verbs. And, as we will see, these schemas and constructions serve to carry out the functions listed at the beginning of this chapter.

3.4 Basic motion-related conceptual structure

As discussed above, the ‘processes’ described by motion verbs are both similar to and different than those described by other kinds of verbs. Like other processes, motion occurs over time. And, as with other processes, we can perceive, imagine, and describe different ‘stages’ of motion. This includes the start of motion (*He started moving*), its continuation (*He kept moving*) and its termination (*He stopped moving*). Furthermore, as with other processes, descriptions of motion indicate that it can take place at different points in time (e.g. relative to speech time), as in *He moved / is moving / will move*. In these respects, then, motion verbs and the processes they describe are similar to other verbs and processes.

However, not all processes described by verbs necessarily include motion. That is, while some descriptions entail that the 'protagonist' moved, others do not, as shown by examples such as the following:

(11) He stayed perfectly still while he slept / blushed /tanned / dreamed of chocolate cake.
(12) The water froze.
(13) The ice melted, but didn't move.
(14) He tightly gripped the handle. (as in maintaining a grip)

So, linguistic evidence indicates that motion-related conceptual structure is both similar to and different from that associated with other types of processes. To represent these differences, we will need more than just a general Process schema. But what elements should this schema include? In other words, how can we characterize and represent (linguistically-relevant) motion-related conceptual structure? To answer these questions, it is useful to consider not only linguistic evidence, but also other forms of evidence relating to motion-related conceptual structure.

Recall a key assumption of simulation semantics: understanding descriptions of experiences involves activation of some of the same (or closely-related) neural structure(s) as are active when participating in, observing, or imagining such experiences. Given this assumption, a relevant question is: What sort of neural structures are active during motion experiences (e.g. when we move, perceive other people or objects moving, or imagine ourselves or others moving)?

The exact details of motion-related neural structure are far from being fully known. And even a review of what is known is outside the scope of this dissertation and my areas of expertise. However, research into areas of the visual cortex which respond to a variety of moving stimuli have been found to also be sensitive to the direction as well as the speed of this motion (e.g. Born and Bradley 2005). Thus, these areas respond to the presence of a mover, as well as differentially responding to its direction and speed of motion.

Similarly, in language, the same motion verb can typically be used to describe motion involving many different types of movers. For example:

(15) The box / My sister / A penguin / Half the hillside slid.

Thus, both neural and linguistic evidence suggest that we can 'de-couple' the structure associated with a schematic mover and its motion from other conceptual structure associated with the particular entity that is moving in some particular instance.

Furthermore, in descriptions of motion events, co-instantiated constructions can indicate something about the speed or direction of the motion described by the verb. E.g. *He slid (rapidly /slowly) (downwards /south/ around)*. Moreover, some motion verbs themselves specify something about the speed or direction of motion, as indicated by the infelicity of certain modifiers. For example, *The balloon rose (*down); The car hurtled (* slowly).* And, while movers do not necessarily move in a constant or readily definable speed or direction, it seems difficult, if not impossible to imagine something that is moving at no speed and in no direction. In this respect motion differs from an experience like sleeping, which does not include either of these elements.

Thus, multiple forms of evidence suggest that our representation of motion-related conceptual structure should include a schematically-defined mover role, as well as parameters relating to the speed and direction of this mover's motion.

3.4.1 A basic Motion schema

This basic motion-related structure is represented by a Motion schema (Figure 3.1). As noted above, motion is similar in some important respects to other types of processes. These similarities are indicated by defining Motion as a subcase of the more general Process schema (Figure 2.12), introduced in the previous chapter. Process has two roles: a protagonist role, for the core participant of the process, and an x-net role that represents the structure of the process itself. As a subcase, Motion inherits both of these roles. Differences from other processes are represented by adding constraints to these inherited roles, and through the addition of further roles.

```
schema Motion
  subcase of Process
  roles
    mover: entity
    x-net: @motion
    speed
    direction
    protagonist
  constraints
    mover ↔ protagonist.
```

```
schema Process
  roles
    protagonist
    x-net
```

Figure 3.1 The Motion and Process schemas (arrow indicates subcase relation).

Within Motion, the inherited x-net role is constrained to be of type 'motion' (x-net: @motion). This indicates that motion is a specific kind of process, and can be modeled using a specific kind of x-net. The @ sign which precedes the name of this x-net indicates that it is more fully defined within a separate x-net ontology. While the x-net is separate from the schema in terms of its full formal representation, it is nonetheless directly linked to and therefore accessible by the Motion schema. As with other x-nets, this motion x-net supplies aspectual-type structure. For example, a bounded motion episode has an initial state (entity is still/motionless), a start transition (starts to move), an ongoing state (is moving), a finish transition (stops moving) and a final state (is once again motionless).

The core participant (i.e. the thing that is moving) is represented using a mover role. Many different types of things can be movers, such as people, animals, leaves, rocks, water, and so on. Consequently, the mover role is only given the very general constraint that its filler must be of type 'entity'. In addition, this mover role is identified with the inherited protagonist role: this is specified in the constraints section as a binding between these two roles.[2] Motion also has roles for speed and direction. Since speed and direction will differ for different instances of motion, no particular values are specified for these roles.

Thus, the Motion schema includes roles that represent recurrent and linguistically-relevant elements of motion-related conceptual structure. More specific instances of motion can be represented by specifying fillers for the mover role, more specific motion x-nets, values for the speed role, and/or values for the direction role.

3.4.2 Using the Motion schema to represent verb meaning

As indicated in the previous chapter, this Motion schema can be used to represent the meaning of basic motion verbs such as (the central sense of) the verb *move*. The Move1 construction (Figure3.2) is defined as a subcase of the general Verb construction, whose meaning is identified with the Process schema. Move1 includes specific constraints about the form of the construction, indicated here by specifying that the orthography is constrained to be "move". The meaning of the construction is identified with the Motion schema. Since the Motion schema is subcase of Process, this is a compatible, but more specific meaning constraint than the one specified in the general Verb construction. Because the verb *move* in itself does not specify motion in any particular direction or at any particular speed, Move1 does not specify any values for Motion's speed or direction roles.

```
construction Move1
  subcase of  Verb
  form
    constraints
      self.f.orth ← "move"
  meaning: Motion
```

```
general construction Verb
  form: WordForm
  meaning: Process
```

Figure 3.2 The Move1 and VERB constructions.

One issue that arises at this point concerns polysemy: is there a single Move construction, or are there multiple constructions with the same form? As will be discussed more fully in later chapters, some differences in sentence meaning may be attributed to other constructions instantiated in that sentence (especially argument structure constructions). Consequently, the grammar doesn't necessarily need to include

[2] In ECG, type constraints such as these are indicated using a single colon (mover: entity). And binding relations are shown via a double-headed arrow (mover ↔ protagonist). To make the figures more compact, inherited elements are often not shown, but they are still assumed to be part of the 'child' schema's structure.

two different verb constructions to handle the difference in meaning between *He moved* and *He moved the box*. In some cases, though, such as in the 'change residence' sense of *move*, it will be necessary to create more than one construction with the same form specifications. This is one reason the current construction, Move1, includes a number as part of its name.

While the basic Motion schema has the structure to represent the meanings of some verbs, it does not include structure related to location changes or to motor-control. Consequently, it does not have the structure needed to fully represent the meanings of many of the motion verbs discussed earlier in this chapter, such as *slide*, *wriggle*, and *walk.* To do so will require the use of use of additional schemas, as shown in the following sections.

3.5 Translational Motion

All types of motion inherently involve some element of location change. However, the nature of this change (and the way we conceptualize it) varies. In some cases, motion involves a progressive change of the mover's location within some larger scene. Moreover, this typically results in the mover's final location being different than its initial location. In other cases, though, the mover as a whole does not necessarily change location. That is, the mover may remain at the same location while motion is ongoing, and/or be at the same location when motion stops as it was when motion started.[3] For 'non-translational' motion such as this, all or part of an entity moves (e.g. changes configuration or orientation), and thus there are at least some very local changes in the location of the entity, or at least parts of the entity. But, only for translational motion does the entity as a whole change location at the scale of the larger scene. [4]

Some verbs, such as *fall, rise, plummet, hurtle*, and *sprint* specifically describe motion that is translational. Such verbs can be used in change of location descriptions, as in (16a and b).

(16) a. The rock fell / slid into the net.
b The girl fell / sprinted into the alley.

But not in 'remain in a location' descriptions, as shown by (17a and b).

(17) a. *? The rock fell / slid in place.

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[3] Linguists have used various terms to describe this 'non-translational' type of motion, including "motion-in-place" (Miller and Johnson-Laird, 1976), "contained motion" (Pinker 1989), and "self-contained motion" (Talmy, 2000). It is also possible to make further distinctions within this general class. Using physics-based terms, we can, for example, say that some verbs describe 'oscillatory' motion (e.g. *sway, nod*), while others describe 'rotational' motion (e.g. *spin, twirl*).

[4] Note that motion that is typically construed as non-translational can often also be construed and/or described as being translational, e.g. *Adam's eyelid fluttered* might also be described as *Adam's eyelid rose and fell (rapidly)*, or *Adam's eyelid went up and down (rapidly)*. *Adam's eyelid plummeted* seems very odd, though, indicating that there are some limits on such construals.

b. *? The girl fell / sprinted in place.

And, when no prepositional phrase is included, there is a non-defeasible inference that the moving entity changed location. Consequently, it doesn't make sense to state otherwise, as in (18a and b).

(18) a. The rock fell (?? but didn't change location).
b. She sprinted (?? but didn't change location).

Other verbs, however, are used to describe motion that is not necessarily translational. For example, *sway, jiggle, nod*, and *spin* all describe motion in which part or all of the entity is moving (and may be changing orientation and/or configuration). But this moving entity doesn't necessarily change its overall location in relation to the larger environment. Unlike the verbs above, these verbs can be used to describe both translational and non-translational motion events. Such verbs may felicitously co-occur with either 'locative' or 'path' prepositional phrase as in (19a and b).

(19) a. The ball spun in place / into the net
b. The girl wriggled in place / into the bag

And, when no prepositional phrase is present, both the translational and non-translational 'readings' are possible, as in (20).

(20) The ball spun wildly (but didn't change location / and changed location).

As the usage of *but* and *and* indicates, the default inference is probably one of locational change, but this inference is defeasible.

Thus, all of the verbs above can be used to describe situations in which something is moving and changing its overall location; in other words, they can be used to describe translational motion. But, some of these verbs (*spin*, *wriggle*) can also be used to describe non-translational motion, while others (*slide*, *plunge*) cannot.

Note that the examples containing verbs from this second set can be analyzed in at least two different ways, as will be described more fully in the following chapter. In both analyses, we can assume that the central sense of the verb is one of 'internal motion' -- motion in which the entity itself is moving, but is not necessarily changing its overall location in relation to its surrounding environment. Translational motion uses (e.g. *The box spun across the floor*) can be analyzed as instances of a second, translational motion sense of the verb. But it is also possible to analyze these examples as instantiating the same central sense of the verb, with the translational motion conceptual structure being supplied by the argument structure construction instantiated in the utterance. The important point here is that for both of these possible analyses, we need a way to represent two different types of motion-related meanings, one in which there is a change in the mover's location, and another in which this is not necessarily the case. Or, to put it another way, in some cases, there is a need to specify presence of translational motion, but in other cases we need to allow for its possible absence.

Significantly, there are some key inferences that hold specifically for translational motion, but not necessarily for all motion. For instance, for translational motion the location of the moving entity changes over time. Furthermore, there is an interrelation of speed, elapsed time and distance. For example, the distance traveled increases with elapsed time and is positively correlated with speed of motion. Representation of the structure of translational motion should specify structure that supports these inferences.

These inferences are similar to those commonly associated with a well-known image schema: the Source-Path-Goal schema (Johnson 1987; Lakoff 1987). It therefore makes sense to use an ECG version of a Source-Path-Goal schema in the representation of the schematic structure of translational motion. But, what should this schema consist of?

We can characterize the prototypical Source-Path-Goal scene as one in which a person moves himself from an initial location, along a path, to some desired 'goal' location. A very rich version of a Source-Path-Goal schema might therefore include structure related to motion and intentional actions, as well as structure related to the progressive change in location over time.[5] However, different elements of this structure can, to some extent, be disassociated from one another. For instance, a person can perform a motor-control action without changing his location, an object can change location without motor-control being involved, and (as already discussed) an object can move without changing its overall location. Consequently, I view the rich structure associated with prototypical Source-Path-Goal scenes as a composition of more 'primitive', potentially dissociable elements. For that reason, I define separate ECG schemas for motion, motor-control, and location change. As we will see later in this chapter, these schemas can then be combined to represent the more complex structure associated with prototypical 'source-path-goal' experiences.

Therefore, as described in the following section, the location change elements of translational motion are represented in the current grammar using a variant of the SPG schema presented in the previous chapter. The full structure of translational motion is represented using the MotionAlongAPath schema, which integrates the structure of this SPG schema with the structure of the basic Motion schema.

3.5.1 The MotionAlongAPath schema

Translational motion is a kind of motion, involving a mover moving in some direction at some speed. Therefore, the MotionAlongAPath schema used to represent the schematic structure of translational motion is defined as a subcase of the basic Motion schema. To represent the mover's progressive changes in location, MotionAlongAPath also evokes an SPG schema.

[5]It might also include force-related components, to handle notions like 'obstacles' and 'burdens'.

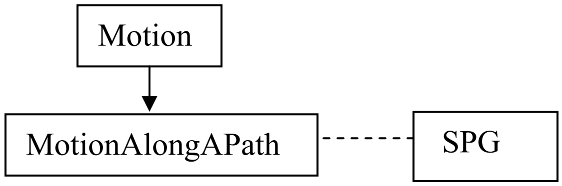

Figure 3.3 The MotionAlongAPath schema's relations to other schemas (arrow indicates subcase relation, dotted line indicates an 'evokes' relation).

As described in the previous chapter, SPG is a subcase of the TL schema, a basic locational schema (Figure3.4). TL essentially specifies that one entity (the trajector) is located in some attentionally-profiled region of space (the profiledArea). Commonly, this region of space is itself defined in relation to some reference entity (the landmark). Unlike TL, which specifies only a single profiled location, SPG (Figure3.4) represents an ordered <u>series</u> of locations that the trajector occupies. Since the trajector's location is linked to the profiledArea, an alternative way of thinking about this locational change is that it involves a change over time of the area being profiled, i.e. that the focus of attention shifts over time to a series of different (but spatially contiguous) regions of space. Rather than having a single profiled area, then, SPG has three, each of which corresponds to one section of this series: the source is the initial location, the path is consists of one or more intermediate locations, and the goal is the final location.

```
schema TL
  roles
    trajector
    landmark
    profiled Area
```

```
schema SPG
  subcase of TL
  roles
    trajector
    landmark
    source
    path
    goal
```

Figure 3.4 The TL and SPG schemas.

For simplicity's sake, the SPG schema used throughout this dissertation includes only the structure mentioned above. But, a more complete version can be created which includes additional structure related to attentional change and to the structure of the path itself. These additional elements are shown in the SPG_enhanced schema (Figure3.5)[6]. Since the Constructional Analyzer does not have an implemented method of handling them, specifications relating to profiling and/or attention have been written as comments (preceded by //) within the SPG_enhanced schema. These commented specifications are intended to indicate that the trajector is initially located at the Source profiledArea, then along the Path profiledArea, and finally at the Goal profiledArea. To capture the fact that the path is itself a series of spatially-contiguous locations, additional structure and constraints are required. As indicated in Figure3.5, this can be handled by evoking a

[6] There are of course other ways to represent SPG, including the creation of a whole family of different schemas. Not surprisingly, each approach has both plusses and minuses.

BoundedPath schema. As described in the previous chapter, the ‘evokes’ relation is more underspecified than the ‘subcase of’ relation, and does not imply that the evoked schema is a ‘parent’ of the schema evoking it. And, while an evoked schema may supply roles and constraints utilized by the current schema, these roles are not automatically inherited. In fact, as noted in Chapter 2, while all of the evoked roles and constraints are ‘accessible’ to the schema being defined, there is no requirement that all (or even any) of them actually be incorporated into this schema’s structure. The BoundedPath schema consists of a ‘curve’ (basically a line of indeterminate shape) that has two ‘ends’ (boundaries). In the SPG_enhanced schema, the source is bound to one end of the curve, the path to the curve itself, and the goal to the other end (e.g. goal↔P.end2). In sum, the BoundedPath schema adds the topological spatial structure associated with Source-Path-Goal, while the temporal structure of locational change is represented via links to temporally-ordered changes in attention.

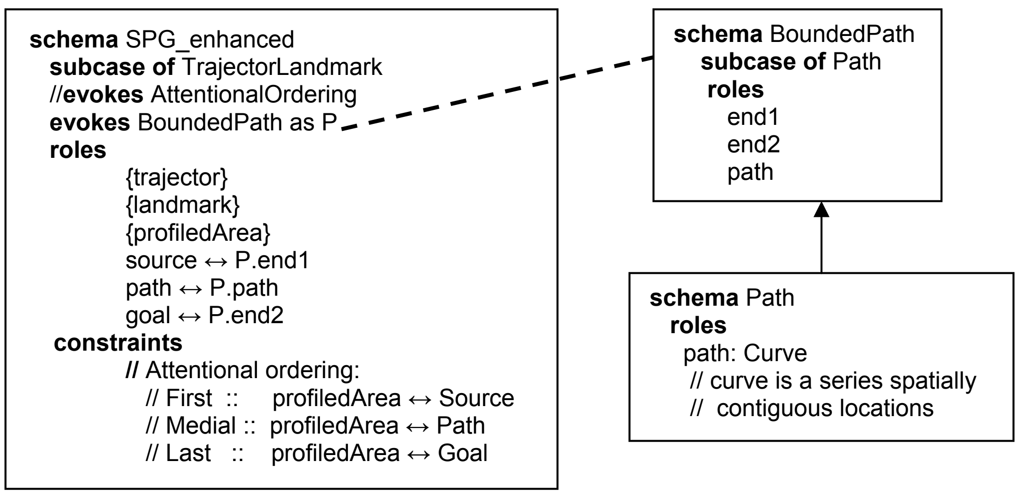

Figure 3.5 The SPG_enhanced, BoundedPath, and Path schemas. Dotted line indicates ‘evokes’ relation, arrow indicates subcase relation.

As a subcase of Motion, the MotionAlongAPath schema (Figure3.6) inherits its roles of mover, speed and direction, as well as a motion x-net role. In addition, MotionAlongAPath evokes the SPG schema, which indicates that MotionAlongAPath also has access to the roles and constraints of SPG. In addition, MotionAlongAPath specifies that the mover role is bound to the trajector role of SPG (mover ↔ spg.trajector). This is a very important relation, because it indicates that the entity that is moving (the mover) is also changing location. In effect, then, the mover role in the MotionAlongAPath schema is a <u>complex</u> role, and partially overlaps the mover role in the more general Motion schema.

```
schema MotionAlongAPath
  subcase of Motion
  evokes SPG as spg
   roles
      mover
      speed
      direction
      x-net: @translationalmotion
   constraints //
     mover ↔ spg.trajector
```

Figure 3.6 The MotionAlongAPath schema. Inherited roles are shown in gray.

Another important relation is the one between the ordered sequence of locations represented by SPG's source, path, and goal roles, and the different stages of translational motion. Specifically, the mover starts at an initial location (the source) and then moves along a contiguous set of locations (the path). And when motion stops, the mover is a final location (the goal).[7]

3.4.2 Using the MotionAlongAPath schema to represent verb meaning

The meanings of many different verbs can be represented, at least in part, using the MotionAlongAPath schema. Use of the same schema in the meaning representations of different verb constructions helps indicate important semantic commonalities between these constructions. At the same time, additional specifications within individual constructions serve to indicate verb-specific meanings, and help capture finer-grained differences in verb meaning without requiring the use of lexically-specific schemas, as discussed below.

One important respect in which translational motion verbs differ is in their specification (or lack thereof) of the speed and the direction of motion. Some verbs specify speed but not necessarily direction (e.g. *hurtle, speed, zoom, inch*), some specify direction of motion and/or change in location but not speed (*fall, rise, exit, enter*), and some specify both (*plummet*).

First, consider verbs such as *hurtle* and *inch*, which indicate something about the speed of motion. Within constructions for these verbs, the fact that they describe translational motion can be specified by identifying their meanings with the MotionAlongAPath schema. Then, to indicate that these verbs specify something about the speed at which a mover is moving, value constraints can be specified for the speed role of this schema. Since these verbs are not associated with an absolute speed of motion, we will want to

[7] These different stages are actually part of the translationalmotion x-net structure, which includes temporally ordered Initial, Ongoing, and Final states. Therefore, these relations are probably best handled as x-net relations. Simulation using this x-net would support the various inferences associated with these relations.

use relative values such as ‘low’, ‘moderate’, and ‘high’. So, for example, *hurtle* can be constrained to have speed value ‘high’, and *inch* to have speed value ‘low’ (Figure3.7).[8]

```
construction Hurtle1
  subcase of Verb
  form
    constraints
      self.f.orth ← "hurtle"
  meaning: MotionAlongAPath
    constraints
      speed ← high
```

```
construction Inch3
  subcase of Verb
  form
    constraints
      self.f.orth ← "inch"
  meaning: MotionAlongAPath
    constraints
      speed ← low
```

Figure 3.7 Constructions for the verbs *hurtle* and *inch*.

Next, consider translational motion verbs such as *fall*, *rise, ascend, descend,* and *plummet*, which specify a change of location with respect to the gravitically-structured environment in which motion occurs. As with the ‘speed of motion’ verbs, the translational motion meaning of these verbs can be specified using the MotionAlongAPath schema.

There is more than one possible way to specify the change of location element of meaning. MotionAlongAPath essentially has two spatial components: one is the direction role provided by the Motion schema, and the other is the series of locations (source, path, and goal roles) supplied by the SPG schema. These two components are inter-related. If a mover moves in a particular direction, he must be consecutively occupying locations along a path that is oriented in that direction. And if a mover is changing locations, he must at the same time be moving in some direction (away from earlier locations, and towards later locations).

A fairly simple way to represent the spatial component of meaning of these verbs is to specify the direction of motion using a value that relates directly to verticality, such as ‘up’ or ‘down’. For example, constructions for the verbs *fall* and *plummet* (Figure3.8) show the constraint that the value for direction is ‘down’. *Plummet* further specifies that the speed of motion is ‘high’, while for *fall*, the speed of motion is unspecified. Similarly, the verb *rise* would indicate that direction of motion is ‘up’.

[8] To be meaningful, terms like ‘low’, ‘moderate’, etc. need to be further defined and grounded. One way this might be done is to define different possible speed values as positions or ranges on a schematically-structured scale. This would also enable us to specify speed relative to some norm (which would itself be defined as a point or range on the scale). Norms are likely to differ for different types of movers; for instance, the normal speed of an ant is far less than that of a car. Consequently, an ant hurtling across a table may be moving at a speed that is higher than normal for an ant, but it will still be moving at a much lower absolute speed than a car inching along in traffic (though maybe not if traffic is really bad).

construction Fall1

construction Fall1
  subcase of Verb
  form
    constraints
      self.f.orth ← "fall"
  meaning: MotionAlongAPath
    constraints
      self.m.direction ← down

```
construction Fall1
  subcase of Verb
  form
    constraints
      self.f.orth ← "fall"
  meaning: MotionAlongAPath
    constraints
      self.m.direction ← down
```

```
construction Plummet1
  subcase of Verb
  form
    constraints
      self.f.orth ← "plummet"
  meaning: MotionAlongAPath
    constraints
      self.m.direction ← down
      self.m.speed ← high
```

Figure 3.8 Constructions for *fall* and *plummet*

Another method would be to specify that the goal is associated with some locational reference area, such as 'sky' or the 'ground'. Furthermore, if we were to utilize the SPG_enhanced schema, which includes the structure of a bounded path object, we could also specify direction by specifying the orientation of this path (e.g. path.orientation ← 'vertical').[9]

Lastly, consider a set of translational motion verbs that specify the mover's direction of motion and change of location in relation to a separate entity within the scene – a spatial landmark. This category includes verb such as *arrive*, *leave*, *enter*, *exit*, and *cross*. For the first two of these (*arrive*, *leave*), change of location is specified in relation to the landmark entity as a whole. For *arrive*, the landmark defines the mover's final (goal) location, whereas for *leave* the landmark is the mover's initial (source) location. Another way to view this is that the landmark serves to define a direction of motion: for *arrive* motion is towards the landmark, while for *leave* motion is away from the landmark.[10]

Verbs such as *enter* and *exit* specify location in relation to a schematically-structured landmark. More specifically, for both of these verbs the landmark is conceptualized as a bounded object of some kind (akin to a container, but not necessarily having all of the force-dynamic properties typically associated with containers, such as solid boundaries). The mover's changes of location are then specified relative to different parts of this bounded object. For *enter*, the mover's goal location is the interior of this bounded object. Furthermore, there is at least one path location at which the mover is at the

[9] As with speed parameter values, the cognitive grounding of these values requires further analysis and representation of additional schematic conceptual structure. In particular, this involves structure related to 'verticality', which is itself grounded in experiences that take place within a gravitically-structured environment. The full representation of the relevant schemas and bindings is outside the scope of the current work. But the important point here is that directional values such as 'up' and 'down' are related to a larger system of embodied conceptual structure. And, as with other types of conceptual structure, this structure can be represented using ECG schemas which can then be used in a variety of constructional meaning representations.

[10] As with other direction values, we would also want to define 'toward' and 'away from' in relation to larger conceptual system.

boundary of this object. And for *exit*, the interior of the bounded object is the mover's source location.

As with other translational motion verbs, Enter1 (Figure3.9) identifies its meaning with MotionAlongAPath. In addition, it evokes the BoundedObject schema (described in Chapter 2 and shown in Figure2.1), and specifies several constraints concerning the relation this evoked schema has to the SPG schema evoked by MotionAlongAPath. BoundedObject's whole role (representing the entire object) is bound to the landmark (self.m.spg.landmark ↔ bo.whole). This indicates that the landmark is conceptualized as having the schematic structure of a bounded object. Additionally, SPG's goal location is bound to the interior of this bounded object, and the path to its boundary. These specifications indicate how the mover's location changes over time with respect to the landmark.

Enter1 is similar to the Into1 construction discussed in Chapter 2 in that the meanings of both of these constructions include SPG and BoundedObject structure. Moreover, they specify the same relations between the roles of each of these schemas. However, there is a key difference: Enter1 identifies its meaning with a 'process' schema (MotionAlongAPath) while Into1 identifies its meaning with a 'spatial relations' schema (SPG). Consequently, Enter1 is distinguished from Into1 by its inclusion of x-net structure (related to the dynamic process of motion). These representations thus capture the semantic difference that is directly related to their differences in use. At the same time they indicate that, although these are different 'parts of speech', they nonetheless exhibit some very strong semantic similarities.

```
construction Enter1
   subcase of Verb
   form
      constraints
         self.f.orth ← "enter"
   meaning: MotionAlongAPath
      evokes BoundedObject as bo
      constraints
         self.m.spg.landmark ↔ bo.whole
         self.m.spg.goal ↔ bo.interior
         self.m.spg.path ↔ bo.boundary
```

Figure 3.9 The Enter1 construction.

3.5.3 Translational motion: a summary

The MotionAlongAPath schema described in this section represents schematic conceptual structure associated with translational motion: motion that involves an overall change in the mover's location. This schema is not defined in isolation. Rather, it incorporates the structure of two other schemas: the more general Motion schema, and the SPG schema, a schema which represents, at least in part, the schematic conceptual structure associated with an ordered series of changes in location. Moreover, the mover role of MotionAlongAPath is related to but distinct from the roles of these two other schemas. Specifically, it bound to the mover role inherited from the Motion schema, and is also bound to the trajector role of SPG. This binding results in a complex semantic role, signifying an entity that is both moving and changing location.

The conceptual structure represented by the MotionAlongAPath schema is not unique to any one specific construction (nor is it unique to language). As shown in this section, this schema can be used in the meaning representations of several different verb constructions, thereby indicating that these verbs have some core conceptual structure in common. This representational method thus provides an explicit basis for drawing generalizations over a group of verbs, of the type that may define a semantic class (e.g. translational motion verbs). Consequently, it avoids one of the problems associated with using lexically-specific roles: the difficulty of capturing more general role meaning.

At the same time, additional specifications within individual constructions serve to indicate construction-specific elements of verb meaning. For some verb constructions, these differences are indicated through the specifications of values for the speed and/or direction roles of MotionAlongAPath. For other constructions, change of location is specified via bindings to the landmark role of the evoked SPG schema. And in at least some cases, these specifications involve the use of additional schematic structure(s). Many other translational motion verbs can be represented in a similar fashion. For example, constructions for verbs like *slide, skid*, and *skip* can evoke a Contact schema, and specify something about the contact between the mover and some ground surface that occurs while motion is ongoing. *Slide*, for instance, would specify continuous contact, while for *skip* contact would be intermittent.[11]

These additional specifications allow us to make relatively fine-grained semantic comparisons between these verbs. For example, verbs may be considered similar to (or different than) one another on the basis of their specifications of motion speed and/or direction. These specifications also help indicate the felicity (or lack thereof) of co-occurring constructions. For instance, since *hurtle* specifies high speed, using the adverb *slowly* to modify it is not felicitous. Similarly, *fall*'s specification of downward motion makes it unlikely that we will encounter the sentence, *He fell upwards*. Thus, even though a group of 'translational motion verbs' may all identify their meaning with the same schema, additional specifications serve to indicate important differences in the meanings of these verb constructions. Hence, the ability to draw generalizations over a group of verbs and verb roles does not come at the cost of being able to identify more construction-specific meanings.

[11] In addition, there may be some force-dynamic elements to the relation and/or the contact surfaces of the mover and the ground (e.g. relatively low friction for sliding, with higher friction for skidding).

Importantly, MotionAlongAPath can also be used in the representation of A-S construction meaning. As we will see in later chapters, use of some of the same schemas to represent both verb and A-S construction meanings serves to indicate commonalities of meaning that motivate their composition. And in general, 'dual use' of schemas helps make clear both why and how the meanings of different constructions compose with one another.

3.6 Animate Motion

The previous sections of this chapter have examined general motion-related conceptual structure, and have also examined motion that is accompanied by changes in the mover's overall location. The following sections will examine another facet of motion-related structure, one that concerns the nature of the mover itself.

Many motion verbs can be used to describe the motion of a wide variety of movers, both animate and inanimate (e.g. *spin, roll, slide, rise, exit*). Many others, however, are restricted in use, only applying to animate entities (*wriggle, saunter*, etc). So, for instance, the motion of a rock might be described as *The rock spun / slid*, but not *The rock wriggled / sauntered*. Thus, it is possible to distinguish between these different groups of verbs on the basis of whether they are selective as to the animacy of the mover.

Note that this distinction cross-cuts the translational motion distinction discussed previously. That is, the group of verbs that allow inanimate movers includes verbs that describe translational motion (e.g. *inch, rise, slide*) as well as those that don't necessarily do so (e.g. *spin, roll*). Similarly, verbs that describe the motion of animate entities can specify change of location (e.g. *walk, saunter, run*) but don't necessarily do so (e.g. *wriggle* and *squirm*).

One way to represent the meaning of 'animate motion verbs' would be to use the motion schemas already presented, with added constraints on the type of entities that could potentially fill the mover role. For example, we could create a construction for *saunter* that identifies its meaning with the MotionAlongAPath schema, and which has a type constraint that the filler of the mover role of this schema must be of type 'animate'.[12]
But such a representation would fail to indicate some very important differences between animate and inanimate motion.

The important thing here is to look beyond the meanings of these different verbs, and consider how we experience (and conceptualize) the different types of motion they describe. If we do so, it becomes clear that what distinguishes animate motion from other types of motion is not just the animacy of the mover per se, but how this animacy

[12] This is similar to how we might want to handle 'fluid motion' verbs, such as *drip* and *flow*. Such verbs could identify their meaning with TranslationalMotion, and constrain Mover to be of type 'fluid'.

interacts with and affects the motion. It is possible, for instance, for animate entities to move in an inanimate fashion (as when falling, being dragged, etc.). And inanimate things can appear to move in an animate fashion (as in psychological experiments using animations of the motion of geometric shapes). The crucial distinction is not so much whether the mover is or is not animate, but whether the motion is characteristic of an animate entity or not.

3.6.1 Conceptual structure and experiences associated with animate motion

What are the characteristics of animate motion? At least three different features distinguish the motion of animate entities from that of inanimate entities: the 'manner' or pattern of motion, the mover's control of the motion, and the goal-directedness of the mover's motion. I will look briefly at each of these things in turn, and then consider how they might be inter-related.

One characteristic of animate motion is that it is typically involves a distinct rhythmic pattern that is associated with motion of parts of the mover's body. For example, walking and running involve legs moving rhythmically, flying involves a bird flapping its wings, slithering involves a snake moving body back and forth. Inanimate motion, on the other hand, either has a pattern of a different kind (e.g. spinning, bouncing), or no observable pattern at all. Corresponding with this, the mover's body motion may create a somewhat irregular motion trajectory. Mandler (1992) theorizes that a key characteristic of animate motion is that rather than following a straight line, biological motion tends to have "certain rhythmic but unpredictable characteristics" (p. 593). Psychological research supports this idea, finding that perception of animacy depends on the presence of non-rigid, rhythmic patterns (e.g. Schlottman et al. 2006).

A second characteristic of animate motion is that it is controlled by the mover. Such motion is typically initiated by the mover himself, rather than being caused by another entity or by environmental factors. Furthermore, the mover's control of his motion extends beyond that of self-initiation, including also self-termination of motion, as well as the ongoing control of the speed and direction of motion. This contrasts with the motion of inanimate movers, which are not in control of their motion; instead, their motion is controlled by their surroundings.

A third characteristic is goal-directedness. For animate motion, not only is the mover in control of the motion, but typically exercises this control in order to achieve some purpose. For locomotion actions, such as running, this purpose has to do with a change in the mover's location. For example, a person may run to quickly get away from an undesirable location, and/or to get to a desired location. Neural research confirms the importance of goal-directedness as a cue for animacy. Schultz et al. (2005) define goal-directedness in terms of an agent which "contingently directs its movement toward (or away from) another object, state, or location" (p. 625). They found that self-propelled objects appeared more animate if they exhibited goal-directed interaction. Furthermore, the amount of interactivity paralleled the level of activity in brain areas known to respond to biological and animate-looking motion.

What ties these three characteristics together? They each depend on the fact that animate motion is typically accomplished via the (volitional) execution of a motor-control routine by the mover. So, for example, think about a person who is walking. Firstly, this person is performing a motor-control action involving the motion of her legs (and possibly arms). While this action is being performed, the mover's body changes its configuration in a characteristic rhythmic pattern. And this pattern will be different when the person executes different motor routines, as when she either runs or hops. In terms of control, the walker is a volitional actor, who starts moving by initiating the motor control action, changes direction or speed by altering it, and stops motion by terminating this routine. As for goal-directedness, the walker is generally also an intentional actor, who performs actions for some purpose. So, for example the walker may start walking to get out of the hot sun, change direction to avoid an obstacle in her path, and stop walking when she is in the shade. Thus, much animate goal-directed motion has the structure associated with prototypical 'source-path-goal' experiences.

Moreover, neuroscience research indicates that animate motion involves the activation of motor-control structure. For instance, imagining locomotor actions has been found to activate cortical regions which are part of "a well-documented neural network associated with the mental representation of motor actions" (Malouin et al. 2003: 56). And watching the motion of animate entities appears to involve activation of motion-related areas as well as motor-control and/or body-related regions (e.g. Giese and Pogio 2003, Peuskens et al. 2005). Thus, it seems reasonable to conclude that experiences of animate motion are structured both by motion-related neural circuitry, and by motor-control related circuitry.

3.6.2 Animate motion schemas

Having considered some of the important characteristics that distinguish animate from inanimate motion, we can turn to the issue of how to represent the schematic conceptual structure that underlies these characteristics. In this section, I present schemas that are related to the motion schemas already presented, but which also provide additional structure related to animate motor-control actions. Following this, I present verb constructions for various 'animate motion' verbs, focusing on ones that involve a change in location (e.g. *walk, saunter, run*).

Thus far, two different motion-related schemas have been described. The first, the Motion schema, represents key elements associated with the basic process of motion. These same elements are present in a very wide range of different motion experiences, all of which involve the motion of part or all of some entity, with motion occurring at some rate, and having an immediate 'direction' (though the direction may not be sustained, and may not result in an overall change in the mover's location). The second, the

MotionAlongAPath schema, inherits the structure of the Motion schema, and adds structure associated with change in location, as represented by the SPG schema.

Neither of these schemas, however, represent the characteristics associated with animate motion that were described above: (1) the distinctive non-rigid rhythmic movement patterns of the mover's body; (2) the mover's control of this movement, and; (3) the larger goals that the mover (attempts to) achieve via this controlled motion.

Therefore, to represent the schematic structure active during experiences of animate motion, additional schemas are needed. Accordingly, in this section I present a basic MotorControl schema, and show how it can be integrated with motion schemas to represent the structure of different types of animate motion (translational and not).

MotorControl (Figure3.10) represents the structural elements relevant to the performance of a wide range of motor-control actions. It includes roles for the person or other animate entity performing the action (the actor), the part of the body the actor uses to perform the action (the effector), the amount of effort the actor expends to perform the action (effort), and the motor-control routine itself (a type of x-net).

As will be seen in this and later chapters, these different roles show up in descriptions of motor-control actions. For instance:

- She (actor) danced (routine) effortlessly (amount of effort).
- She (actor) crawled (routine) on her hands and knees (effectors).

Moreover, this set of motor-control roles correspond with key roles that are active during various <u>experiences</u> of motor-control actions:

- <u>actor</u> -- When a person (or other animate entity) executes a motor-control routine, it will involve activation of motor-control areas of the actor's brain. Moreover, certain neurons within motor-control brain areas, known as mirror neurons, are active both when the individual performs a particular action <u>and</u> when he observes another individual performing a similar action (di Pellegrino et al. 1992; Gallese et al. 1996; Rizzolatti et al. 1996a). Originally discovered in monkeys, there is also evidence of a mirror neuron system in humans (review in Rizzolatti and Craighero 2004). Thus, there is evidence that motor-control regions include a structural "role" for the entity performing a particular motor-control action, an actor role that can potentially be 'filled' by various (animate) entities (i.e. not just the 'owner' of the brain).
- <u>effector</u> -- Somatotopic organization of motor-control areas of the brain provides a basis for distinguishing between various body parts used in motor-control. Within these areas, different groups of neurons will be active during motor-control actions performed by different parts of the body (feet/legs, hands/arms, teeth/mouth). For example, the execution, observation, or imagination of actions involving hands (e.g. grabbing) will activate different groups of neurons than actions involving teeth (e.g. biting) (Buccino 2001; Ehrrson et al. 2003). Furthermore, researchers have found evidence that words relating to actions performed by different effectors (e.g. *kick,*

lick, pick) also activate the motor system in a somatotopic manner (Hauk et al. 2004; Buccino et al. 2005; Pulvermuller and Friedemann 2005; Pulvermuller, Hauk et al. 2005; Pulvermuller, Shtyrov, et al. 2005). This somatotopic organization suggests that motor-control regions support a structural role for the part(s) of the body that carries out the motor-control action.

- effort – Execution of any motor-control routine takes some amount of effort. The actor's perception of the amount of effort or exertion seems to be related to several different sensory cues, such as respiratory rate and sensations of muscular strain (Hampson et al. 2001).
- x-net (routine) -- This role corresponds to the motor synergies involved in the execution of the motor-control action. At the level of this general MotorControl schema, this role represents the schematic structure common to all motor-control routines, not a specific motor routine or synergy. As described in Chapter 2, x-nets were originally inspired by research in motor-control.

Thus, the basic MotorControl schema is consistent with NTL's assumption of simulation semantics, in that it represents schematic structural elements that are present both in descriptions of and other forms of experience of motor-control actions in which an actor executes some motor-control routine involving one or more parts of his body.

To capture the similarities motor-control has to other processes, MotorControl is defined as a subcase of the more general Process schema. The inherited protagonist role is identified with MotorControl's actor role. This is indicated in the constraints section via a binding between these two roles (actor ↔ protagonist). Unlike the more general protagonist role, the motor-control actor is constrained to be an animate entity.

Motor-control routines differ from many other types of processes in that they are typically under the direct control of the actor/protagonist. For instance, in general the actor can volitionally start, maintain, and/or terminate the routine. Consequently, the type of x-net needed to simulate these actions differs from the x-nets associated with many other types of 'processes'. This difference is indicated here by adding the constraint that the inherited x-net role is of type '@routine' (i.e. is an x-net associated with a motor-control routine).[13]

MotorControl also includes an effector role, the body part used to perform the action. In addition, it includes an effort role, which is associated with the amount of effort that the actor is exerting while performing the motor-control routine. The amount of effort

[13] Individual schemas and constructions can constrain this role to have a more specific value; many details of motor actions will, however, be left underspecified in ECG representations. One reason for this is that we may not be consciously aware of many of the details of the routine being performed (e.g. which specific muscles are involved, how subroutines are coordinated with one another). Another reason is that some details will be contextually determined (e.g. the size and location of an object will determine some of the details of the routine we use to interact with that object).

involved in a particular motor-control action will vary according to several factors, including but not limited to the type of routine that is being performed.

```
schema MotorControl
  subcase of Process
  roles
    actor: @ animate
    effector
    effort
    x-net: @routine
  constraints
    actor ↔ protagonist
```

Figure 3.10 The MotorControl schema.

Schemas for animate motion integrate the structure of the MotorControl schema with the structure of a motion schema. As pointed out earlier, animate motion is in many cases associated with a change in the mover's overall location. For instance, walking, running and other locomotor actions are typically performed by an actor with the objective of changing his location. But, this is not always the case. Wriggling and dancing, for example, involve controlled motion of the mover's body, but don't necessarily result in a change in the mover's location (nor are they necessarily intended to do so).

To capture this distinction, I define two separate, though closely related, schemas. Both apply to situations where the mover uses a motor-control routine to control his motion, but differ as to what sort of motion they specify. The Locomotion schema applies specifically to situations in which an animate mover is (intentionally) changing his location. The AnimateMotion schema is more general, specifying only that there is some type of motion controlled by the mover, but not specifying the presence of any locational change. Both of these schemas are shown in Figure3.11.

The structure associated with these schemas is not solely related to that of motor-control, nor that of motion. Rather, it reflects an interaction of these two processes. To represent this interaction, both AnimateMotion and Locomotion are also defined as subcases of ComplexProcess.

As described in the previous chapter, ComplexProcess is a structure-building schema that specifies how two processes can be composed to form a single, more complex process. Or, describing it from a slightly different perspective, we could also say that ComplexProcess represents the internal structure of a complex process that involves two (or more) inter-related subprocesses. ComplexProcess has a role for each of these subprocesses: process1 and process2. It also has an x-net role (constrained to be of type @complexxnet) that integrates the x-nets of each of these subprocess. The general ComplexProcess schema does not, however, specify any particular relation between these subprocesses. Subcases of ComplexProcess may constrain the x-net to be of some more specific type that has a particular kind of relation (e.g. ordered or concurrent).

ComplexProcess also has two protagonist roles: protagonist is the protagonist of the first subprocess (process1) and protagonist2 is the protagonist of the second subprocess (process2).

For both AnimateMotion and Locomotion, one subprocess involves motor-control, and the other involves motion. The two schemas differ, however, as to what type of motion is specified. For AnimateMotion, the second process is constrained to be Motion, consistent with the idea that this schema doe not specify anything about changes in the mover's location. Locomotion is defined as a subcase of AnimateMotion, and has the more specific constraint that the second process involves translational motion (process2: MotionAlongAPath).

While these two process role constraints tell us something about the nature of the two subprocesses, they do not indicate how these two subprocesses are related to one another. The specification of this relation will be handled via the inherited x-net role. As with other x-nets, the full details of this complex x-net will be specified within a separate x-net ontology. However, in simulation, the structure represented by this x-net will support many of the inferences associated with locomotion experiences and descriptions. Therefore, it is important to explain a bit more about the structure of this x-net, the relations it specifies, and the inferences it would support.

For both schemas described above, the complex x-net would indicate that the two subprocesses are cotemporaneous: motion starts when motor-control starts, is ongoing while motor-control is ongoing, and stops when motor-control finishes. So, for example, a person can execute a 'walk' routine to start moving, and will continue to move as long as she continues to perform that routine. Furthermore, ongoing motion requires ongoing motor-control and, therefore, ongoing effort. From this we can also infer that the longer the mover is moving, the more effort she needs to expend. In addition, the x-net would indicate that the execution of the motor-control routine is directly related to motion parameters. For example, changes in speed or heading are related to adjustments in the motor-control routine.

For Locomotion, further inferences arise due to the fact that the SPG schema is evoked by the MotionAlongAPath schema (which in turn serves as process2 of the Locomotion schema). The x-net for Locomotion should therefore also indicate that execution of the motor-control routine is directly related to changes in location: (1) the mover initiates a motor control routine to move away from the Source location; (2) ongoing motor-control serves to progress the mover along the Path, towards the Goal; and (3) when the mover arrives at the desired Goal location, she stops moving by terminating the motor-control routine. Thus, simulation of the x-net supports the inferences associated with what might be termed the 'classic' Source-Path-Goal schema.

```
schema AnimateMotion
  subcase of ComplexProcess
  roles
      process1: MotorControl
      process2: Motion
      x-net: @animateMotion
      mover
constraints
       mover ↔ protagonist ↔ protagonist2
           // protagonist↔ MotorControl.actor
          // protagonist2 ↔ Motion.mover
```

```
schema Locomotion
  subcase of AnimateMotion
  roles
      process1: MotorControl
      process2: MotionAlongAPath
      x-net: @locomotion
constraints
       mover ↔ protagonist ↔ protagonist2
```

Figure 3.11 The AnimateMotion and Locomotion schemas.

Each of these schemas also includes a mover role for the entity that is both acting and moving. While the same role name is used as in other motion schemas, the way this role is defined within these two schemas differs in some significant ways. As shown in the 'constraints' sections of AnimateMotion, the mover role is bound to the protagonist roles of both of the two subprocesses. This means that this mover role is bound to the actor role of the MotorControl schema (process1), and to the mover role of the Motion schema (process2). Because the second process in Locomotion is MotionAlongAPath, this means that its mover role is also bound to the trajector role of the SPG schema. In each case, then, these schemas define a semantically-complex, schema-specific mover role, one which reflects the fact that the same entity is simultaneously an actor and a mover. More specifically, for locomotion actions, the schema constraints indicate that the actor is a mover who is changing location.

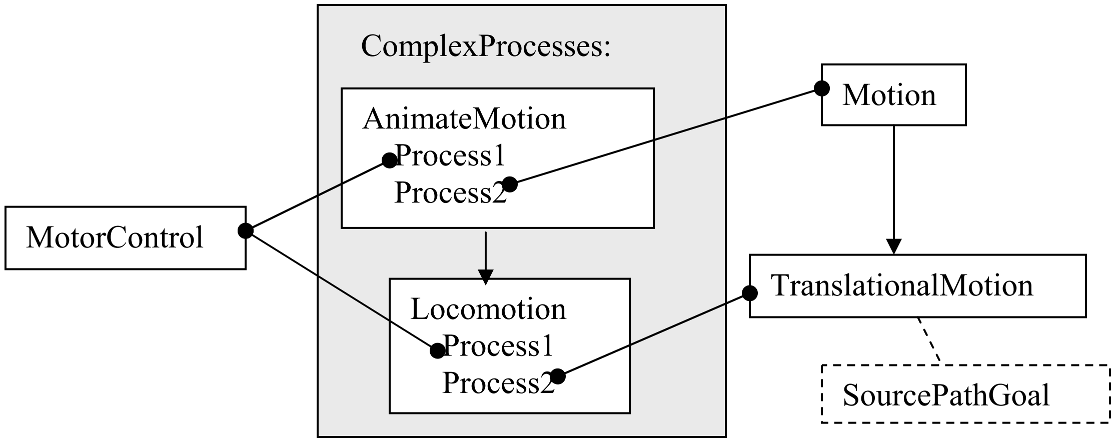

Figure 3.12 AnimateMotion and Locomotion as complex processes with relations to motor-control and motion schemas (solid lines indicate identity relations, arrows indicate subcase, dotted line indicates an 'evokes' relation).

3.6.3 Locomotion Verbs

As with other schemas, Locomotion represents conceptual structure that is utilized by language, but is not unique to any particular linguistic construction. As a consequence, it can be used to represent the meaning of many different verb constructions. Use of the same schemas to represent meaning makes the semantic similarities of these verbs readily apparent. At the same time, differences in meaning can be indicated, at least in part, through the specification of different parameter values.

First, consider the verbs *walk*, *saunter*, and *trudge*. Each of these verbs can be represented by constructions which identify their meaning with a Locomotion schema. These verbs can all be analyzed as involving basically the same motor-routine (a walking gait). This can be represented by specifying that they all utilize the same x-net structure (@walk)[14]. Furthermore, each of these actions involves the use of the legs (process1.effector ← legs). But, these actions differ in some respects, such as the speed of motion and the amount of effort involved. These differences can be captured as different value constraints for the speed and effort roles. For example, Walk1 does not specify values for either of these roles, Saunter1 specifies that speed and effort are both

[14] Within the x-net ontology, the @walk x-net provides a much more detailed model of the walk routine, including, for instance, alternating leg motions, and maintenance of upright posture and balance (Narayanan 1997, 1999). This additional structure is necessary for a full simulation of this action, and is also necessary to support many of the entailments associated with descriptions of such actions. For example, 'X walked' entails that X's legs moved in a particular alternating pattern, that X was upright, etc. It is important to keep in mind that although these details are represented in different part of the system, these parts are inter-related, and all of this information is accessible for simulation. Furthermore, this representational division of labor is not meant to imply that is there is an underlying division in conceptual and/or neural structure.

low, and Trudge1 also specifies low speed but a higher amount of effort. The Saunter1 and Trudge1 are shown in Figure 3.13.

```
construction Saunter1
   subcase of Verb
   form
      constraints
         self.f.orth ← "saunter"
   meaning: Locomotion
      constraints
         self.m.x-net ← @walk
         self.m. process1.effector ← legs
         self.m.process2.speed ← low
```

```
construction Trudge1
   subcase of Verb
   form
      constraints
         self.f.orth ← "trudge"
   meaning: Locomotion
      constraints
         self.m.x-net ← @walk
         self.m. process1.effector ← legs
         self.m.process2.speed ← low
         self.m. process2.effort ← high
```

```
construction Sprint1
   subcase of Verb
   form
      constraints
         self.f.orth ← "sprint"
   meaning: Locomotion
      constraints
         self.m.x-net ← @run
         self.m. process1.effector ← legs
         self.m.process2.speed ← high
```

Figure 3.13 Constructions for *saunter, trudge* and *sprint*.

Verbs such as *run*, *sprint* and *jog* can be handled in a similar fashion. As with walking verbs they identify their meaning with Locomotion. However, they specify a different x-net since they involve a different motor-routine (i.e. a running gait). Figure 3.13 includes a Sprint1 construction for the verb *sprint*.

Most locomotion verbs can be used to describe the motion of a variety of different types of animate entities. For many verbs, though, certain types of movers are more typical than others. For verbs like *saunter, trudge,* and *stroll*, for instance, the mover is typically a person. But for some verbs, the mover is typically an animal of some kind, e.g. horses *gallop*, birds *fly*, and snakes *slither*. Furthermore, for a given verb, the physical properties associated with the prototypical mover may serve as constraints on other possible movers. Most 'people motions', for instance, require that the mover has at least two legs, galloping typically involves four legs, flying needs wings, and slithering does not require any limbs, but does probably need an elongated body. Consequently, for at least some locomotion verbs, it may be useful to specify additional constraints on possible fillers of the mover role.

The conceptual structure represented in the Locomotion schema supports many of the sorts of inferences we are likely to make about different kinds of locomotion actions, including:

- Both speed and direction of motion are under the actor/mover's control

- During motion, actor is executing a motor-control routine (hence the infelicity of *He walked / sauntered / ran, but didn't move a muscle*)
- During motion, actor is exerting effort
- Motion speed is correlated with amount of effort used
- When someone is walking, they are both exerting some amount of effort, and also moving in relation to their surroundings.

Note that some of the structure that supports these inferences may be more explicitly represented within the x-net specified by a given construction.

3.6.4 Animate Motion verbs

Some motion verbs (e.g. *wriggle*, *squirm*) describe motion that controlled by the mover, but which doesn't necessarily involve a change in the mover's location, as in *The dog wriggled (in his crate*). My analysis of these verbs is similar to that for other types of verbs that specify motion, but not necessarily change in mover's location (e.g. *spin, roll*). The main difference is that constructions verbs like *wriggle* identify their meaning with AnimateMotion, rather than the more general Motion schema. This serves to indicate that the mover is also an actor, though this mover is not necessarily changing location. The structure of the AnimateMotion schema will support relevant inferences, e.g. that the motion is correlated with a motor-control routine and that the mover is exerting some amount of effort. It will also support the default inference that the mover is in control of the speed and direction of motion.

3.6.5 Animate motion summary

The verb representations in this section provide analytic advantages that are similar to those I described for translational motion. Use of the same schema to represent the meanings of several different verbs makes the semantic similarity of these verbs and their participant roles readily apparent. Consequently, we can effectively identify a semantic class of verbs based on the conceptual structure that is common to all of them. For instance, the set of locomotion verbs, including *walk, saunter, trudge, saunter, jog, sprint*, etc., all identify their meaning with Locomotion. And, for each of these, the mover is an actor who controls his motion and change of location. At the same time, by specifying values for schema parameters, we can make fine-grained semantic distinctions between verbs within this class. For example, sauntering involves less effort than does trudging, and jogging is slower than sprinting. Parameter values also make it clearer why some adverbs are (or are not) felicitous to use with these verbs: some specify meanings that are consistent with verb meaning, while others conflict as in (21a and b).

(21) a. She slowly / ??rapidly sauntered into the room.
b. He tiredly / ??effortlessly trudged /logged through the mud.

Similarly, we can identify a semantic class of 'animate motion' verbs, such as *wriggle, squirm, dance* etc., which describe situations in which an animate mover controls his motion, but does not necessarily have the objective of changing his location.

3.7 Chapter Summary

Verbs used to describe motion-related events exhibit several cross-cutting similarities and differences in meaning. In this chapter, I showed how the meanings of these verbs can be analyzed and represented in a way that explicitly specifies similarities and differences in meaning at different granularities and along different dimensions of comparison. In this way, this analysis and representation simultaneously captures many fine-grained distinctions and several broader generalizations we can make about these verb meanings and their associated semantic roles.

The methodology used in this chapter is a variant of one common in cognitive linguistics, in which a range of different expressions relating to a particular semantic domain are examined with the objective of identifying non-lexically-specific, recurrent conceptual structures. NTL assumptions suggest that, in addition to examining descriptions about motion-related events, it is also important to consider the nature of the neural circuitry that may be active during various modes of experiencing these events. Importantly, NTL helps provide answers as to *why* we find the recurrent conceptual structures we do. As illustrated in this chapter, ECG provides a means to formally represent these conceptual structures, and to use them in turn to represent the meanings of various motion-related verbs.

An examination of motion-related experiences (and descriptions of such experiences) indicates that while they are similar in some important respects, they also exhibit some significant differences. In this chapter I focused on two key elements which are present in some – but not all – motion experiences: changes in the mover's location and the mover's control of his motion. As I demonstrated, the recurrent, schematic structure associated with each of these elements can be analyzed and represented using ECG schemas. Three basic primitive schemas were defined:

- Motion: basic motion structure, which includes a mover role
- SPG: change in location structure, includes a trajector role
- MotorControl: basic motor-control structure, which includes an actor role

Three additional schemas were defined to represent various compositions of these basic structures. Each of these 'composite' schemas includes a more complex 'mover' role:

- MotionAlongAPath: motion and SPG structure, includes a mover-trajector role
- AnimateMotion: motion and motor-control, includes a mover-actor role
- Locomotion: motion, SPG, and motor-control. Includes a mover-trajector-actor role.

Together, these inter-related schemas reflect the potential complexity of motion-related experiences. Moreover, they do so in such a way that indicates the potential dissociation of complex structure into more 'primitive' elements.

In addition, I showed how these schemas can be used in the analysis and representation of various lexical 'motion' verb constructions. Each of the verb constructions presented in this chapter is a pairing between a given verb form and a 'core' meaning: a meaning that is consistently present across a range of different uses of that form. The schematic structure of this core meaning is represented using one of the motion-related schemas described above. For example:

- Spin, roll = (rotational) motion, represented using the Motion schema
- Fall, slide, exit = translational motion, represented using MotionAlongAPath
- Wriggle, squirm = animate motion, represented using AnimateMotion
- Walk, saunter, sprint = animate translational motion, represented with Locomotion

Thus, these representations indicate that the core meanings of these different motion verbs vary as to the nature and complexity of their schematic conceptual structure.

Importantly, this analysis and representational method fills the important functions outlined at the beginning of this chapter. For one thing, the schemas with which these constructions identify their meaning serve to provide participant roles that are relevant for semantic composition with other constructions. Significantly, in some cases, these roles are (internally) complex. In addition, these schemas provide structure that support important inferences associated with each construction. At the same time, each construction indicates construction-specific meaning via the specification of additional meaning constraints (e.g. additional schematic structure, and/or bindings and value specifications). In this way, it is possible to specify lexically-specific meaning without using lexically-specific schemas and roles.

Very importantly, specified relations between schemas provide a way to compare and contrast the meanings of these various verb constructions. When several different verb meanings are represented using the same schema, this indicates a fairly close similarity of verb meaning and associated participant roles. This serves to identify various overlapping semantic 'classes' of verbs, e.g. translational motion verbs, animate motion verbs, locomotion verbs, etc.

At the same time, schema relations enable us to identify broader similarities of meaning, at different granularities and along different dimensions of comparison. Furthermore, the way roles are defined within these schemas helps indicate similarities <u>and</u> differences between the semantic roles associated with different verb constructions. For instance:

- Motion verbs show some broad semantic similarities. This is captured by the fact that the different motion-related schemas used to represent their meanings all include the basic structure and roles of the Motion schema.
- Motion verbs have similarities and differences with verbs that describe other types of processes. This is captured by Motion's subcase relation to the more general Process schema, which indicates that it has some structure in common with other processes, but also has unique structure of its own. Correspondingly, Motion's mover role is related to, but distinct from the protagonists of other processes.
- Motion verbs may differ along one or more different semantic dimensions:

    - presence/absence of location change. Indicated by whether or not the schema the verb identifies its meaning with includes SPG.
    - animate vs. inanimate motion. Captured by the fact that motion schemas differ as to whether or not they include MotorControl.
- Verbs that describe animate motion are both similar to and different than those which describe other actions, and animate movers are both similar to and different than other actors. This similarity is indicated by the inclusion of MotorControl structure within both AnimateMotion and Locomotion, along with its use in schemas that represent the meanings of other actions. One key difference is captured by the fact that not all motor-control schemas necessarily specify that the actor is a mover.

Thus, these semantic roles capture some of the same broad generalizations as do thematic-type roles such as ‘Actor’ or ‘Theme/Mover’. But due to the internal complexity and inter-relations between these roles, they also support the recognition of many additional cross-cutting semantic similarities and differences. For instance, not all themes/movers are actors, but some are. And, some theme/movers change location, but this is not necessarily always the case.

In this method of constructional representation, semantic relations between verbs (and their associated participant roles) are captured by the relations between the schemas and roles used to represent their meanings. It is important to keep in mind that these inter-related schemas are intended to represent the schematic nature and interconnectivity of the neural substrate that is active during motion-related experiences and descriptions thereof. The larger story here is that we observe the verb relations we do because of the nature of the underlying embodied conceptual system, a system which is not unique to any particular construction, nor even unique to language. As we will see in following chapters, schema relations also enable us to recognizing various semantic relations between verbs and A-S constructions. Thus, these relations also play a crucial part in the compositional account of sentence meaning presented I this dissertation.

3.8 Looking ahead: sentence meaning variations

As indicated above, the analysis and representation of motion-related conceptual structure described in this chapter plays a key role not only in the analysis and representation of verb constructions, but also in the analysis of sentences in which these verbs occur. In turn, the way these sentences are analyzed will affect the types of verb constructions that are posited for the grammar. While these topics will be more fully addressed in later chapters, a few examples at this point will help indicate the important role that this conceptual structure plays within a larger scope of analysis.

The verb constructions presented in this chapter are all intended to represent a verb’s core meaning: meaning that is consistently present across a range of uses. In many uses of these verbs, the schematic structure expressed by the sentence as a whole is similar to that of the core verb meaning. For example, *walk*'s core meaning was analyzed as being one of 'animate translational motion', represented using the Locomotion schema. And the event described by the sentence *She walked into the room* can also be characterized as one of animate translational motion.

However, in some cases, the schematic structure of the sentence-described event differs from that of the verb's core meaning. For instance, *wriggle*'s core meaning was analyzed as one of animate (but not necessarily translational) motion. And, this verb is commonly use in descriptions of animate motion (*The dog wriggled in his crate*). However, it can also be used in descriptions of animate motion that results in location change (*The dog wriggled under the gate*). Similarly, *slide*'s core meaning of translational motion does not include motor-control. Consistent with this, it is often used to describe the translational motion of inanimate objects (*The box slid*). But, it can also be used in descriptions of translational motion that is at least partially controlled by the mover *(The girl carefully slid down the hill*). Thus, motion verbs are often used in sentences that describe motion events whose schematic structure is similar to that of the verb's core meaning. But, this is not always the case.

As the above examples demonstrate, a variety of motion verbs can be used in sentences that describe animate translational motion. But, in some cases the core meaning of the verbs is not one of animate translational motion. In such cases, the core meaning of the verb, by itself, will not be sufficient to indicate the 'animate translational motion' meaning of the sentence as a whole.

The analysis of such sentences faces two important types of challenges, one of which is semantic, and the other of which is constructional. Both of these challenges are briefly sketched out here, and will be much more fully addressed in later chapters. Two key questions illustrate the semantic challenges: (1) How can we analyze the motion-related meaning associated with these sentences? And: (2) How is this meaning related to the core meaning of the verbs in these sentences? The analysis and representation of meaning presented in this chapter helps provide answers to both of these questions.

Firstly, we can assume that these sentences utilize the same system of motion-related conceptual structure as is accessed by individual verb constructions. And that, consequently, key schematic elements of their meanings can be represented using some of the same schemas as are used to represent verb constructions. Thus, for the 'animate translational motion' sentence examples above, we can represent the motion-related event structure using the Locomotion schema.

Given the internal complexity of this schema, and its relations to other schemas in the schema lattice, it then becomes a relatively straightforward matter to analyze the relation between the motion-related meaning of the sentence as a whole, and the core meanings of the verbs in these sentences. For example, *The dog wriggled under the gate* can be analyzed as a composition of the verb's core schematic meaning (AnimateMotion) and source-path-goal (SPG) structure. Whereas *She carefully slid down the hill* can be analyzed as a composition of the verb's core meaning of translational motion (MotionAlongAPath) with motor-control structure (MotorControl). And in both cases, the structure that results from this composition is that of 'animate translational motion' (Locomotion). Thus, it is possible to analyze the motion-related meanings of these sentences compositionally: as a verb's core meaning plus additional schematic structure.

The key <u>constructional</u> issue is whether we want to posit additional verb constructions to account for these richer meanings, or whether they should instead be handled via composition of the core verb construction with meaningful non-lexical constructions (i.e. A-S constructions). In essence, then, the issue is one of whether we choose to analyze this compositional process as being construction-internal (i.e. occurring 'within' the verb construction) or as being construction-external (i.e. occurring as the result of the composition/unification of two or more constructions). This constructional issue will be addressed more fully in the following chapter. The important thing to note here is that the semantic analysis presented in this chapter gives insight into and provides a means of formally representing the semantic composition involved in either type of constructional analysis.

Chapter 4

Constructional Composition

4.1 Introduction

As I discussed in Chapter 1, a primary objective for this dissertation is to present an account that explains how sentences containing many of the same words, in different combinations, can be used to convey a wide range of different meanings. One important component of this account involves the analysis and definition of constructions (form-meaning pairings) for the various individual words that occur in the sentences being examined. This includes constructions for the motion-related verbs discussed in the previous chapter, as well as constructions for various 'action' verbs which will be discussed in later chapters. But in order to figure out how it is possible for the 'same' words to be used in sentences that describe different types of situations, we need to do more than just figure out the individual meanings of the various words in these sentences. For one thing, we need to determine what other relevant form-meaning patterns may be present in these sentences. For another, we need to figure out how all these different form-meaning parts fit together into a whole (i.e. the form and meaning of the sentence). Moreover, we need to make sure that this whole captures the deep meaning of the sentence, including the sometimes subtle elements of meaning that linguists have recognized to be characteristic of various verb 'alternations' (Levin 1993).

As I demonstrate in this chapter, ECG enables us to formalize and integrate important inter-related aspects of a constructional, compositional approach to sentence analysis. In terms of meaning, it supports recognition and representation of the schematic content of the events described by these sentences, as well as indicating important aspects of how that event is conceptualized. In terms of constructions, ECG supports the development of a structured inventory of the constructions (and their meanings) that are instantiated in a variety of sentences. This inventory includes non-lexical argument structure (A-S) constructions, which will be discussed at length in this chapter. By defining these constructions as part of a larger, simple but comprehensive grammar, it is possible to use these constructions in the analysis of a range of sentence examples, including – but not limited – to those examined in this dissertation. Significantly, the precision of ECG representations has made it possible to computationally implement the sentence analysis process, utilizing ECG grammars (Bryant 2008). This analysis process produces a SemSpec (semantic specification) that supplies relatively sparse, schematic parameters for the simulation of the event described by the utterance. The context in which the utterance occurs provides additional information, and simulation further fleshes out the details of the described event, utilizing various kinds of additional conceptual structure related to the understander's experiences, belief state, etc. In this way, relatively schematic constructionally-specified meanings give rise to a much fuller understanding of the utterance in which these constructions are instantiated.

What sorts of constructions are needed to support a compositional analysis of deep sentence meaning? Consider one of the examples that is examined later in this chapter: *She walked into the room*. Several of the constructions instantiated in this particular example have been discussed in prior chapters, including those for *walk*, *into*, and *the room*. But the meaning of this sentence is not a set of disjoint elements: rather, it is an integrated whole in which the meaning elements associated with these different parts are <u>connected</u> with one another. Our understanding of this particular sentence includes the fact that *she* is a 'walker' and that *into the room* describes where she walked (her path of motion). Moreover, this event is described from the perspective of this moving person: attention is focused on the mover, not the room. Note that outside this particular sentence context, these individual constructional 'parts' are not necessarily associated with these same rich and complex meanings.

In many cases, we can identify general grammatical rules that indicate how these parts should be put together. For instance, in sentences that include motion verbs and which are of the same general form as the example above, the general compositional rule is that the subject NP is linked to the verb's Mover role. In ECG and other construction grammars, compositional 'rules' such as these are specified within constructions. As seen in Chapter 2, for example, prepositional phrase constructions specify rules of composition with respect to their preposition and NP constituents.

The A-S constructions discussed in this chapter can be viewed as non-lexical constructions that serve to indicate general rules of argument expression Each A-S construction specifies a general pattern in which a verb (from some semantic class) plus associated 'arguments' are used to describe some sort of basic scene. One purpose served by A-S constructions is to indicate how the forms and meanings of the verb and the NPs which express the argument roles are related to one another. But each A-S construction does more than just specify how these different parts are put together: it also specifies a schematic meaning that is associated with the pattern itself. Significantly, this can include meaning that is not necessarily specified by the individual parts in the pattern. Thus, as with other constructions, A-S construction meaning is not necessarily (fully) predictable from the meaning of its parts in isolation (i.e. outside the context of that pattern).

A large part of the analytical power of A-S constructions comes from Goldberg's (1995) key discovery that an A-S construction may have meaning that is not present in the <u>verb</u> with which it is co-instantiated. This recognition enables an alternative, non-polysemy approach to the analysis of sentences that contain the same verb form, but which describe different kinds of events. Rather than necessarily positing two (or more) distinct verb constructions, each with the same form but different meanings, it is possible to analyze many of these sentences as compositions of the same verb construction with A-S constructions of different meanings.

In order for A-S constructions to be incorporated into an ECG grammar that will support analysis of sentence meaning, several issues need to be addressed. One central challenge, discussed Chapter 1, is to analyze and formally represent verb and A-S construction such that the motivation for and results of their semantic composition is readily apparent. Increasing the difficulty of this challenge, many different types of semantic relations between these constructions are often possible. This suggests that in many cases it is essential to recognize (and represent) the internal complexity of these constructional meanings, as well as the various relations they may have to one another.

In a compositional analysis of sentence meaning, one of the ultimate objectives is to determine the conceptual composition that occurs: how are the meanings of the instantiated constructions composed to create a conceptual whole? Essential to the success of the current analysis, the schematic meanings represented in these A-S constructions are 'compatible' with those of the verb and other constructions instantiated in these example sentences. Consequently, when the instantiated constructions unify, their meanings integrate to form a coherent whole. Moreover, the wholes associated with these different motion sentences are both similar to and different from one another, thereby capturing both similarities and distinctions between the meanings of these different sentences.

One very important piece of this account is that constructions in the current ECG grammar are defined such that they support sentence analyses within a simulation-based model of language understanding. As described in Chapter 2, this model of language understanding has two phases: analysis and simulation. In the first phase, analysis of a given sentence yields a best-fitting interpretation of which constructions that sentence instantiates, and how they are unified with one another (i.e. how they are bound together). The determination of the best-fitting interpretation requires an examination of the semantic and syntactic factors specified by the constructions in the grammar, as well as a consideration of factors relating to the context a particular sentence occurs in.[1] The best-fit interpretation of sentence meaning is in the form of a semantic specification (SemSpec), which consists of a set of schemas, bindings, and role value specifications.

Single-clause sentences such as the ones being examined are used to describe various kinds of events. The SemSpec produced by the analysis of a given sentence example can be viewed as a set of basic 'stage directions' for how to imagine (or simulate) the event described by the sentence. In addition to specifying information about the 'content' of this event (e.g. the event participants and what they are doing), these directions also indicate something about how this event is conceptualized (e.g. which elements attention is focused on).

[1] For a full description of the computational implementation of this process see Bryant (2008).

The second phase of the model involves the actual enactment or simulation of this described event. Because the simulation process makes use of the simulator's knowledge of the world, personal beliefs, understanding of the current context, etc., the simulation can potentially be far richer and more detailed than the relatively schematic stage directions provided by the SemSpec.

In sum, the best-fitting interpretation of a given sentence yields a SemSpec that indicates the relatively schematic, sparse semantic parameters specified by the unified constructions instantiated in that sentence. We might consider these parameters to be the constructionally-specified 'meaning' of the sentence. Through simulation, these specified semantic parameters give rise to a much fuller understanding of that sentence.

Significantly, this process of best-fit interpretation has been successfully implemented in a computational system called the Constructional Analyzer (Bryant 2008; Feldman, Dodge & Bryant 2010; Bryant & Gilardi, to appear). Given a grammar and a particular utterance, the best-fit metric used in this system computes the conditional likelihood of different interpretations of that utterance. This computation considers both syntactic and semantic factors. The syntactic factor incorporates construction-specific preferences about constituent expression and the kinds of constructional fillers preferred by each constituent. The semantic factor scores a SemSpec in terms of the fit between roles and fillers.

In order to support this simulation-based model, constructions in an ECG grammar need to be defined such that they include the semantic and syntactic specifications that support the analysis and best-fit interpretation of various sentences. Moreover, in order to support computational implementation of these processes, these specifications need to be both precise and consistent. In addition, for the best-fitting interpretation of a given sentence, the unified instantiated constructions should produce a SemSpec that includes directions as to the content and conceptualization of the event the sentence describes. As we will see, this is done by representing constructional meaning using a variety of schemas, including the EventDescriptor schema described in Chapter 2. This SemSpec should be 'coherent'; in other words, the schemas and roles associated with the different constructions should be bound together into a connected whole. However, these constructions, and the SemSpecs they give rise to, cannot include all of the full rich details associated with the actual simulation of this event.

Chapter overview

A core premise of my work is that if we want to explain how words can be used to express the variety of meanings they do, it is essential that we examine these words within the larger contexts in which they convey these meanings. Since my more specific objective is to explore the question of how verbs, in conjunction with A-S constructions, can be used in sentences that convey various meanings, it is therefore essential to examine verb and A-S constructions within the contexts of these sentences. To this end, later in this chapter I present an analysis of several different sentences that describe motion-related events. This includes sentences such as *The box slid / spun into the room*, which describe motion events in which an inanimate entity changes location, as well as sentences such as *She walked / wriggled / slid / spun into the room*, each of which can be used to describe an event in which an person (or other animate entity) is in control of at least some aspects of her motion and accompanying location changes.

As discussed in the previous chapter, it is possible to recognize certain recurring schematic similarities in (our understanding of) the different types of situations that motion verbs such as these are used to describe. However, motion verbs differ as to what sort of schematic meaning is consistently present. For instance, *walk* is consistently used to describe animate translational motion, while *wriggle* consistently describes motion that is controlled by an animate mover, but which does not always involve a change in the mover's location. To reflect these sorts of differences, the 'core' meanings of different groups of motion verbs are represented using different but related motion schemas. For instance, constructions for *walk* (and *jog, saunter*, etc.) identify their meaning with the Locomotion schema, and constructions for *wriggle* (and *dance*, etc.) identify their meaning with the AnimateMotion schema.

In some sentences, the core meaning of a verb has the same motion-related schematic conceptual structure as the sentence as a whole. Such is the case for *She walked into the room*. But, for examples such as *She wriggled /inched /spun into the room*, the situation is different. Even though these sentences can be used to describe animate translational motion events, the core meanings of the verbs themselves do not necessarily include the full 'animate translational motion' structure associated with such events.

One way to capture the full meaning of this second set of sentences would be to posit additional verb constructions in which the verbs' core meanings are augmented by additional schematic structure. For instance, we could posit a second, locomotion sense of *wriggle*, in which 'change of location' structure is added to the verb's core meaning of animate motion. However, the inclusion of meaningful A-S constructions in the grammar makes possible the alterative analysis presented in this chapter. In this analysis, the 'augmented' schematic structure is supplied by the A-S construction. Consequently, the verb construction instantiated in these 'locomotion' sentences need not include any (motion-related) schematic conceptual structure other than that which is consistently associated with this verb form in other sentences.

The constructions and sentence analyses I present later in this chapter are rather complex. In order to clarify the reasoning behind many of the details of the constructions and sentence analyses presented later in this chapter, I first review the larger framework in which I am working and some of the implications this framework has as to how constructions in the current grammar are defined. Following this, I provide some background information on how A-S constructions have been defined by Goldberg and others. As part of this section, I discuss some of the issues that need to be addressed in order to analyze and formally represent A-S constructions as part of a larger ECG grammar. With this background information in place, I then describe how A-S constructions are defined within the current grammar, and show how they can be used to the support a compositional constructional analysis of the motion-related sentences mentioned above. Importantly, these analyses capture both the similarities and the differences in the deep meanings of these sentences.

4.2 The constructional analysis of sentence meaning

4.2.1 ECG framework

To start, let us consider the constructional analysis of a sentence like *The bottle rolled into the room*. As with most sentences, this sentence instantiates several different meaningful constructions, both lexical and non-lexical. Furthermore, these individual constructions are unified with one another, creating the form and meaning specification of the sentence as a whole. Thus, this sentence can be analyzed as a set of unified instantiated constructions (or 'constructs').

Consequently, to analyze the meaning of this sentence requires that we determine which constructions it instantiates, what meanings are associated with these constructions, and how these constructions unify to specify the meaning of the sentence as a whole. In addition to instantiating a verb and an intransitive motion A-S construction, this example also instantiates several other constructions, including a clause-level (declarative) construction, phrasal constructions (NP, and prepositional phrase constructions), and individual word-level constructions. Each of these constructions need to be defined such that they unify with each other to yield an 'appropriate' meaning, in the sense that this meaning captures the semantic elements that we recognize as being important. So, in order to assess the adequacy of a particular analysis, we need to have arrived at some 'standard' for what meaning the unified constructions should specify.

Constructions represent <u>recurring</u> form-meaning pairings, ones that can be recognized within many different sentences. Therefore, when examining the constructions instantiated in one particular sentence, it is important to keep in mind that these constructions can also occur -- in different combinations – in other sentences. For instance, both the verb and the A-S construction in the example above also occur in other combinations in other sentences, such as *The ball rolled across the floor*; *She rolled the bottle*; and *The bottle slid into the room*. Consequently, the constructions we define to support the analysis of one specific sentence should also support the analysis of the other sentences in which these constructions occur. One important implication of this is that each construction needs to be defined such that it unifies properly with many <u>different</u> sets of constructions (i.e. those that are co-instantiated in the various sentences in which that construction occurs). In sum, we need a system of compatible constructions – a simple grammar – that will support the analysis of a range of different sentence examples.

As discussed in Chapter 2, a given ECG grammar can be characterized as the conceptual structure (represented as lattices of schemas) and structured inventory of constructions shared by members of a particular language community.[2] As with other usage-based construction grammars (e.g. Langacker 1991, Croft 2001, Goldberg 2006) constructions in an ECG grammar capture both local and broader generalizations. Furthermore, the grammar is structured in a way that reflects various patterns of cognitive organization, including prototypes (Rosch 1975, 1978) and radial category structure (Lakoff 1987). Consequently, in addition to discussing specific individual A-S constructions later in this chapter, I also discuss relations between different A-S constructions, larger generalizations we can make, and how these are represented in the current grammar.

4.2.2 A-S constructions: background, challenges

While the sentences being examined in this chapter instantiate several different kinds of constructions, my main focus is on verb and A-S constructions. In this and the following section, I provide some general background on how A-S constructions have been defined in other works (Goldberg 1995, 2002, 2003, 2006; Michaelis 2003), and discuss some issues that need to be addressed when defining A-S constructions as part of a larger ECG grammar that can be used to support the analysis of various sentences.

As with other constructions, A-S constructions pair form and meaning. Building on the basic notion that each A-S construction designates some kind of basic, humanly relevant scene (Slobin 1985), Goldberg analyzes this form-meaning pairing as a pattern of linkages between a selected set of scene participants (argument roles) and different grammatical functions (e.g. subject, direct object). While A-S constructions have close relations to verbs, their meanings are typically more general than the verbs they co-occur with. For a particular sentence, the verb will unify with the instantiated A-S construction, with the result that the verb's participant roles are 'fused' with the more general argument roles of the A-S construction. In this way, the verb participant roles become linked to NPs filling different grammatical functions.

In a given sentence, then, the meaning of the verb combines with that of the A-S construction. While these meanings are presumably related, they are not necessarily the same. As noted earlier, Goldberg's recognition that a given verb may potentially combine with A-S constructions that differ as to their meaning and/or pattern of argument expression enables a non-polysemy analysis of many verb 'alternation' patterns, and

[2] Because of commonalities in brain function and types of basic experiences, people across different language communities presumably share much of the same core conceptual structure. Constructional inventories will show greater divergence, however.

alleviates the need to posit multiple, sometimes implausible senses of a given verb. One implication of this is that a given verb may potentially have different kinds of semantic relations to the different A-S constructions with which it composes. Or, to put it another way, a given verb meaning may potentially be integrated with more than one type of scene. This raises some important questions: how – and why – can the meaning of a given verb combine with different scene types? And what sort of integrated wholes result from these different combinations?

Goldberg describes the “principles of integration” between verbs and (A-S) constructions as follows:

> “Constructions must specify in which ways verbs will combine with them; they need to be able to constrain the class of verbs that can be integrated with them in various ways … and they must also specify the way in which the event type designated by the verb is integrated into the event type designated by the construction.” (Goldberg 1995; p. 49)

Furthermore, according to Goldberg’s ‘Semantic Coherence Principle’, in order for verb and A-S construction meanings to ‘fuse’, they must be semantically ‘compatible’. Because they are typically able to combine with more than one A-S construction, a given verb meaning must therefore presumably be ‘compatible’ with more than one type of A-S construction meaning. Prototypically, this semantic compatibility may be based on the fact that the verb meaning is a more specific ‘instance of’ the A-S construction meaning. But as Goldberg (1995) and Michaelis (2003) both recognize, other semantic relations are also possible.

These principles and this basic characterization of A-S constructions indicate some of the essential elements that need to be included in ECG representations of such constructions. For instance, each A-S construction should specify:

- the event type it designates
- constraints on the class of verbs it combines with
- how its meaning integrates with the meanings of verbs in this class

In order to precisely and consistently represent these elements, several issues need to be addressed. Some of these issues concern the semantic relation between verbs and A-S constructions. For instance, how can we analyze and represent verb and A-S construction meaning in such a way that it is possible to recognize their (potential) compatibility? Which in turn raises the more general question of what constitutes semantic ‘compatibility’. Additionally, for a given A-S construction, how can we best analyze and specify the particular way in which verb meaning is integrated into that of the event designated by the A-S construction? As we will see, ‘process’ schemas such as those discussed in the previous chapter play a key part in dealing with these issues.

To support a compositional analysis of a given sentence, it is therefore crucial to determine the relations between that the verb and A-S construction instantiated in that sentence. But, it is also necessary to analyze the constructional and semantic relations between the A-S construction and the other constructions instantiated in the sentence. In terms of constructional relations, one question is how to represent grammatical functions. If we assume, as Croft (2001) does, that these are not conceptual primitives, then they need to be represented somehow within the constructions in the grammar. Another very important constructional question is whether or not A-S constructions should be viewed as clause-level patterns. Correspondingly, is the sentence 'subject NP' a constituent of the A-S construction, or not?

With respect to meaning, it is important to keep in mind that when the instantiated constructions unify, their composed meanings should yield a SemSpec that supports appropriate simulation of the event described by that sentence. Accordingly, the A-S construction and other constructions instantiated in a given example need to include meaning specifications (schemas, bindings, and values) that indicate how the meanings of these different constructions will integrate with one another. To accomplish this, in addition to specifying semantic relations to verbs, we also need to specify the semantic relations A-S constructions have to other co-occurring constructions, thus indicating a larger pattern of meaning integration. As we will see in later sections of this chapter, the use of various ECG schemas to represent constructional meaning will enable us to recognize and explicitly represent the relevant constructional meanings and relations.

Later in this chapter, I provide an overview of how A-S constructions are analyzed and represented in the current grammar. Following this overview, I examine some sentence examples, and discuss the specific A-S constructions they each instantiate. Consistent with the work of Goldberg and others (e.g. Goldberg 1995, Goldberg and Jackendoff 2004), A-S constructions in the current grammar exhibit many similarities to one another in terms of their general form and/or meaning. As I show in this chapter, it is possible to specify precisely specify both the similarities and differences between these constructions, and the relations between them. But before looking directly at A-S constructions and their representations, I first address the question of whether or not A-S constructions should be analyzed as clause-level constructions.

4.2.3 Are A-S constructions clause-level constructions?

In this dissertation I focus on an examination of simple single clause declarative sentences. One of the constructions instantiated in such sentences will need to be a clause-level construction that spans the entire sentence, and which serves to indicate certain aspects of the meaning of the sentence as a whole. This basic clause construction will include 'subject-predicate' structure that indicates how the 'subject' NP is linked to the event being described by a given sentence. And this construction will indicate that the sentence as a whole is used to describe an event of some kind. An important question is, should A-S constructions be defined as clause-level constructions? Or, is it better to analyze the sentence patterns as a composition of an A-S construction with a separate clause-level construction?

Consider, for instance, the 'intransitive motion' A-S construction instantiated in the sentence *She walked into the room*. In the analysis of this sentence, we will want to recognize that it describes some kind of motion event, that the 'subject' NP is linked to the mover role of this event, the verb indicates something about the motion, and the meaning of the PP elaborates the mover's path of motion. But should all of these elements be specified within the A-S construction? More specifically, should the A-S construction include the subject NP as one of its constituents?

To answer these questions, we need to consider a relatively broad range of sentence examples that a comprehensive grammar should be able to analyze. First, consider some examples that include a description of the same type of event, but in which this event description serves a different pragmatic function, as in (1a-d).

(1) a. She walked into the room.
    b. Did she walk into the room?
    c. She wanted to walk into the room.
    d. The room she walked into was cold and dark.

All of these include a description of an event involving a 'motion action' (*walk*), a mover/actor (a 'walker' – *she*), and the walker's path of motion (*into the room*). But, this event description plays different roles in the overall meanings of these different sentences. For instance, the simple declarative clause serves as a way for a speaker to convey information about the event to a hearer, while in the question the speaker is requesting further information about that event. And, accompanying these differences in functions, there are also clearly differences in the 'form' of these different sentences. If we were to define A-S constructions as clause-level constructions, we would need to define different A-S constructions to analyze these different examples.

Next, consider examples which describe different types of events, but which exhibit some very general similarities in form and meaning, as in (2a-d).

(2) a. She walked into the room.
    b. She smiled.
    c. She kicked the box.
    d. She threw the ball into the box.

In each, the sentence as a whole serves as a description of some event, the verb describes a process related to overall event, and the 'subject' NP describes a (focal) participant of that event. Furthermore, other elements (where present) elaborate other aspects of that event. However, the nature of the event differs for different sentences (e.g. as to whether it involves motion and/or causation).

Together, examination of examples such as these indicates that it is effective to identify 'phrasal' patterns that are used to describe different types of events, and that these patterns are dissociable from the clause-level patterns that signal different pragmatic functions for these event descriptions. Consistent with this, A-S constructions are <u>not</u>

defined in the current grammar as clause-level constructions. Instead, the grammar includes a separate (but related) set of clause-level constructions, which can compose in different ways with 'phrasal' A-S constructions. Examples (1a-d) can then be analyzed as instantiating the same A-S construction, but different clause constructions. Examples (2a-d) can be analyzed as instantiating the same clause construction, but different A-S constructions. In this way, the grammar captures important generalizations while, at the same time, supporting a productive compositional analysis of a wide range of sentences.

Declarative sentences such as *She walked into the room* are therefore analyzed in the current grammar as instantiating a clause-level declarative construction that unifies with a phrase-level 'intransitive motion' A-S construction. It is outside the scope of the current work to delve into an analysis of different types of clauses and the constructions they instantiate[3] But, before looking more closely at A-S constructions, it will be useful to first briefly look at the declarative clause construction instantiated in this and other declarative sentences, including (2a-d) above.

4.2.4 An ECG construction for declarative clauses

There are a few very basic generalizations that can be made about declarative clauses:

- They can be analyzed as having two constituents: a 'subject' and a 'predicate'.
- Prototypically, the form of the 'subject' constituent precedes that of the 'predicate'.
- The clause as a whole serves to describe some event.
- The constituents each provide meaning related to this event.
- In terms of meaning, one of the main features associated with 'subject' is its prominence. Langacker, for example, characterizes the subject as "the primary Figure with respect to the profiled relationship" (1999: p.33).

Each of these elements are represented in the Declarative construction (Figure 4.1), described below.

Some of the generalizations we can make about declarative clauses also apply to other types of main clauses. These broader generalizations are represented in the grammar using more general constructions within a hierarchy of clause-level constructions.
Reflecting the fact that declarative clauses are similar in many important respects to other types of 'subject-predicate' constructions, Declarative is defined as a subcase of the more general S-With-Subj construction (not shown). Declarative includes all the structure of this 'parent' construction, as well as having some construction-specific structure of its own.

[3] Various clause-level constructions are presented in Bryant (2008), as well as in Feldman, Dodge, and Bryant (2010).

```
construction Declarative
  subcase of S-With-Subj
  constructional
   constituents
        subj:NP
        fin: ArgStructure
   constraints  // inherited from S-With-Subj
         fin.features.verbform <-- Finite
         subj.features.person <--> fin.features.person
         subj.features.number <--> fin.features.number
        subj.features.case <-- "nom"
  form
   constraints
        subj.f before fin.f
  meaning:  EventDescriptor
      constraints
        self.m <--> fin.m.ed
        subj.m.referent <--> self.m.profiledParticipant
```

Figure 4.1 The Declarative construction.

Declarative has two (inherited) constituents: subj and fin. Subj is specified to be a type of NP (described in Chapter 2), and fin to be of type ArgStructure. These constituents are constrained to agree with one another in terms of person and number features. Furthermore, subj specifies that its case value is 'nominative'. Declarative's form constraints specify that prototypically the form of subj precedes that of fin.[4]

As with other construction that have constructional constituent parts, Declarative specifies how these parts are integrated into a larger whole, and specifies bindings that are asociated with this particular compositional pattern. As noted above, the meanings of declarative clauses can be viewed as descriptions of events. Therefore, to represent the meaning of the clause as whole, the meaning of Declarative is identified with an EventDescriptor schema. As described in Chapter 2 (Figure 2.15, repeated below as Figure 4.2), this schema has roles that correspond to various constructionally-specified parameters about the content and conceptualization of events.

The fin constituent supplies several important parameters about the event being described by the clause. To indicate that Declarative and its fin constituent are both supplying parameters about the same event description, the EventDescriptor schemas associated with each are bound together (self.m <--> fin.m.ed).

[4] Agreement properties here are thus analyzed using various 'feature' roles. While this method supports compositional analysis of full clauses, no commitment to this particular analysis of agreement is implied by its use in this dissertation.

```
schema EventDescriptor
   roles
     eventType: Process
      profiledProcess: Process
      profiledParticipant: @entity
      profiledStage
```

Figure 4.2 The EventDescriptor schema (repeated from Figure 2.15)

The referent described by the subj constituent is the primary 'focal' participant in this event. This is specified by binding the referent role associated with the meaning of subj, to the profiledParticipant role of EventDescriptor. (subj.m.referent <--> self.m.profiledParticipant)

As illustrated by Declarative, the notion of 'subject' is handled within constructions in the grammar (consistent with Croft's views), rather than being considered a grammatical primitive of some kind. Declarative's subj constituent has constraints related to constructional type (NP), ordering, and agreement properties. These constraints thus formally specify several properties typically associated with subjecthood. Moreover, this constituent has the semantic constraint that the referent described by the subj constituent is the 'focal participant' (profiledParticipant) of the event being described. Thus, this subj constituent also has semantic properties consistent with Langacker's insights about the central meaning associated with subjecthood.

Declarative does not, however, specify <u>which</u> event-related semantic role the subj constituent is associated with. Nor does it specify what type of event is being described. This information is instead supplied by the construction that serves as its fin constituent. Crucially, because of the way the A-S construction hierarchy is defined, the many different specific A-S constructions in the grammar will meet the general constructional type constraint on this fin constituent.

4.3 Argument Structure Constructions in the current grammar

A-S constructions are a set of generally-defined constituent structures that occur in some particular form order, and which are associated with the description of some kind of basic humanly relevant event. In addition to specifying these different elements, A-S constructions in the current grammar also indicate how the meanings of these parts are integrated with the meaning of the event as a whole, as well as indicating other aspects of how this event is conceptualized.

Below, I provide a general overview of how A-S constructions are represented in the current grammar, and address some of the issues raised in earlier sections. In addition, I describe a general A-S construction that represents some high-level generalizations we can make about A-S constructions, then, in the sections that follow this one, I describe several specific A-S constructions and show how they are used in the analysis of different types of motion-related sentence examples.

4.3.1 Constructional Relations

As discussed above, A-S constructions can serve as constituents in clause-level constructions like Declarative. Since A-S constructions are not defined as clause-level constructions, they do not include the 'subject' NP as a constituent. They do, however, include other constituents. One defining characteristic of A-S constructions is that they include a verb constituent. Additionally, other constructional elements that express A-S construction 'argument roles' are also defined as constituents of the A-S construction (e.g. 'direct object' NP and/or prepositional phrases)

A-S construction constituents are not typically defined at a lexically-specific level; instead, each constituent is constrained to be of some particular constructional 'type' (e.g. verb, noun phrase). Because each constructional type has a meaning, these type constraints will also serve as general constraints on constituent meaning. The A-S construction may also include more specific semantic constraints on its constituents. In particular, specific A-S constructions bind the meaning of the verb constituent to some particular Process schema. In this way, a given A-S construction specifies constraints on the semantic class of verbs that it will combine with.

4.3.2 Form and meaning specifications

Each A-S construction has a characteristic 'form' pattern. This is represented as a constraint on the prototypical ordering of the A-S construction's constituent forms. For instance, a specific A-S construction may specify that the verb form (canonically) precedes that of its 'direct object' NP constituent.

In terms of overall meaning, A-S constructions designate some type of scene of event. This is represented by binding the meaning of the A-S construction to the eventType role of an (evoked) EventDescriptor schema. As noted in Chapter 2, some of the main types distinctions in event structure that are recognized (though not fully agreed upon) as being relevant are: (1) the distinction between simple vs. complex events; (2) the presence or absence of causal relations; and/or (3) the presence or absence of motion (for overview see Levin and Rappaport Hovav 2005). Consistent with Goldberg's work, specific A-S constructions each designate some particular humanly relevant basic event. In addition, I make the reasonable assumption that events which involve humans performing goal-directed actions are especially relevant to us, as are other events with human participants. This does not necessarily mean that all events described by A-S constructions directly involve human participants, however.

For the A-S constructions in the current grammar, the event type associated with a particular A-S construction is represented using a 'process' schema: Process (Figure 2.12), or a subcase thereof. My claim is that the schemas in the process schema lattice that I've developed represent schematic structures that recur in humanly relevant basic scenes. Moreover, different schemas reflect important, linguistically-relevant differences between different types of events. For instance, process schemas differ from one another with respect to the presence/absence of motion, location change, and/or animate control of an action/process. In addition, as shown in later chapters, they also differ as to whether or not they include structure related to force and causation. Thus, not only do process schemas provide a way represent the different types of events A-S constructions are used to describe, they also indicate elements of event structure that are relevant to argument realization.

A-S constructions include meaning constraints that specify how the meanings of its constituents are integrated with the event type designated by that A-S construction. Since constituents are usually defined at a general (rather than lexically-specific) level, this means that the A-S construction's semantic relations to these constituents have to be analyzed and represented at a general (rather than lexically-specific) level as well.

Recognition and representation of the relations between verb and A-S construction meaning is facilitated by the fact that both identify their meanings with process schemas. A basic premise is that it is the schematic structure that verb and A-S constructions have in common that makes them semantically 'compatible' with one another, and that this commonality serves as the key element in the integration of their meanings.[5] Accordingly, semantic relations between an A-S construction and its verb constituent are specified in terms of the schematic structure that they share. As we will see, in some cases, both constructions identify their meaning with the same schema, indicating that the schematic structures of each are the same. But in other cases, one construction has only a portion of its schematic structure in common with the other construction. Use of schemas from same schema lattice to represent the meanings of verb and A-S constructions enables us to use schema relations to identify and specify the different semantic relations between these constructions. This is one more important benefit to using process schemas to represent A-S construction meanings. Semantic relations to other constituents are also analyzed and represented via bindings to schemas and schema roles associated with the A-S construction.

A-S constructions also include specifications that relate to the conceptualization of the event described by the A-S construction. In particular, the verb meaning is specified to 'profile' some aspect of this event. And specific A-S constructions also indicate which of the event participants is the 'profiled', or focal participant. These constraints are specified as bindings to roles in the evoked EventDescriptor schema. As discussed in Chapter 2,

[5] Consistent with Lakoff's 'cog' theory (Gallese and Lakoff 2005).

the profiledProcess role of this schema indicates which process or subprocess of the event receives focal attention. And the profiledParticipant role indicates which event participant is the focal participant; simulation of the event will focus on elements that are relevant to this participant. Moreover, since the profiledParticipant role is bound to the 'subject' constituent in Declarative and other clause constructions, when an A-S construction unifies with such a clause construction, the event participant role that is bound to profiledParticipant will be identified with the referent described by this subject constituent.

4.3.3 The general ArgStructure construction

As discussed in Chapter 2, ECG grammars include **general** constructions, each of which serve to indicate broad commonalities in the constituency, form and/or meaning of a group of more specific constructions. For A-S constructions, the current grammar includes a very general ArgStructure construction, of which all other A-S constructions are subcases. One valuable purpose this general construction serves is that it can be used as a constructional type constraint on the constituents of other constructions. For example, the Declarative construction, discussed above, constrains its fin constituent to be of type ArgStructure. As subcases of ArgStructure, all A-S constructions in the current grammar will meet this constructional constraint.

Two central elements are common to all of the A-S constructions in this grammar. First, they all include a verb constituent. And second, they all are assumed to describe some basic type of scene or event. Furthermore, the verb constituent meaning provides more specific information about this event, serving to 'elaborate' all or some portion of the event. Accordingly, the general ArgStructure construction includes specifications about these common elements. However, it does not include specification of elements that may vary for different A-S constructions, such as the number and type of additional constituents, and the specific type of event being described; these elements will be specified in more specific subcases of ArgStructure.

Details about the formal representation of ArgStructure (Figure 4.3) are as follows. ArgStructure has a v constituent that is constrained to be of constructional type Verb. Constructional constraints indicate that the A-S construction has whatever features (if any) that its verb constituent does (self.features <--> v.features). This constraint is necessary to assess agreement between the fin and subj constituents in Declarative and other clauses.

```
general construction ArgStructure
  subcase of  VP
  constructional
    constituents
       v : Verb
    constraints
       self.features <--> v.features
  meaning: Process
    evokes EventDescriptor as ed
    constraints
       self.m <-->ed.eventType
       v.m  <--> ed.profiledProcess
```

Figure 4.3 The general ArgStructure construction.

The meaning of the construction as a whole is identified with the very general Process schema. A given subcase of ArgStructure typically identifies its meaning with a more specific subcase of Process. In addition, this construction evokes the EventDescriptor schema and gives it the local name 'ed'. The meaning pole of ArgStructure is bound to the eventType role of this evoked EventDescriptor, (self.m <-->ed.eventType). Together, these constraints specify that the process-related meaning of the A-S construction indicates what type of event is being described. In addition, the meaning of the verb constituent is bound to the profiledProcess role of the EventDescriptor (v.m <--> ed.profiledProcess), indicating that the verb serves to 'profile' some particular facet(s) of this event.

4.4 Specific A-S constructions instantiated in 'intransitive motion' sentences

For the analysis of utterances, a single general ArgStructure construction is not sufficient: the grammar also needs to include A-S constructions that have more specific specifications of constituents, form, and meaning. Specific A-S constructions in the current grammar indicate: (1) the specific number and type of constituents; (2) the (prototypical) order of the constituent forms; (3) the particular type of humanly relevant scene the A-S construction is used to describe; (4) the focal participant within this scene, and; (5) the semantic relations between the A-S construction and its constituents. A given A-S construction cannot include potentially conflicting specifications. Therefore, recognition of differences with respect to one or more of these elements prompts the definition of separate A-S constructions.

Examples such as the following clearly differ with respect to the constituency and form of the A-S constructions they instantiate:

(3) She walked into the room. (V > PP)
(4) She cut the bread. (V > NP)
(5) She threw the bread into the room. (V > NP > PP)

Significantly, there is also an accompanying semantic difference in terms of what type of event is being described using these different form patterns. For (3) it is some type of motion event, for (4) it is a 'cause effect' event, and for (5) it is a 'caused motion' event'. Therefore, we will clearly want to analyze these sentences as instantiating different A-S constructions.

But the situation gets a bit trickier when we look at sentences where the instantiated A-S constructions appear to be similar both in terms of the general type of constituents they include and as to canonical ordering of these constituent forms. For instance, the general 'form' pattern for all the sentences in (6a-e) is (V > PP)[6]:

(6) *a.* She walked into the room.
b. She wriggled into the room.
c. The box slid into the room.
d. The box spun into the room.
e. She slid / spun into the room.

Clearly these sentences differ as to their specific meanings. The question is, which of these differences should prompt the definition of separate A-S constructions? Consistent with my characterization of A-S constructions, described above, I theorize that two especially important semantic differences are: (1) differences with respect to the types of events being described, and; (2) differences as to the relation the verb meaning bears to a particular type of event.

Moreover, as I show in the following sections, we can recognize (and represent) these distinctions at the level of the schema. Accordingly, A-S constructions in the current grammar capture similarities (and differences) with respect to:

- the specific 'process' schema the A-S construction identifies its meaning with
- the schema associated with the 'core' meaning of the verb
- the relation between these two schemas

Identifying similarities and differences at the level of the schema provides several analytical and representational benefits. For one thing, because many verb constructions can potentially identify their meanings with the same schema, this provides a straightforward way to identify a 'class' of semantically similar verbs that can serve as constituents for a particular A-S construction. Additionally, because both verb and A-S construction meaning are represented using 'process' schemas, it is a fairly simple matter to recognize and represent various semantic relations between different A-S constructions and their verb constituents.

[6] The examples all exhibit the general form-meaning pattern of Goldberg's 'intransitive motion construction', in which the subject NP expresses the 'theme' (mover) and the 'goal' of motion is expressed by an oblique (Goldberg 1995, p.160). Since A-S constructions in the current grammar do not include subject NP as a constituent, the relevant form pattern here can be characterized as (V > PP).

To fully understand how specific A-S constructions are defined in the current grammar, and how they are used in a compositional analysis of sentence meaning, we need to look in more detail at some specific sentence examples. Accordingly, in the remainder of this chapter I more closely examine the motion-related sentence examples listed above (6a-e). First, I analyze one example – *She walked into the room* – in detail. I describe the specific A-S construction instantiated in this example, and explain how this construction is represented using the ECG formalism. Then, having discussed the A-S construction and other constructions instantiated in this example, I show how these constructions are used in a 'best fit' constructional interpretation of the sentence as a whole. In this interpretation, the instantiated constructions are unified with one another, and their composed meanings yield a SemSpec which specifies parameters for the simulation (and fuller understanding) of this particular sentence. In this way, the constructional interpretation indicates how the constructions instantiated in this sentence are composed to indicate the sentence's deep meaning.

Following the detailed examination of this first example, I next look at (6b-e) in turn. The forms and meanings of these examples are quite similar to *She walked into the room*. Not surprisingly, the A-S constructions and SemSpecs associated with these examples are also quite similar. In my examination of these sentences I therefore focus primarily on how these later examples differ from the first example, especially with respect to event type and verb meaning. Significantly, as I discuss, constructional analyses of each these sentences produce SemSpecs that capture both the similarities and differences of meaning of these various sentences.

4.4.1 A prototypical 'locomotion' description: *She walked into the room*

4.4.1.1 What type of A-S construction does this example instantiate?

When attempting to define and represent the A-S construction instantiated in a given sentence, one of the first things to consider is the type of event this construction designates. In other words, what kind of basic humanly relevant event is described by the sentence? In the case of *She walked into the room*, we could characterize this event very generally as one in which a mover is moving along some path. However, the motion-related schemas described in the previous chapter enable us to make finer-grained (yet still 'schematic') distinctions between different kinds of motion-related events. Accordingly, the event described by this sentence can be more specifically characterized as one in which a person performs an action with the objective of changing his overall location. One clear advantage of this more specific characterization is that it better indicates the humanly-relevant aspects of this particular event.

Thus, we can analyze the event being described by *She walked into the room* as having the schematic structure represented by the Locomotion schema (Figure 3.11). This schema includes two roles expressed in this sentence: an animate mover who performs a motion-related motor-control routine (she) and a landmark that this mover is moving in relation to (the room). In addition, this schema includes structure related to various assumptions we can make about this event, such as the fact that the mover can be assumed to be exerting some amount of energy and is in control of her speed and direction of movement.

Another thing we need to determine is how to characterize the A-S construction's verb constituent. As discussed in the previous chapter, the core schematic meaning of 'walk' can also be analyzed and represented using the Locomotion schema. Furthermore, many other verb constructions in this grammar identify their meaning with this same schema, including constructions for *jog, saunter, trudge, run,* and *sprint*. Consequently, by specifying a semantic constraint that the meaning of its verb constituent is identified with a Locomotion schema, we can define an A-S construction that can be used to analyze a variety of similar sentences, all of which describe 'goal-directed self-motion events, such as those shown in (7).

(7) She walked / jogged / sauntered / trudged /sprinted into the room

In this particular case, then, the verb constituent meaning includes the same schematic conceptual structure as the A-S construction itself. Thus, the semantic compatibility and motivation for the 'fusion' of their roles is clear. This is another advantage of characterizing the event type as being one of 'locomotion'.

In examples such as these, the meaning of the verb includes additional, more specific information that is not part of the A-S construction's meaning. Consequently, in sentences such as these, the A-S construction's verb constituent serves to elaborate some facets of the event (and the event participant roles), providing information that is not directly specified within this A-S construction. For instance, the verb may indicate something about the particular motor-control routine the mover is executing, her speed of motion, and/or the amount of effort she is exerting.

In the current example (*She walked into the room*), the prepositional phrase provides information about the particular locations the mover occupies, specified here as spatial relations to a particular landmark (the room). Many other prepositional phrases can serve this same general purpose, though they may differ as to the specific landmarks they include and the specific spatial relations they specify, as illustrated by (8).

(8) She walked across the field / over the hill / through the woods / to the store

Therefore, we can analyze the sentence *She walked into the room* as a specific instance of a more general pattern, in which a 'locomotion' verb followed by a 'path' prepositional phrase is used to describe an event in which an animate entity performs a motor-control action which results in change of location with respect to some landmark.

Accordingly, the A-S construction instantiated in the current example can be defined as having a prepositional phrase constituent, in addition to its verb constituent. As

discussed in Chapter 2, we can make the semantic generalization that prepositional phrases such as those in the examples above all evidence 'source-path-goal' schematic structure. Therefore, we can further specify that in order to serve as a constituent in this A-S construction, this prepositional phrase must have 'source-path-goal' meaning.
Because of the way prepositional phrases are analyzed in this grammar, this restriction can be specified as a constructional type constraint on this constituent. Specifically, this constituent can be constrained to be of constructional type Path-PP, a general prepositional phrase construction which identifies its meaning with an SPG (source-path-goal) schema (Figure 2.2).

By making the general specification that this prepositional phrase constituent has SPG meaning, this A-S construction can be used to analyze sentences with a variety of different path descriptions including, but not limited to those above. At the same time, this constraint will effectively exclude prepositional phrases that do not have SPG meaning. As a result, even though sentences such as *She walked with her friends / by herself* have the same general form, they will not be analyzed as instantiating this same A-S construction.

Another important advantage of defining the meaning of the prepositional phrase constituent in this way is that it clearly indicates the meaning that this constituent has in common with the A-S construction itself. Recall that the Locomotion schema integrates the structure of the SPG schema.[7] Therefore, both the A-S construction and its prepositional phrase constituent include 'source-path-goal' meaning. Recognition of this commonality of schematic structure makes it possible to precisely specify, within the A-S construction, the (semantically motivated) integration of its meaning with that of the prepositional phrase constituent.

As noted before, the subject NP of the sentence is considered a constituent of the clause-level construction instantiated in this sentence, and is therefore not included as a constituent of this (or other) A-S constructions. But, this A-S construction does indicate that the mover is the 'profiled participant' of this event. As we will see below, unification with Declarative will result in this mover role being bound to the meaning of the 'subject' NP in sentences such as *She walked into the room*.

Thus, we can define an A-S construction that represents a general, non-lexically-specific pattern of 'argument realization' associated with the description of a particular type of basic, humanly relevant event. Furthermore, the schematic structure of this type of event, and its associated semantic roles, can be represented using the Locomotion schema, a specific kind of 'process' schema. Significantly, the 'event type' structure provided by

[7] Specifically, Locomotion is a type of complex process, with MotionAlongAPath as one of its subprocesses. And, MotionAlongAPath integrates the structure of Motion with that of SPG, to represent the schematic structure of motion that is accompanied by changes in the mover's location.

the Locomotion schema aids the recognition and representation of general patterns of meaning integration between the A-S construction and its constituents.

4.4.1.2 The IntransitiveLocomotion1 A-S construction

The A-S construction described above is named IntransitiveLocomotion1 in the current grammar. In this section I describe how this key elements of this construction are represented using the ECG formalism.

IntransitiveLocomotion1 (Figure 4.4) is defined as a subcase of the general ArgStructure construction. IntransitiveLocomotion1 shares all the structure of this general ArgStructure construction 'parent', but also has the following additional specifications:

- In addition to a verb constituent, it also has a prepositional phrase constituent.
- It includes constraints on the ordering of these constituent forms.
- A-S construction meaning is identified with a more specific subcase of Process (the Locomotion schema).
- Bindings indicate the semantic relations between the A-S construction and its constituents (thus indicating how their meanings are integrated).
- A meaning constraint indicates which event participant role is 'profiled' (the mover).

A description of the full structure of this construction, including both inherited and 'unique' structure is given below.

IntransitiveLocomotion1 has two constructional constituents: a verb (v), and a prepositional phrase (pp). The prepositional phrase is constrained to be of type Path-PP, which indicates that its meaning is identified with an SPG schema. As indicated by the form constraints, the verb prototypically precedes the prepositional phrase.

The meaning of IntransitiveLocomotion1 is identified with the Locomotion schema. In addition, this construction evokes an EventDescriptor schema, and binds its meaning to the eventType role. Together, these constraints indicate that this particular pattern is used to describe goal-directed self-motion ('locomotion') events.

```
construction IntransitiveLocomotion1
  subcase of ArgStructure
  constructional
   constituents
        v : Verb
        pp: Path-PP
   constraints
         self.features <--> v.features
  form
   constraints
         v.f before pp.f
  meaning: Locomotion
   evokes EventDescriptor as ed
   constraints
       self.m <--> ed.eventType
       v.m  <--> ed.profiledProcess
       self.m <--> v.m
       self.m.process2.spg  <--> pp.m
       self.m.mover <--> ed.profiledParticipant
```

Figure 4.4 The IntransitiveLocomotion1 construction (inherited structure in gray).

IntransitiveLocomotion1 also indicates the specific relations that the meanings of the constituents have to the meaning of the construction as a whole. For the verb constituent, this involves two constraint specifications. One is the inherited constraint that the verb meaning effectively 'profiles' a process associated with the event (v.m <--> ed.profiledProcess). The other constraint indicates the semantic relation the verb constituent has to the A-S construction. In this particular case, the schematic structure associated with the verb is the same as that associated with the A-S construction (i.e. both constructions identify their meaning with Locomotion). To indicate this identity of schematic structure, the meaning of the the A-S construction is bound to that of its verb constituent (self.m <--> v.m). This binding also serves to indicate the 'semantic class' of verbs that can potentially serve as constituents in this A-S construction: they all have 'locomotion' meaning. As indicated above, this includes verbs such as *walk, saunter, trudge, jog*, *sprint*, etc.

For the pp constituent, the specified relation indicates that the SPG meaning of the prepositional phrase should be identified with the SPG component of the A-S construction meaning (i.e. the SPG structure that is part of the translational motion subprocess of Locomotion). This is represented as a binding constraint (self.m.process2.spg <--> pp.m).

In addition, IntransitiveLocomotion1 indicates that, for this particular pattern, the mover is the focal participant of the locomotion event being described (self.m.mover <--> ed.profiledParticipant). Note that this does <u>not</u> indicate how this mover role is actually <u>expressed</u>; this will be accomplished via unification with a clause construction.

4.4.1.3 A compositional constructional analysis of *She walked into the room*.

Having described the A-S construction instantiated in *She walked into the room*, we are now in a position to analyze the sentence as a whole. As mentioned earlier, the construction-based process of sentence analysis has been computationally implemented in a system called the Constructional Analyzer. ECG grammars typically support multiple possible interpretations of a given utterance, each of which involves instantiation of a somewhat different set of constructions from that grammar. The Constructional Analyzer combines constructions with best-fit processing in order to determine which constructional interpretation of a given sentence is the 'best-fitting' one (i.e. which interpretation is most likely, given the grammar and the utterance). As with the other examples I examine in this dissertation, the analysis I discuss below is the best-fitting constructional interpretation of this sentence

Using the current grammar, the sentence *She walked into the room* is analyzed as instantiating the following constructions (see Figure 4.6):

- Lexical constructions for each of the words, including a WalkPast construction (for discussion of walk, see Chapter 3), and an INTO1 construction for 'into' (Figure 2.4)
- NP constructions for 'She' and 'the room'
- Path-PP construction for 'into the room' (Figure 2.7)
- InstransitiveLocomotion1 construction
- Declarative construction

Each of the non-lexical constructions listed here has one or more constituents. In order for one construction instance to serve as a constituent of another, it needs to 'fit' the constraints specified for that constituent. For example, IntransitiveLocomotion1 includes a v constituent whose constructional type is Verb, and whose meaning is bound to a Locomotion schema. The WalkPast construction meets both of these constraints. Similarly, Path-PP has a prep constituent that is constrained to be of type PathPrep, and the lexical construction INTO1 fits this constraint.

Declarative is the clause-level construction instantiated in this example. Declarative's meaning is identified with an EventDescriptor schema, indicating that this construction is used to describe an event of some kind. The meaning of its subj constituent is identified with the profiledParticipant role of this EventDescriptor schema. In this example, this subj constituent unifies with SHE, indicating that the entity that fills the profiledParticipant role is, in this case, 'femaleAnimate'. Declarative also specifies that the EventDescriptor schema associated with the fin constituent is identified with that of Declarative, indicating that both provide information about the <u>same</u> event. In this particular example, the fin constituent unifies with IntransitiveLocomotion1, which thereby indicates what type of event is being described by this clause.

When these instantiated constructions unify, they produce a SemSpec (Figure 4.5) that supports simulation of the event described by this sentence. This SemSpec consists of a set of semantic schemas, value constraints, and bindings.

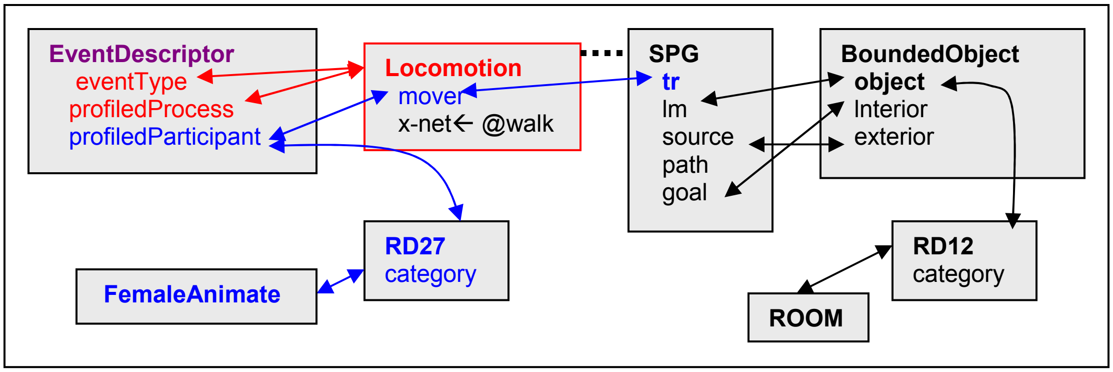

Figure 4.5 Schemas and bindings in Semspec for *He slid into the room*.

Using the current grammar, the sentence *She walked into the room* is analyzed as instantiating the constructions shown in Figure 4.6. Figures 4.5 and 4.6 both display the output of the analysis process in a format that is intended to be easily understood by the reader. Computational implementation of the analysis process, using the Constructional Analyzer, can be accessed via the ECG Workbench (http://ecgweb.pbwiki.com/). Chapter 6 includes a screenshot of an interactive SemSpec that was produced by the Constructional Analyzer (Bryant 2008) for the analysis of *She cut the bread* (Figure 6.2).

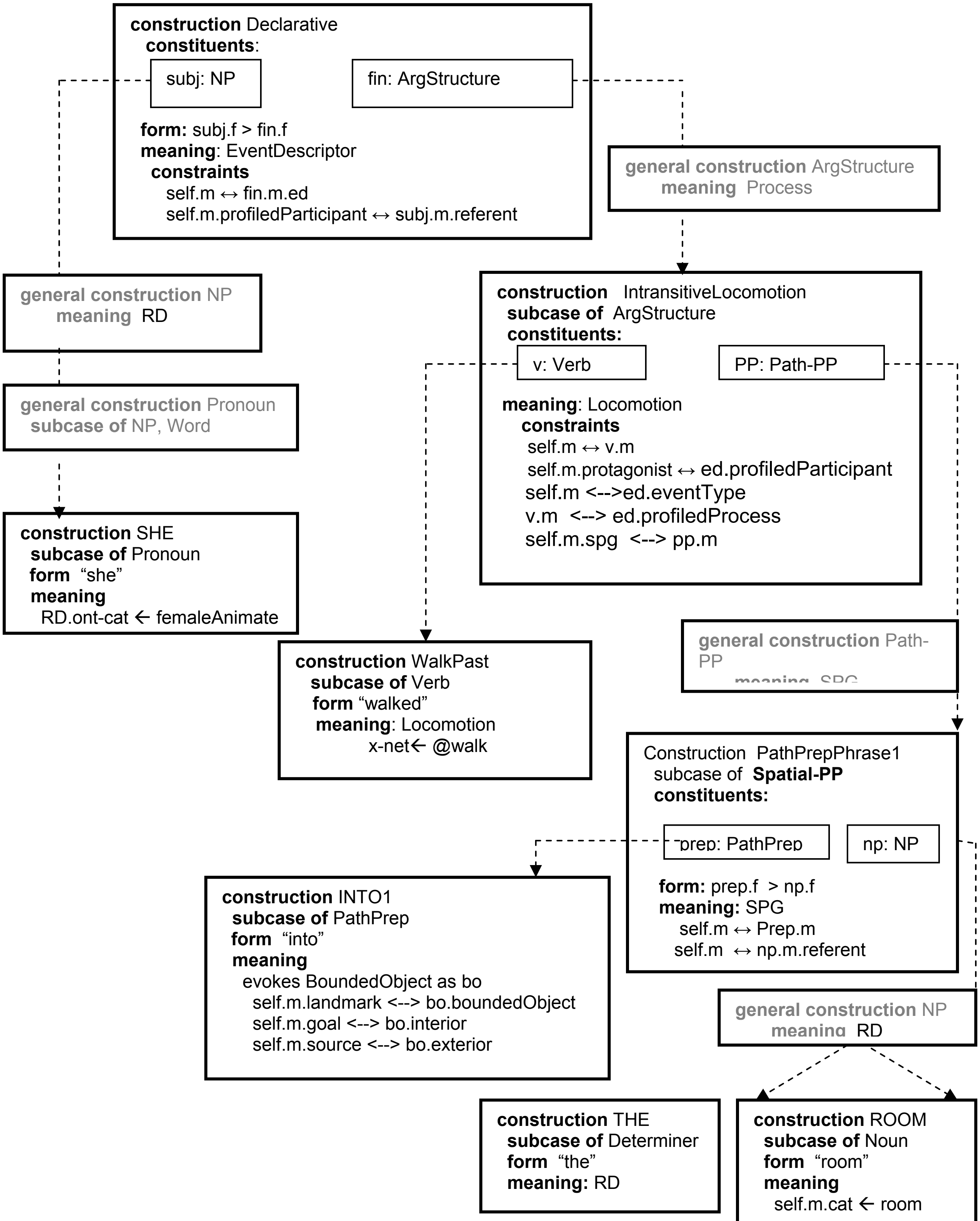

Figure 4.6 Constructions instantiated in *She walked into the room*.

The SemSpec includes an EventDescriptor schema, which provides some key simulation parameters. In this SemSpec, the EventDescriptor's eventType role is bound to the Locomotion schema, which is the schema that the A-S construction identifies its meaning with. The profiledProcess role is bound to the meaning of the verb construction, which also identifies its meaning with the Locomotion schema. Additional meaning specifications in the verb construction can serve to provide further information about this process, including details about the relative speed of motion, and amount of effort the actor is exerting. WalkPast, for example, specifies that the relevant x-net for this profiled process is one of 'walking'. Thus, via these bindings to the EventDescriptor roles, the A-S construction supplies information about the general type of event being described, and the verb provides additional information about the specific processes involved in this event.

In addition, this SemSpec provides various kinds of information about the two 'participants' of this event. In each case, SemSpec bindings indicate the internal complexity of the participant role, and also indicate something about the entity which 'fills' this role in this particular event description.

The central participant in this event is the person who is walking and changing location. This event participant is represented here by the mover role in the Locomotion schema. As described in the previous chapter, Locomotion's mover role is semantically complex, as indicated by its bindings to roles in the Motion, MotorControl, and SPG schemas. InstransitiveLocomotion1 specifies that this mover role is bound to EventDescriptor's profiledParticipant role, indicating that this mover is the focal participant in the event being described. Declarative specifies that the profiledParticipant is bound to the referent described by its subj constituent. Consequently, when the constructions instantiated in this sentence unify, the following elements are bound together:

- profiledParticipant of EventDescriptor
- referent described by 'she' (a female animate entity)
- mover (and protagonist) role of Locomotion.
- mover (and protagonist) Motion
- actor (and protagonist) of MotorControl
- trajector of SPG

Thus, the SemSpec indicates that a complex semantic role (mover-actor-trajector) is filled by a particular type of referent (a female animate entity) and that, moreover, this event should be simulated from this participant's perspective. Furthermore, if we also know something about the context in which this sentence is used, we can resolve which particular referent is being described, thus gaining further insight into the nature of the 'filler' of this participant role.

The other event participant expressed in this sentence is an entity that the mover is moving in relation to. This participant is represented by the landmark role associated with the Locomotion schema (specifically, the landmark role of the SPG schema that is part of the 'translational motion' subprocess of Locomotion).

Several of the instantiated constructions include specifications that relate to SPG and its landmark role. InstransitiveLocomotion1 specifies that the SPG component of Locomotion should be identified with the SPG structure of its pp constituent. Path-PP specifies that its SPG landmark role is bound to the referent described by its np constituent. And INTO1, which serves as Path-PP's prep constituent, specifies that landmark is bound to the whole role of a BoundedObject schema. As a result, when these construction unify, the SemSpec shows that the following elements are bound together:

- landmark role of SPG
- referent described by 'the room'
- whole of BoundedObject

Furthermore, the Source role of SPG is bound to the exterior of BoundedObject, and the Goal role is bound to its interior.

Thus, the SemSpec indicates that this sentence describes a situation in which a female animate actor (she) moved from a location outside a landmark (the room), to a location in the interior of that landmark. Additionally, this mover executed a 'walking' motor-control routine to bring about this motion and change in location. Therefore, the mover was presumably in control of her speed and direction of motion, and had to exert some amount of effort to achieve this change of location. This event is described from (and should be simulated from) the perspective of this actor/mover.

During simulation, an understander may draw additional, more specific inferences about a described event. For instance, for the current example we are likely to infer that the mover's action did not require her to exert very much energy, that the distance she moved was relatively short, and that this change in location did not take very much time to accomplish. Contrast these inferences with the ones we may make for a sentence that describes a very different path, such as *She walked to the top of the Eiffel Tower*. For this second sentence, we will most likely assume that a great deal more energy, distance, and time are involved than for the sentence just examined (*She walked into the room*).

It is important to note, though, that while the SemSpec supplies parameters for simulation, much of our rich understanding of a sentence is a product of the simulation these parameters support. Moreover, the simulation process can make use of world knowledge that is not necessarily specified within these constructions. So, for instance, in both examples the WalkPast construction indicates that the mover is exerting effort in order to move. And the SemSpecs will indicate something about the mover's final location (e.g. in the interior of the room, or at the top of the Eiffel Tower). But the constructions themselves do not specify that the Eiffel Tower is very tall and that to get to the top of it one presumably has to move upwards a great distance. Nor do the constructions specify anything about the amount of exertion needed to travel in a vertical vs. a horizontal direction. Therefore, the SemSpec itself does not directly specify that it will likely take much more effort (as well as time) to walk to the top of the Eiffel tower than to walk into the kitchen. The SemSpec provides the necessary parameters to 'set up' the appropriate scene, but it is through simulation that the scene is actually enacted, yielding all the rich details that we typically associate with a full 'understanding' of a given sentence.

4.4.1.4 Variations on a theme: other sentences which describe 'locomotion' events

The IntranstiveLocomotion1 A-S construction supports the compositional analysis of many other sentences besides *She walked into the room*. These sentences can differ as to the specific lexical and/or phrasal constructions they instantiate, but these constructs will still need to meet the constraints specified by IntranstiveLocomotion1. Such sentences may differ as to:

- Specific NPs. In each case, though, the referent described by the 'subject' NP must be (conceptualized as) being an animate entity, as in *A thirsty man / The deer / My sister walked into a bar / a clearing / the lake.*
- Prepositions. The constraint here is that the larger prepositional phrase describes a change in location (e.g. *She walked across /through / out of the room*.). As described in Chapter 2, prepositional phrases in which a 'locative' preposition indicates a final (goal) location will meet this constraint. For instance, *She walked* ***in*** *the room*, with the reading that her 'source' location was somewhere outside the room, and the interior of the room is her 'goal' location.[8]
- Verbs. As was already pointed out above, IntranstiveLocomotion1 is defined such that it can be used to analyze sentences that contain different verbs from the same semantic class as *walk*. Specifically, this includes any verb construction which identifies its meaning with the Locomotion schema, and therefore includes verbs such as *amble, stroll, saunter, trudge, slog, march, trot, sprint, lope, gallop*, etc.

Thus, because its constituents are not lexically-specific, IntranstiveLocomotion1 supports the compositional analysis of a wide range of sentences that exhibit similar form-meaning patterns. Moreover, because IntranstiveLocomotion1 is not defined as a clause-level construction, it can also be used in the analysis of other types of clauses, e.g. *Did she walk into the room; Which room did she walk into? Walk into the room!*, etc.

4.4.2 A similar description with an 'animate motion' verb: *She wriggled into the room*.

The sentence *She wriggled into the room* is clearly quite similar to *She walked into the room* with respect to both form and meaning. Of particular relevance here, both of these

[8] Thus, this A-S construction defines one context in which such 'locative' phrases can be used to describe a 'path' of motion. As Goldberg (1995) points out, the conceptualization shift which occurs here is one involving endpoint focus (Brugman 1998); the location described by the phrase is conceptualized as the endpoint of a path of motion.

sentences describe a 'locomotion' event in which a person performs an action with the objective of changing his overall location.

However, *wriggle* differs from *walk* in terms of the range of situations it can be used to describe. As the sentences above show, both of these verbs can be used to describe events in which the mover's motion results in a change of location. But, as discussed in the previous chapter, while verbs such as *wriggle, dance* and *squirm* are consistently used to describe animate motion, this motion doesn't always necessarily result in a change in location (e.g. *He wriggled in his saddle; He danced in place for a few minutes*). For this reason, the constructions that represent the 'core' meanings of *wriggle* and these other verbs identify their meanings with AnimateMotion. This schema represents the schematic structure associated with motion that is controlled by an animate mover, but which does not necessarily result in a change in location (nor is it necessarily intended to do so). In this respect, this schema differs from its subcase, Locomotion, which includes change of location (SPG) structure. This means that these instances of these verb constructions do not meet the constraints on IntransitveLocomotion1's verb constituent (which indicates that verb construction meaning is identified with Locomotion).

A constructional interpretation of *She wriggled into the room* should produce a SemSpec indicating that the verb's core meaning of animate motion is integrated with 'change of location' structure. There are at least two different ways to define constructions that will produce this result. One option is to assume that this sentence instantiates a second *wriggle* verb construction, whose meaning is Locomotion, and which would therefore meet the semantic constraints on IntransitveLocomotion1's verb constituent. The second option, described at further length here, is to define an additional A-S construction, with many of the same specifications as IntransitveLocomotion1, but with different constraints on the semantic class of verbs that can serve as its verb constituent and, necessarily, with a different type of semantic relation to this constituent.

4.4.2.1 An extension to the central case: IntransitiveLocomotion2

As with IntransitiveLocomotion1, this second A-S construction (named IntransitveLocomotion2) identifies its meaning with Locomotion, indicating that it describes animate translational motion events. The key difference is that it specifies that its verb constituent has the schematic structure associated with AnimateMotion, not Locomotion. Because Locomotion has additional SPG structure that is not present in AnimateMotion, the schematic meaning elements of the verb constituent are only the same as part of the A-S construction's schematic meaning. Therefore this A-S construction has a different semantic relation to its verb constituent than does IntransitiveLocomotion1. Importantly, though, these constructions still have some schematic meaning in common. This is a clear indication of their semantic 'compatibility', and provides a basis for the meaning of the verb to integrate with that of the A-S construction.

What relation does IntransitiveLocomotion2 have to IntransitiveLocomotion1? In IntransitiveLocomotion1, the schematic structure of the A-S construction is the same as its verb constituent, whereas in IntransitiveLocomotion2 the meanings diverge to some extent. It seems reasonable to assume that the tighter relation serves as a prototype, from which the looser relation develops as an 'extension'. This is consistent with a learning story in which A-S constructions are initially learned as generalizations over the argument realization patterns associated with verbs that are consistently used to describe a particular kind of basic scene (e.g. see Goldberg 2006). In this particular case, the relevant argument realization pattern used to describe locomotion events may have initially been learned for locomotion verbs like *walk* and *run*. Then, this pattern may have later been extended to include 'animate motion' verbs such as *wriggle* and *dance*. Therefore, I consider IntransitiveLocomotion1 to be a 'central case' A-S construction, and view IntransitiveLocomotion2 as a radial category extension in which the verb's schematic structure is related to -- but not the same as – that of the A-S construction.[9]

To represent this type of relation, IntransitiveLocomotion2 (Figure 4.7) is defined as a subcase of IntransitiveLocomotion1. This subcase is the same as its parent in most respects, but differs with respect to the meaning associated with its verb constituent, which is one of 'animate motion' rather than 'locomotion'. This difference is specified as follows. One meaning constraint in IntransitiveLocomotion2 indicates that the parent's specification that the (schematic) meaning of the verb is the same as that of the A-S construction should be ignored (**ignore** self.m < -- > v.m).[10] A second constraint indicates that the verb constituent's meaning is bound to an evoked AnimateMotion schema (anmotion <--> v.m). This second constraint indicates that in order to serve as the verb constituent, a verb has to identify its meaning with AnimateMotion. And a third constraint identifies the mover of the evoked AnimateMotion schema with the mover of the Locomotion schema (self.m.mover <--> anmotion.mover).

[9] One question that may arise at this point is why we don't just broaden the constraint on IntransitiveLocomotion1's verb constituent. One reason is that it would not allow us to specify the different relations that different verb meanings have to the event type, nor how these meaning 'fuse' with one another. Additionally, there is the issue of capturing local generalizations, which is related to the idea of how we learn A-S constructions in the first place.

[10] Use of the 'ignores' keyword helps indicate that the subcase is a radial category extension of the central case 'parent' that shares most – but not all -- of the parent's structure. This method aims to indicate cognitively-plausible relations using the tools provided by the ECG formalism. Note, though, since these subcases do not include all of the structure of the parent, this invalidates the assumption of substitutability that is associated with strict inheritance.

```
construction IntransitiveLocomotion2
  subcase of IntransitiveLocomotion1
  constructional
   constituents
        v : Verb
        pp: Spatial-PP
   constraints
        self.features <--> v.features
 form
   constraints
        v.f before pp.f
 meaning: Locomotion
   evokes EventDescriptor as ed
   evokes AnimateMotion as anmotion
   constraints
      self.m <--> ed.eventType
      v.m  <--> ed.profiledProcess
      self.m <--> v.m
      ignore self.m <--> v.m
      anmotion <--> v.m
      self.m.mover <--> anmotion.mover
      self.m.process2.spg  <--> pp.m
      self.m.mover <--> ed.profiledParticipant
```

Figure 4.7 The IntransitiveLocomotion2 construction. (Inherited structure in gray)

4.4.2.2 Analysis of *She wriggled into the room*.

She wriggled into the room, in its best-fitting interpretation, instantiates all of the same constructions as *She walked into the room*, except:

- The verb construction is WrigglePast (rather than WalkPast)
- The A-S construction is IntranstiveLocomotion2 (rather than IntranstiveLocomotion1)

The unification of these instantiated constructions is similar to the previous example, as is the SemSpec this unification produces.

One important difference is that in the SemSpec for the current example, the profiledProcess role of the EventDescriptor schema is bound to AnimateMotion, not Locomotion. Therefore, unlike the 'central case' situation, the profiledProcess is not the same as eventType: the verb only profiles a portion of the event as a whole.

Significantly, this SemSpec specifies that the actor that performs the animate motion routine ('wriggling') is also a trajector who changes location with respect to a landmark (in this case, a room that is conceptualized as a bounded object). Thus, even though it is not part of the 'core' meaning of *wriggle*, this sentence is analyzed as a description of an event in which the animate mover changes her location.

As with IntransiveLocomotion1, instances of the IntransiveLocomotion2 A-S construction can be used in the compositional analysis of many other sentences, as long as the other constructions instantiated in these sentences meet the constraints specified by this A-S construction. For IntransiveLocomotion2, this means that the instantiated verb construction is required to identify its meaning with AnimateMotion. Consequently, it is possible to analyze sentences such as *She danced /writhed /shimmied /flailed /slouched across the stage* as describing 'locomotion' events, even if the grammar only includes constructions in which these verb forms are paired with AnimateMotion meaning. It is important to note that while these analyses indicate that we do not necessarily <u>need</u> to posit additional 'locomotion' verb constructions for these verb forms, neither does it preclude us from doing so; whether to do so (or not) is largely an empirical question that can best be answered through the examination of additional data.[11]

4.4.3 Inanimate translational motion: *The box slid / spun into the room*

Thus far, two type of examples have been examined, and I have described the closely related A-S constructions they instantiate.

(9) She walked / sauntered / sprinted into the room. (IntransitiveLocomotion1)
(10) She wriggled /danced / shimmied into the room. (IntransitiveLocomotion2)

Next, let us consider two additional sentences of the same general form as these other examples:

(11) The box slid into the room.
(12) The box spun into the room.

As with examples (9) and (10), examples (11) and (12) describe a situation in which a mover changes location. And, the prepositional phrase provides information about the mover's path of motion. However, unlike the earlier examples, the mover is not animate, and is therefore presumably not executing any sort of motor-control routine to control its motion. Thus, the type of event described by these examples differs in some significant ways from the ones associated with the previous examples.

The verbs in these examples are also different than those in the previous examples in terms of their 'core' meaning that is consistently present across a range of different uses.

- *Slide* (and verbs such as *inch*, *hurtle*, *fall*, and *skid*) are consistently used to describe motion events that involve a change in mover's location, but this motion

[11] Note that while these analyses indicate that we do not necessarily <u>need</u> to posit additional 'locomotion' verb constructions for these verb forms, neither do they preclude us from doing so; whether to do so (or not) is largely an empirical question that can best be answered through the examination of additional data.

is not always necessarily controlled by the mover (e.g. *The box slid into the room; The landslide inched towards the houses*.)

- Verbs such as *spin*, *twist*, and *shake* are also used to describe motion events in which the motion is not necessarily controlled by the mover. However, unlike the first set of verbs, this motion also does not necessarily involve a change in the mover's location (e.g. *The top spun in place; The leaves shook on the trees*.)

For each of these types of verbs, this core meaning can be represented as a construction that pairs a particular verb form with a motion-related schema. The 'translational motion' meaning of verbs such as *slide*, etc. is represented using MotionAlongAPath. And the meanings of verbs such as *spin* are represented using the more general Motion schema (a schema which does not include SPG structure). Note that unlike verbs such as *walk*, *saunter*, *dance* and *wriggle*, the schemas used to represent the core meanings of these verbs do <u>not</u> include motor-control structure.

Hence, examples (11) and (12) differ from the ones examined earlier, such as those in (9) and (10), with respect to two of the elements that were identified as being relevant to the definition of A-S constructions: (a) event type, and; (b) verb meaning (semantic class). Because of this, the current pair of examples cannot be analyzed using either of the 'intransitive locomotion' A-S constructions discussed thus far. However, they can be analyzed using two A-S constructions that are only minimally different from the previous ones.

The first of these A-S constructions, IntranstiveMotionAlongAPath1 (Figure 4.8), has the same specifications as IntransitiveLocomotion1 except that (as its name indicates) it identifies its meaning with the MotionAlongAPath schema rather than the Locomotion schema. As with other central case A-S constructions, the verb constituent of IntranstiveMotionAlongAPath1 has the same schematic conceptual structure as does the A-S construction itself (self.m <--> v.m). In this case, this means that verb constructions which identify their meaning with MotionAlongAPath can serve as the verb constituent of this construction. This includes verb constructions for the core meanings of *slide*, *inch*, *hurtle,* etc. In this A-S construction, the profiledParticipant role is bound to the mover role of MotionAlongAPath. Unlike the mover role in Locomotion, this mover is <u>not</u> constrained to be an animate entity.

```
construction IntransitiveMotionAlongAPath1
  subcase of ArgStructure
  constructional
     constituents
         v : Verb
         pp: Spatial-PP
     constraints
         self.features <--> v.features
  form
      constraints
          v.f before pp.f
  meaning: MotionAlongAPath
      evokes EventDescriptor as ed
      constraints
          self.m <--> ed.eventType
          v.m  <--> ed.profiledProcess
          self.m <--> v.m
          self.m.process2.spg  <--> pp.m
          self.m.mover <--> ed.profiledParticipant
```

Figure 4.8 The IntranstiveMotionAlongAPath1 A-S construction (instantiated in examples such as *The box slid into the room*).

As with the intransitive locomotion A-S constructions, we can also define an extension to this central case in which the meaning of the verb is related to, but not the same as the A-S construction meaning (MAAP). This second A-S construction, IntranstiveMotionAlongAPath2 (Figure 4.9) is defined as a subcase of IntranstiveMotionAlongAPath1. It is the same as its parent except that it specifies that the meaning of the verb constituent is bound to an evoked Motion schema portion of the MotionAlongAPath schema (motion <--> v.m). This constraint effectively serves to constrain the class of verbs that can occur as verb constituent to ones which identify their meaning with Motion (e.g. motion verbs like *spin*, *twist*, etc.).

```
construction IntransitiveMotionAlongAPath2
  subcase of IntransitiveMotionAlongAPath1
  constructional
     constituents
         v : Verb
         pp: Spatial-PP
     constraints
         self.features <--> v.features
  form
      constraints
          v.f before pp.f
  meaning: MotionAlongAPath
       evokes EventDescriptor as ed
       evokes Motion as motion
       constraints
          self.m <--> ed.eventType
          v.m  <--> ed.profiledProcess
          self.m <--> v.m
          ignore self.m <--> v.m
          motion <--> v.m
          self.m.mover < -- > motion.mover
          self.m.process2.spg  <--> pp.m
          self.m.mover <--> ed.profiledParticipant
```

Figure 4.9 The IntransitiveMotionAlongAPath2 constructions (instantiated in examples such as *The box spun into the room*).

The central case IntransitiveMotionAlongAPath1 can be used to analyze sentences containing translational motion verbs, such as *slide*, *skid*, *fall*, etc., as in (13).

(13) The box slid /skidded / fell into the room.

And its extension, IntransitiveMotionAlongAPath2 can be used to analyze sentences containing Motion verbs, as in (14a-d):

(14) a. The box spun into the room.
b. Snowflakes whirled through the air
c. The ball rolled under the table.
d. My laptop shook across the table.

In both cases, the referent described by the subject NP is <u>not</u> constrained to be animate.

The SemSpecs for *The box slid /spun into the room* are similar in many respects to those for *She walked / wriggled into the room*. They differ, however, as to the type of schema that is bound to the eventType role: for the current examples, this event type is MotionAlongAPath which, unlike Locomotion, does not include motor-control structure. The SemSpecs also differ as to two of the bindings to the mover role. For one thing, the mover is bound to a different kind of referent (‘the box’, not she’). For another, it is not bound to the actor role of MotorControl. Bindings to the landmark role, which is the other event participant expressed in these sentences, are the same as in the prior examples.

The SemSpecs for *The box slid /spun into the room* indicate that these sentences describe a situation in which an object (the box) moved from a location outside a landmark (the room), to a location in the interior of that landmark. This event is described from (and should be simulated from) the perspective of this mover. In each case, the verb supplies additional information about the situation (e.g. indicates that box was in contact with a surface and/or that it is changed orientation). Unlike the SemSpecs for the earlier examples, these SemSpecs do not include structure that would support the inference that the mover was exerting effort and was in control of the speed and/or direction of motion. Thus, the SemSpecs for these different sentences capture important differences between animate and inanimate motion events.

One question that might come up at this point is why the A-S constructions instantiated in the first set of locomotion sentences are not handled as additional extensions of the IntransitiveMotionAlongAPath1 construction. That is rather than defining a separate set of IntransitiveLocomotion constructions whose meaning is identified with Locomotion, why not define additional subcases of IntransitiveMotionAlongAPath1 in which the verb constituent would have richer schematic structure than the A-S construction (e.g. self.m <--> v.m.MotionAlongAPath). One reason that I did not follow this approach is that I view scenes involving goal-directed motions of people as more humanly relevant and experientially basic than ones with inanimate entities. Consequently, it seems more cognitively plausible to view the A-S construction instantiated in sentences such as *She walked into the room* as a central member of a radial category than as an extension. Additionally, as I show below, is that this approach facilitates the definition of further extensions to IntransitiveLocomotion1 that can be used to support a 'self-controlled motion' interpretation of sentences which include verbs that do not include this as part of their core meaning.

4.4.4 Multiple interpretations: *She slid / spun into the room*.

In addition to describing the motion of inanimate entities, verbs such as *slide*, *inch*, and *spin* are also often used to describe the motion of animate entities, as shown in (15).

(15) She slid / inched /spun / rolled into the room.

One possible constructional interpretation of these sentences is that they instantiate one of the IntransitiveMotionAlongAPath A-S constructions described above. In such an interpretation, the SemSpecs will be essentially the same as they would be if the subject NP described an inanimate referent, such as a box, with the only difference concerning the referent itself. Therefore, while these SemSpecs would indicate that the mover is an animate entity, they would not include schematic structure that would support assumptions that the mover is executing a motor-control routine of some kind that would enable her to control her speed, direction, and/or location changes.

In some cases, at least, this seems to be an apt characterization of the event the sentence is being used to describe. For instance, if we add the word 'helplessly' to these examples, it seems clear that the mover, though animate, is not in control of her motion, as in *She helplessly slid / inched /spun / rolled into the room.* In these cases, an analysis that these sentences instantiate an IntransitiveMotionAlongAPath A-S construction yields an appropriate SemSpec.

In other cases, though, we are very likely to assume that the mover is in fact control of her motion, as in sentences such as *The dancer* (*carefully / gracefully) slid / inched /spun / rolled across the stage.* One way to indicate that these sentences support additional inferences about the mover's control of motion is to analyze them as instantiating an A-S construction with Locomotion meaning. This approach requires that the grammar include a couple of additional 'intransitive locomotion' A-S constructions: IntransitiveLocomotion2 and IntransitiveLocomotion3.

Both of these A-S constructions can be regarded as minimally different extensions of the central case IntransitiveLocomotion1 construction described earlier (Figure 4.4). The only difference these subcases have to their parent concerns the semantic constraints on their verb constituent and its relation to the A-S construction's meaning. As with IntransitiveLocomotion2 (used to analyze sentences such as *She wriggled into the room*), these extensions specify that the verb constituent does not have the same schematic semantic structure as the A-S construction (ignore self.m <--> v.m).

Recall that Locomotion is a complex process, and that one of its subprocesses (process2) is MotionAlongAPath, which is itself a subcase of Motion. To specify the relevant relation for one extension, verb meaning is therefore bound to the MotionAlongAPath element of the A-S construction's meaning (self.m.process2 <--> v.m). Verbs which identify their meaning with MotionAlongAPath, such as 'slide', can serve as a verb constituent in this A-S construction. For the other extension, verb meaning is bound to an evoked Motion schema, indicating its commonality of meaning with the motion subcomponent of this second subprocess. Verbs which identify their meaning with Motion, such as 'spin', can serve as a verb constituent in this A-S construction.

Because Locomotion constrains its mover to be an animate entity, only sentences in which the subject NP referent describes an animate referent will be analyzed as instantiating these intransitive locomotion A-S constructions (e.g. *She slid into the room* but not *The box slid into the room*). Note though, that such sentences will also meet the constraints of the intransitive 'motion along a path' A-S constructions (i.e. IntransitiveMotionAlongAPath1 and 2). Consequently, two different and competing interpretations of such sentences are possible, each of which will produce somewhat different SemSpecs. Additional factors would need to be considered in order to determine which interpretation is the best-fitting one in a particular context.

These additional 'intransitive locomotion' A-S constructions indicate that a particular pattern of constructions (animate entity NP > motion verb > path pp) is consistently associated with the description of 'locomotion' events. This is a relatively local generalization, one which may be part of a broader generalization concerning the combination of animate entities plus motion verbs. For instance *She slid* and *She spun* may also be understood as descriptions of animate motion. We could argue that this is itself a basic cognitive pattern, e.g. that we recognize that animate entities often are in control of their own motion. At the same time, though, it seems to be a fact about English that verbs which can be used to describe the motion of inanimate entities (which are not in control of their motion), can also be used to describe the motion of animate entities that are in control of their motion. The additional extensions to IntransitiveLocomotion1 serve to include this fact as part of the current grammar.

4.5 Summary and Remarks

A compositional construction-based analysis of sentence meaning involves the determination of which constructions a given sentence instantiates, how these constructions unify with one another, and how the meanings of these constructions are integrated with one another to indicate the meaning of the sentence as a whole. In ECG, this integrated meaning is in the form of a SemSpec that provides parameters for the simulation of the situation described by the sentence. For the sentences being examined here, these parameters should include information about the 'content' of the event being described (e.g. the type of event, who the participants are, and what they are doing) as well as information about how this event is conceptualized (e.g. where attention is focused, and from which event participant's perspective the event should be simulated).

In this chapter, I examined two types of constructions that play important parts in this integration process. One is the Declarative construction, which represents a clause-level pattern present in declarative sentences such as the ones examined here. This pattern involves a 'subject' and a 'predicate' (subj and fin constituents) that are used to describe some kind of event, from the perspective of the referent described by the 'subject' NP. The other type of constructions are A-S constructions, which are a crucial part of the sentence analyses presented throughout this dissertation. The specific A-S constructions examined in this chapter represent a pattern in which a 'motion' verb (from some particular semantic 'class'), in conjunction with a 'path' prepositional phrase, is used to describe a particular type of motion-related event. In addition, these A-S constructions indicate that these events are described from the perspective of the 'mover' participant in the event. In sentences that instantiate these two kinds of constructions, constructional unification result in a binding between the 'profiled' event participant role specified by the A-S construction and the referent described by the 'subj' NP of Declarative (i.e. the clause's 'subject'). Thus, the 'subject' NP can be seen as expressing the (filler of) the mover role.

The analyses of sentences presented in this chapter build upon the examination of motion-related experiences (and descriptions of these experiences) presented in the previous chapter. In that chapter, I identified some conceptual elements that recur across these experiences (such as the presence of a 'mover'), and other elements that are present in some – but not all – experiences (e.g. change in location and mover's control of his motion). As I showed, different combinations of these elements can be represented using an inter-related set of motion schemas. In addition, I defined core verb constructions for various motion verbs. Each of these core constructions identifies its meaning with a particular motion schema, indicating the nature of the schematic structure that is consistently present across a range of uses of this verb form. For instance, *walk* is consistently used to describe situations in which an animate entity executes a motor-control routine in order to move himself to a different location. Accordingly, the core meaning of this verb is identified with a Locomotion schema. Since verbs like *saunter*, meanings for these verbs are also identified with *sprint*, etc. are also consistently associated with this same schematic structure, core Locomotion. In this way, it is possible to define a semantic 'class' of verbs with similar schematic structure. These verbs differ, however, as to other specific details, such as the speed of motion, nature of the motor-control routine executed, etc.

All of the sentences examined in this current chapter can be generally characterized as descriptions of motion events. However, given the finer-grained analysis of motion-related experiences presented in the previous chapter, it is possible to recognize (and represent) distinctions between the specific kinds of motion events described by different sentences. For instance, sentences such as *She walked into the room* can be characterized as descriptions of 'locomotion' events, basic humanly relevant scenes in which an animate entity executes a motor-control routine with the objective of moving and changing location). And sentences such as *The box slid into the room* can be seen as describing 'translational motion' events, in which a mover changes location, but is not (necessarily) in control of its motion. Because differences in event type are one basis for distinguishing between A-S constructions, sentences such as these are analyzed here as instantiating two different A-S constructions, one which identifies its meaning with a Locomotion schema, and the other which identifies its meaning with a MotionAlongAPath (translational motion) schema.

One key function served by a given specific A-S construction is to indicate how the meanings of its constructional constituents are integrated into the event type associated with the A-S construction as a whole. In what is presumed to be the central case, the schematic structure associated with the A-S construction is the same as that of the core meaning of its verb constituent. In this situation, the specification of the semantic relation between the A-S construction and its verb constituent is a straightforward one of schema identity (represented by a binding between the meanings of these two constructions).

This relation can be stated in a general, non-lexically-specific way, applying to all verb constructs which identify their meanings with a particular schema.

Because of the way that constructional meanings are analyzed and represented here, it is apparent in some cases that the core schematic meaning of the verb is different than that of the event type associated with the A-S construction. For instance, for *She wriggled across the room*, the sentence describes a 'locomotion' event, but the verb's core schematic meaning is one of 'animate motion', which does not include 'change in location' (SPG) structure. So in this case, the core AnimateMotion meaning of the verb differs from the Locomotion meaning of the A-S construction instantiated in the sentence. The analysis and representation of different types of motion experiences using different schemas thus facilitates recognition of differences in constructional meaning. At the same time, because these schemas are inter-related schemas it is also possible to recognize schematic commonalities of the meanings of the verb and A-S construction. For the example here, since Locomotion incorporates the structure of AnimateMotion, the two constructions have AnimateMotion structure in common. Thus, in this particular case the schematic conceptual structure associated with the verb is the same as part of that associated with the A-S construction.

In the table below (Figure 4.10) I list the event type and core meaning of the verb constituent for the different A-S constructions discussed in this chapter.

Construction name	Event type	Core verb meaning	Sentence example
IntransLocomotion1	Locomotion	Locomotion	*She walked into the room*
IntransLocomotion2	Locomotion	AnimateMotion	*She wriggled into the room*
IntransLocomotion3	Locomotion	MAAP	*She slid into the room*
IntransLocomotion4	Locomotion	Motion	*She spun into the room*
Intrans.MAAP1	MAAP	MAAP	*The box slid into the room*
Intrans.MAAP2	MAAP	Motion	*The box spun into the room*

Figure 4.10 Intransitive motion A-S constructions. (MAAP = MotionAlongAPath)

Many motion verbs can also be used in the description of other kinds of events than the ones examined here. For instance, as the sentence *She slid the box into the room* indicates, the verb *slide* can also be used in the description of events that include causal structure. As I will show in following chapters, sentences such as these can be analyzed in a similar way, as a composition of the verb's core motion meaning and additional conceptual structure. And, as in this chapter, I will show how this can be done by utilizing meaningful A-S constructions. Clearly these sentences differ from the ones examined in this chapter both as to constituency and as to the type of event being described. Consequently, to support their analysis, the grammar needs to include additional A-S constructions, as well as additional 'process' schemas to represent the causal structure present in these events. These additional elements are discussed more fully in the next two chapters.

In sum, using the approach described in this chapter, it is possible to analyze and represent various sentence contexts in which the core meaning of the verb is 'augmented' by additional schematic structure. Due to the presence of meaningful A-S constructions in the grammar, it is possible to analyze these sentences without necessarily positing additional verb constructions (i.e. ones with 'non-core' meanings). But an even more important point to be made here is that regardless of our constructional analyses of these different sentences, in order to fully capture their different meanings we need to analyze (and represent) the different patterns of conceptual composition they evidence.

Chapter Five

An Embodied Account of Force, Causation, and Affectedness

Thus far, I have focused on verb and A-S constructions that are used to describe various motion-related events. In addition, I've presented compositional constructional analyses of sentences that instantiate these constructions, such as *She walked into the room* and *The box slid into the room*. However, my larger objective is to analyze a broader range of examples, including the several 'slap' examples discussed in the first chapter, such as:

(1) a. She slapped the box (off the table).
b. She slapped at the box.
c. She slapped her hand on the box.

To do this, the grammar needs to include additional verb and A-S constructions. Especially important, it also needs to include schemas to represent the meanings of these constructions. Moreover, these schemas and constructions need to be defined such that the constructions instantiated in each of these examples will unify to produce SemSpecs that capture the different event conceptualizations associated with these examples.

Consequently, in this and the following chapters, I examine some additional semantic domains, propose schemas to represent the conceptual structure of these domains, and define verb and A-S constructions whose meanings are represented using these schemas.
In the current chapter, I focus on verbs such as *push*, *pull*, *slap*, *kick*, *cut* and *throw* and the actions they are used to describe, in which an actor forcefully acts on another entity and at least potentially affects that other entity in some way. One objective here is to define schemas that capture conceptual elements related to force, causation, and affectedness. Within this chapter, I show how these schemas can be used to represent the 'core' meanings of the verbs examined here. These schemas also play a central part in the following chapter, in which I examine transitive argument realization patterns and the event conceptualizations associated with them. That chapter includes an analysis of sentences such as *She cut / slapped / slid the box*. Then, in later chapters, I explore more complex compositions of motion/spatial structure with force/causal structure, introducing some additional schemas and constructions, and analyzing sentences such as *She slapped at the box* and *She slapped her hand on the box*.

5.1 Chapter Overview

Talmy's seminal work (1976, 1985, 2000a) provides many important insights into causation and force-dynamics and how they are expressed in language. Inspired in large part by Talmy's ideas, many linguists have theorized about the central role that causal event structure plays in patterns of argument realization (e.g. Langacker 1987, 1991; Jackendoff 1990; Croft 1991, 1998. For overview see Levin and Rappaport Hovav 2005). In addition, many of Goldberg's (1995) proposed A-S constructions have meanings that include causal structure (e.g. Cause-Move, Cause-Receive). Clearly, causation and affectedness are grammatically-relevant concepts. But what is the exact nature of these concepts, and how can they best be formally represented as schemas in an ECG grammar?

In this chapter, I discuss how we can analyze force, affectedness and causal event structure within the theoretical framework provided by NTL. One fundamental NTL assumption is that understanding the description of a given event involves activation of neural structure that is closely related to that which is active when we perform, observe, plan, and/or imagine such an event. This suggests that one way to gain insights into how we conceptualize causal events is to consider how we actually experience them. A further assumption we can make is that our richest and most complex experiences of events are ones in which we are an active, direct participant in the event. For causal events, then, our richest experiences are most likely those associated with a prototypical causal scenario, in which a person forcefully acts on another entity with the objective of affecting this entity in some way. This includes, for instance, specific experiences like pushing something in order to move it to a different location.

My basic premise, then, is that a rich, embodied understanding of causal scenarios (and descriptions of such scenarios) arises from the utilization of neural circuitry associated with direct experiences of such scenarios, especially experiences in which we are an active participant. However, only some components of this rich structure are 'grammatically-relevant'. That is, only certain schematic elements of these experiences are regularly specified in descriptions of such scenarios.

Within the NTL simulation-based model of language understanding, we can view this distinction between rich experiential structure and schematic grammatically-relevant structure as follows. First, recall that one basic assumption is that declarative sentences such as the ones being examined here are descriptions of some (conceptualization of) an event or scene. The SemSpec that results from analysis of these sentences is in the form of basic, relatively sparse 'stage directions' for this scene, indicating for example, who the event participants are, what sort of activity they are engaged in, and from which participant's perspective the scene should be conceptualized. In the simulation phase of the understanding process, the scene is actually enacted (simulated). Because this simulation process utilizes the rich, complex conceptual structure associated with our actual experiences of similar scenes, the enactment of the scene will be much richer and complex, fleshing out the skeletal stage directions provided by the SemSpec.

One question that arises is which aspects of rich experiential structure are typically singled out to serve as stage directions for the simulation of these scenes? As described in this chapter, I make the general assumption that in descriptions of various kinds of basic actions, the elements we consistently focus on and/or express are ones which are directly relevant to the actor's accomplishment of whatever objective he has for performing the action. For instance, for actions in which the actor's objective is to affect another entity in some way, the focus will be on parameters relevant to achieving that effect, such as the amount of force the actor transfers to the other entity, and the effects that are caused by this force transfer. Thus, for such actions the focus is on schematic elements related to force, causation, and effect.

By defining schemas for these actions that incorporate these elements, we can indicate how these seemingly abstract 'disembodied' concepts are grounded in everyday experiences. Moreover, we can do so as part of a larger story about how relatively schematic specifications provided by the constructions instantiated in a sentence which describes a causal event can give rise to a much fuller 'understanding' of that event.

As I show, the general schematic structure associated with these actions can be analyzed and formally represented as 'composite', internally complex schemas which integrate the structure of other, more 'primitive' schemas. These schemas and roles capture similarities and differences between the meanings of different 'transitive' verbs, such as *push* and *cut*. Significantly, these roles also reflect the various 'clusters' of properties commonly associated with 'agent' and 'patient' roles. Moreover, as we will see in later chapters, these schema(s) play a key part in the compositional analysis of transitive sentences, helping to capture similarities and differences of event conceptualizations associated with the transitive argument realization pattern.

The basic methodology I employ in this chapter is similar to that of Chapter 3, in which I examined motion-related verbs and schemas. To start, I look at verbs such as *push* and *cut* that describe specific types of actions in which an actor transfers force to and at least potentially affects another entity. Then, I consider in some depth how we experience the actions designated by these verbs, and define schemas that represent elements of these actions that are relevant to grammar. Following this, I define verb constructions whose meaning is represented using these schemas. Sentences which describe causal events, and the A-S constructions these sentences instantiate, are examined in later chapters.

5.2 Examination of linguistic data

There are many different verbs that describe actions in which an actor executes a motor-control routine that allows him to control some part of his body. The sentences in which these various 'action' verbs appear are often similar in some important respects. For instance, consider the following:

(2) a. He smiled.
b. He walked.
c. He pulled the rope
d. He cut the rope

Each of these examples describes an event in which a person performed some kind of action. Furthermore, in each case this actor participant is expressed by the 'subject' NP. However, sentences containing action verbs such as these often differ as to what additional participant roles, if any, they express. As these examples illustrate, verbs such as *smile* and *walk* frequently occur in intransitive sentences that do not express any additional participant roles. Whereas 'physical interaction' verbs (such as *pull* and *cut*) typically occur in transitive sentences in which a 'direct object' NP expresses a second participant role.

Significantly, this additional participant is conceptually present even when these 'physical interaction' verbs appear in different argument realization patterns. For instance, if we hear the sentence *Sara pulled, but nothing happened*, we assume that Sara was pulling <u>something</u>. Similarly, for an example like *Sara cut, while I diced* we infer that <u>something</u> is being chopped and diced even though it is not explicitly expressed in the sentence. [1] Smiling and walking may, in some situations, involve another participant entity (e.g. *He smiled at her*, *She walked towards him*.). But, when no participant is expressed, we do <u>not</u> necessarily assume that the event being described necessarily includes a second participant. We can, for instance, easily imagine a person smiling or walking without any other entities being involved. Thus, these different types of verbs contrast not only in terms in their of their typical argument realization patterns, but also in terms of the participant roles that are conceptually present in different uses of these verbs.

These differences suggest that in addition to including an 'actor' role of some kind, the schemas used to represent the meanings of verbs such as *pull* and *cut* should also include an additional participant role. But what is significant about the actions described by these verbs is not just that an additional entity is present, but that the actor is physically acting on and potentially affecting this entity in some way. In

[1] This is a case of Indefinite Null Instantiation, in which a particular participant is conceptually present but only optionally expressed (e.g. see Fillmore et al. 2003, pages 245-246)

terms of semantic roles, these two central participants might therefore be characterized as an ‘agent’ and a ‘patient’.

What exactly are ‘agents’ and ‘patients’, and how can these roles be defined within the context of motor-control actions? The importance of force transmission as a component of event structure has been widely recognized by many linguists (e.g. Talmy 1976, 1985, 2000a; Langacker 1987, 1991; Jackendoff 1990; Croft 1991, 1998; Rappaport Hovav and Levin 2001, Levin and Rappaport Hovav 2005). One key element that can be used to distinguish agent and patient roles from other types of semantic roles is the presence of a force or energy transmission from the agent to the patient. Langacker (1991), for instance, describes an archetypical agent as “a person who volitionally carries out physical activity which results in contact with some external object and the transmission of energy to that object” (p. 210). Langacker continues, “The polar opposite of an agent is an inanimate ‘patient’, which absorbs the energy transmitted by externally initiated physical contact and thereby undergoes some change of state.” Given such a characterization, it thus appears that to capture the properties commonly associated with agent and patient roles we need a schema that includes:

- An actor that performs an action that transfers force to another entity
- Another entity that is affected by the reception of this transferred force

Such a schema would be similar to other motor-control schemas in that it includes an ‘actor’ role. But, it differs in that this action involves transfer of force to another entity, which is thereby affected by this action.

One immediate complication for this approach is that ‘forceful action’ verbs such as *push*, *pull*, *kick, slap, cut,* and *crush* exhibit some differences with respect to the types of expectations of affectedness that they support. Based on these differences, we can divide these verbs into two groups.

For one group of verbs, such as *cut*, *crush*, *slice*, and *chop*, we have strong expectations that the described action will have a particular kind of effect on the entity which is acted upon. Consequently, some expressions of the end states of this affected object seem more felicitous than others. Consider:

(3) a. He cut the rope into pieces / ? flat
    b. He crushed the can flat / ? into pieces

For each example, the first result accords with our expectations, while the second seems odd.[2] Furthermore, it does <u>not</u> make sense to indicate that there was <u>no</u> effect of any kind. For instance:

(4) a. He cut the rope, but the rope was unaffected by his actions.
    b. He crushed the can, but the can was unaffected by his actions.

[2] Even if we can imagine a situation where such a description is appropriate, the effects here are most likely secondary ones. E.g. when he crushed the can, it ended up breaking up into pieces.

For verbs such as these, then, affectedness of the other participant seems to be a necessary entailment, even when the particular effect is not described in the sentence.

Verbs in the second group, such as *push*, *pull*, *drag, kick*, *punch*, and *tap*, can be used to describe a much wider range of effects, e.g.:

(5) She kicked / punched the box flat / into pieces / across the room

Additionally, the types of effects we are likely to infer often depend a great deal on the nature of the entity being acted upon. To illustrate this point, think for a moment about what effects we expect for *He punched the pillow / vase / cat / wall*. Thus, for a given verb of this kind, there does not seem to be any specific effect that is consistently associated with its different uses. Moreover, inferences of affectedness are often defeasible. This is apparent in the sentence *She tapped her watch violently, but the second hand would not move* [3], which indicates that the actor performed an action with the intention of affecting her watch, but was unsuccessful. Similarly, the sentence *She kicked the wall, but nothing happened to it* also indicates non-affectedness (though in this case we may expect that the actor was affected -- ouch!). In short, for verbs in this second group, while we commonly expect that the 'acted upon' participant is (noticeably) affected in some way, this is a defeasible inference, not a necessary entailment.

Based on a comparison of English and Japanese resultatives, Washio (1997) proposes a similar distinction, observing that verbs such as *drag* specify that the other participant is 'affected' but do not specify how or whether it changes, while verbs such as *sharpen* (or *cut*) specify that this participant undergoes some specific change of state.

Another noteworthy point is that for this second set of verbs, expectations of affectedness are often considerably decreased when the acted upon entity is expressed using a prepositional object NP rather than a direct object NP. For instance, when we imagine the situation described by sentences such as the following, we are not likely to consider what consequent effects the actor's actions may have had on the table:

(6) a. She pushed on / against / at the table
b. She pushed off from the table.
c. She slapped her hand on the table

Moreover, as Levin and Rappapport Hovav (2005) note, there is some evidence that the non-agent participant of verbs such as these is not consistently expressed as a direct object in all languages, appearing instead in forms such as those in (6a). As illustrated by (7a – b), verbs like *cut* and *crush*, on the other hand, do not generally occur in sentences of the forms shown in (6a – c).

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[3] Accessed 5/18/10 on www.hmssurprise.org/Fiction/mvt.html

(7) a. ?* She crushed at / on / against the can.[4]
b. ?*She cut the knife into the bread. [5]

This further indicates that for verbs such as *cut*, the affectedness of the 'acted upon' entity is a central and necessary part of our understanding of the situations they are used to describe.

Sentences such as (7a-b), in which the 'acted upon' entity is expressed as part of a prepositional phrase, will be examined more fully in later chapters. The main point here is that such examples provide further support for the idea that there are significant differences between these two different types of 'physical interaction' verbs with respect to the types of inferences we make concerning the effects the action has on the 'acted upon' entity.

In sum, all of these 'physical interaction' verbs are often used in sentences in which we infer that this other participant is affected in some way by the actor's actions. But for many of these verbs (e.g. *kick*[6], *push*), there is no one specific type of effect that is consistently associated with different uses of the verb. And in some cases, these verbs may be used to describe situations where there is <u>not</u> necessarily any effect to this other participant.

As I will discuss more fully in the following sections, these differences between these two groups of verbs can be captured by representing their meanings using two different, but related, schemas. Both of these schemas include structure related to an action that involves transfer of force to another entity. But, one of these also includes structure relating to the 'effect' that this force transfer has on this other entity. Thus, one can be characterized as including:

- An actor that performs an action that transfers force to another entity
- An 'acted upon' entity that receives this force

While the other includes:

- An actor that performs an action that transfers force to another entity
- Another entity that is <u>affected by</u> the reception of this transferred force

The first of these schemas can be used to represent the meanings of verbs such as *kick* and *push*, which specify something about the 'force-application' action itself, but do

---

[4] There are some rare uses of 'cut at'. But, rather than indicating a complete lack of affect, these seem to indicate that the actor did not accomplish full affectedness goal. E.g., *She cut at the rope, but didn't sever it*.

[5] A google search (made on 5/5/10) for "cut the knife into" yields only 472 hits, many of which are duplicates, or are otherwise not relevant.

[6] Note that *kick* is also used to describe leg motion actions that are not necessarily performed in relation to another event participant, as in *The baby / swimmer kicked her legs*. This indicates the need to define two separate Kick constructions, one which has a 'physical interaction' sense, and another that has a 'leg motion' sense.

not necessarily specify anything about the consequent effects such actions may have. Nonetheless, given that a transfer of force occurs, we are still likely to expect that the recipient of this force will be affected in some (perceptible) way. The second schema can be used to represent meanings of verbs which do specify some particular effect that occurs to the 'patient' (e.g. *cut*, *crush*). Thus, the grammar will include two different but related schemas that provide different but related 'acted upon' entity roles for these verbs, and which support different inferences about the effects these actions have on this acted upon entity. Moreover, these schemas also play a very important part in the analysis of transitive A-S constructions, as I show in the next chapter.

While this linguistic examination gives some indication of the conceptual elements these schemas should include, by itself it does not really tell us much about how to analyze and formally represent them. Moreover, it is important to keep in mind that my objective is not just to define schemas that can be used to formally represent the meanings of these verbs; my objective is to define schemas that reflect the (linguistically-relevant) schematic regularities present in the actions described by these verbs. Consequently, in addition to looking at different uses of these verbs, it is also essential to examine the actions these verbs describe. And, as part of this examination, we need to seriously consider the questions of how and why these actions incorporate seemingly abstract concepts such as force, causation and affectedness.

5.3 Schematic conceptual structure associated with motor-control actions

As noted earlier, a central assumption of simulation semantics is that we understand descriptions of different motor-control actions by utilizing structure that is similar to that which is active when we perform, observe, plan, and/or imagine such actions. The work in this dissertation also builds on another key NTL assumption: although the rich structures activated in specific experiences will differ as to their details, we can recognize (and represent) 'schematic' components that recur across these different experiences. Furthermore, these schematic components are central to the constructional analysis of conceptual composition presented here.

In Chapter 3, I described a basic MotorControl schema (figure 3.10) that represents schematic structural elements that recur across a wide range of motor-actions, all of which involve an actor executing a motor-control routine that allows him to control some part of his body. This schema includes roles for the actor, the body part this actor uses, the amount of effort exerted, as well as including an x-net role for the routine the actor is performing.

By using this schema as part of the meaning representation of different action verbs, we can capture commonalities in their meaning. Especially important to the current work, this helps indicate that each of these verbs is associated with certain semantic roles (actor, effector) and that we can consistently make certain assumptions about the actions described by these verbs (e.g. that they require some exertion of effort by the actor). This schema does not, however, provide all the semantic roles we associate with many action verbs. Therefore, to represent the meanings of such verbs, additional motor-control schemas are also needed.

In order to define these additional motor-control schemas, it is necessary to identify additional types of recurrent schematic elements that may be present in motor-control actions. What sorts of schematic structural elements are relevant? My hypothesis is that for motor-control actions, it is especially important to recognize and represent elements that are related to the objectives the action is being used to accomplish. More specifically, we need to consider what main things the actor needs to attend to in order to achieve a particular kind of objective.

For instance, in Chapter 3 I examined various 'locomotion' verbs, all of which describe actions in which the actor executes a motor-control routine with the objective of moving his body to another location. For these actions, the relevant roles and inferential structure relate to these objectives (i.e. the actor's motion and changes in location). Furthermore, in such actions, these different elements are inter-related with one another (e.g. as the actor executes the motor-control routine, his location changes). As I showed, the complex schematic structure associated with these types of actions can be represented by a composite Locomotion schema, which integrates the structure of the basic MotorControl schema with that of Motion and SPG schemas. This Locomotion schema can be used in the meaning representations of many different verbs that are used to describe such actions, such as *walk*, *sprint*, *saunter*, etc.

The verbs being examined in the current chapter describe actions which are commonly performed with the objective of affecting another person or object in some way. To perform such actions, in addition to attending to the part(s) of his body being used to perform the action, the actor also has to attend to the 'acted upon' participant. Consequently, the schemas used to represent the meanings of these verbs need to include more structure than is contained in the basic MotorControl schema. For one thing, they clearly they need to include an additional participant role. But they also need to include structure related to the transfer of force to this other participant, and the effects this force transfer causes. As I stated at the beginning of this chapter, although force, causation and affectedness are often viewed as abstract 'disembodied' concepts, I argue that we can better understand these concepts and their embodied grounding by examining them within the context of the actions described by the verbs being examined here.

In the sections which follow, I take an incremental approach to the analysis and representation of motor-control actions that involve the transfer of force and potential effects to another person or object. There are three main parts. First, is an examination of force application actions, absent any particular consequent effects these actions may have. This includes an analysis of the types of conceptual structure(s) that may be associated with these actions, and schemas to represent them. Second, these actions are examined within a larger 'cause-effect' gestalt. Specifically, I look at force application actions that are performed with the immediate goal of physically affecting another entity in a particular way. For these 'cause-effect' actions, I examine the sorts of schematic elements that regularly recur, and present a schema to represent them. Third, I discuss verb constructions whose meanings are represented using these two schemas. Consistent with the analysis present in the previous section, these verbs are divided into two basic categories: (1) those that specify the type of action that is performed (e.g. *kick*, *squeeze*); and (2) those that specify the type of effect that results from a forceful action (e.g. *cut*, *crush*).

5.4 Force Application

In this section, I discuss some evidence regarding an additional participant role that is an integral part of some motor-control structures. In view of this evidence, this role is included as part of a ForceApplication schema, which is a subcase of MotorControl. Next, I look at concepts of contact and force-transfer, discuss how these concepts may be 'embodied', and propose additional schemas to represent their schematic structure. By integrating the structure of these additional schemas, ForceApplication represents the recurrent schematic structure present in actions in which an actor performs an action that transfers force to another 'acted upon' entity.

5.4.1 An extra participant role

Let us start by examining one of key elements that distinguishes actions such as pushing, grasping, and slapping from many other motor-control actions: the presence of an additional participant that the actor contacts and interacts with in some particular way. First, consider the role this participant plays with respect to the actor's performance of such actions. To successfully perform an action such as slapping or grasping, an actor needs to adjust this motor-control routine in accordance with some of this object's properties. For example, the way we shape and orient our hand to grasp something depends on the shape and orientation of the thing to be grasped.

There is neuroscientific evidence that suggests which motor-control regions contain neurons that are sensitive to information that aids this process. Within the network of motor-control areas, some neurons are activated by the sight of objects. While neurons in different parts of this network may respond to somewhat different sets of object properties, as a whole this network seems to use the physical properties of the object to select an appropriate motor schema for interacting with that object (Murata et al 1997; Sakata et al., 1998; Murata et al 2000; Nelissen et al 2005). For instance, for "graspable" objects, object properties that determine selection of the type of grip and the orientation of the wrist are relevant (Raos et al., 2006). These properties appear to include the object's 3-D shape and its orientation, but not its specific identity. These neurons, termed 'canonical' neurons, thus appear to respond to the presence of the entity that an actor acts upon.[7] But, while these neurons are sensitive to certain schematic properties of these entities, their specific identity does not appear to be relevant. Thus, canonical neurons can be viewed as processing information related to an additional motor-control participant role, that of the 'acted upon' entity.

As a first step to representing 'force-application' actions, we can define a schema that is related to the basic motor-control schema introduced in Chapter 3 (figure 3.10), but which also includes this additional participant role. Defining this new ForceApplication schema as a subcase of MotorControl indicates that it has all the same basic structure as other motor-control actions. As a subcase, ForceApplication will inherit MotorControl's roles: actor, effector, x-net (motor-control routine), and effort. In addition, we can add a new role for the additional participant: actedUpon.

```
schema ForceApplication  // partial version
   subcase of MotorControl
   roles
      actor
      effector
      effort
      actedUpon: @entity
      x-net: @forceapplication
```

Figure 5.1 The ForceApplication schema, preliminary version (inherited roles shown in gray).

Thus, in accordance both with linguistic and neural evidence, the ForceApplication schema shown in figure 5.1 includes participant roles both for the actor performing the action and the entity that the actor is acting upon. But, in addition to supplying a role for the acted upon entity, there is also a need for structure that will support some of the key entailments and inferences associated with experiences and descriptions of these actions. For example, as discussed in an earlier section, *He pushed the cup* entails he contacted and applied some amount of force to the cup.

To support such inferences, the schema associated with actions such as pushing, squeezing, kicking, etc. should ideally reflect the fact that these actions involve physical contact between the actor and the entity the actor is acting upon and that,

[7] While many of these findings are based on research performed on monkeys, research on humans supports the presence of similar structures in humans (Rizzolatti et al., 1996; Grefkes et al, 2002; Grèzes et al 2003).

moreover, there is some transfer of force from the actor to this other entity. There are various ways one might go about analyzing and representing contact and force interaction. But, as already mentioned, the goal for this work is to examine these concepts within an 'embodied' context, in which they are part of a richer experiential gestalt.

5.4.2 Experience of force

How do we experience force? One way to approach this question is to consider some of the ways that experiences of actions that involve force transfer may differ from those that do not. Imagine, for instance, the action of pushing a cup across a table. Then imagine the same motor-control action, but without the cup being present. The two experiences will be similar in many respects. In each case, the actor executes a routine that will (presumably) involve the activation of the same muscle groups, e.g. a routine that straightens the actor's arm. And in each case, some amount of exertion is required. Thus, both actions contain structural elements that are represented in the basic MotorControl schema (i.e. both include an actor, a motor-control routine, some effector used to carry out that routine, and the exertion of some amount of effort).

However, there will also be some significant differences between the actor's experiences in the two scenarios, with these differences extending beyond the mere presence or absence of an additional object. These differences include the following elements.

- Contact. In the first (forceful) situation, there will be experiences related to contact between the actor and the other object, in this case, a cup. This contact can be perceived in several ways: visually (e.g. the actor's hand is immediately adjacent to the edge of the cup); tactilely (the actor feels the cup); and through secondary neural structures, in which cues of contact for self, others, or even inanimate entities lead to activation of these areas (Keysers et al, 2004). Thus, experiences of contact are not restricted to one sensory modality. There are two important things to note about contact as it relates to force interaction. First, contact-related experiences can occur independent of force-application actions. Second, while contact is necessary for physical force transfer to occur, contact-related experiences are not directly correlated with differences in the amount of force being transferred.[8] So, while contact is a necessary condition for force transfer to occur, contact alone is not equivalent to force interaction.

[8] At the point where the actor contacts the other entity, their may also be sensations of pressure/load. There is probably some positive correlation between the amount of pressure experienced and the amount of force being 'transferred', though it may be more strongly correlated with experience of force reception than application (i.e. correlated with the actor's experience of resistance and the actedUpon entity's experience of force reception). While schematic elements related to the experience of pressure might also be represented as a schema, this will be left for future work.

- Muscle tension and joint torque. In each case, the actor will experience some level of muscle tension and joint torque, but levels may be higher in the forceful scenario, where he is pushing the cup. Since these elements are generally not consciously noticed, they are not represented within the current motor-control schemas.
- Effort exerted. In each case, the actor exerts some amount of effort to activate the muscles and move his arm. If the outcome of the two scenarios is the same (e.g. arm is successfully straightened, at some particular rate), then the actor will have to exert more effort in the forceful scenario than in the non-forceful one. That is, it takes more effort to push a cup than it does to just straighten one's arm. In some cases, it is debatable whether we are likely to be consciously aware of this difference, such as when pushing a Kleenex. But in other situations, where the object offers more resistance, it will be more readily apparent (e.g. pushing a large box full of hammers). So, one key difference between forceful and non-forceful actions concerns the amount of effort the actor will expend while performing a particular motor-control routine.

Based on this comparison, then, it appears that contact and effort are both significant parts of our direct experience of physical force while performing motor-control actions.

5.4.3 Representation of force and force-application actions

Given these two elements, the next question is how to go about actually representing the force that is 'applied' during actions such as pushing and squeezing. The ForceTransfer schema I introduce in this section is intended to be consistent not only with direct experiences of force, but also with a 'commonsense' or 'naïve physics' view of active forces. In this commonsense understanding, active agents are seen as having the power to "create impetus and transfer it to other objects" (Hestenes, Wells and Swackhamer, 1992, p. 4). Impetus, in this case, would be variously termed 'force', 'energy', or 'power' by an individual expressing such views. The transfer of this impetus requires direct contact. In such a view, then, the force relation between these two entities is asymmetric: force originates with the actor, and then moves and/or is transferred to the entity that is being acted upon. Scientific physics tells us that there is also an equal and opposite return 'flow' of force, and we know that we may experience this 'return flow' as resistance. However, this return flow is not necessarily a prominent part of our conceptualization of most force-application actions. Furthermore, because the return flow is dependent on the initial force transfer, it seems reasonable to view the initial force transfer as conceptually primary.

Force transfer is thus a key component of forceful motor-control actions, and these actions may provide the 'experiential', embodied basis for our conceptualization of force and force transfer. However, the notion of force transfer also seems to be potentially dissociable from such actions. For example, there are also non-agentive situations, such as a falling branch hitting the ground, which can be conceptualized as involving a transfer of force. Though we do not necessarily have a direct experience of force in such situations, we may infer its presence based on observations of contact and subsequent changes to the entities involved. Due to this potential dissociability, rather than defining the structure of force transfer directly within a motor-control schema, I will create a separate ForceTransfer schema, and then integrate it into a schema representing forceful motor-control actions.

The schematic conceptual structure of force transfer is represented in the ForceTransfer schema (figure 5.2). This schema includes two key participant roles: the supplier and the recipient. These names are intended to be suggestive of how force transfer 'unfolds': initially the supplier 'has' the force, but then transfers it to the recipient. In addition ForceTransfer has a role for the amount of force that is being transferred: forceAmount. [9]

Contact is a (pre)condition for the transfer of physical force. To represent this fact, ForceTransfer evokes a Contact schema (figure 5.2). The Contact schema is specified to be a subcase of a more general SpatialRelation schema (not discussed here), a schema whose subtypes represent a limited set of possible topological relations between objects.[10] In the constraints section of ForceTransfer, the supplier and recipient roles are each bound to one of the roles of the evoked Contact schema. In this way, ForceTransfer schema specifies that the supplier and recipient are in contact when force is transferred.

```
schema ForceTransfer
  evokes Contact as Cont
    roles
      supplier: @entity
      recipient: @entity
      forceAmount
   constraints
      supplier  ↔ cont.entity1
      recipient ↔ cont.entity2
```

```
schema  Contact
   subcase of SpatialRelation
    roles
      entity1: @entity
      entity2: @entity
```

Figure 5.2 The Contact and ForceTransfer schemas.

We are now in a position to define a fuller version of the ForceApplication schema (see figure 5.3), one in which motor-control and force transfer structures are integrated into a larger gestalt. As in the partial version, the full version of ForceApplication is a subcase of MotorControl. However, this fuller version also

[9] This is a fairly simple version of ForceTransfer. More complex versions might include specifications related to the fact that such transfers occur over some span of time.
[10] As noted previously, there are various ways we actually experience contact. And we might want to have a separate schema for Contact as an experience (roughly, 'touch'), which would presumably be related to this spatial relation version. But, I will use a spatial relations schema here since it seems to be more generally applicable.

evokes and incorporates the structure of the ForceTransfer schema.[11] Relations between MotorControl and the ForceTransfer schemas are specified in the constraints section. Role bindings specify that the actor is the initial supplier of force (actor ↔ ft.supplier), and the acted-upon entity is the recipient of this force (actedUpon ↔ ft.recipient). In addition, the forceAmount role is bound to the inherited effort role, indicating the actor's (inexact) identification of amount of force applied with the amount of effort exerted.

```
schema ForceApplication
    subcase of MotorControl
    evokes ForceTransfer as ft
    roles
        actor
        effector
        effort
        actedUpon: @entity
        x-net: @forceapplication
    constraints
        actor ↔  ft.supplier
        actedUpon ↔  ft.recipient
        effort ↔  ft.forceAmount
        actor  ↔ protagonist
```

Figure 5.3 The ForceApplication schema, full version.

The ForceApplication schema thus captures the fact that the actor plays a somewhat different (and more complex) role in forceful actions than in non-forceful actions. As this schema indicates, in addition to being the executor of a motor-control routine, the 'force-application' actor also supplies some amount of force that gets transmitted to a second, acted upon entity. And, in order for force transfer to occur, the actor needs to be in contact with this other entity.

However, the ForceApplication schema does not include structure associated with any effects these actions may have on the entity that is acted upon. Therefore it is not, by itself, adequate for representing the meanings of many 'transitive' verbs and A-S constructions. To do so, we need a schema that includes schematic structure related to cause and effect.

5.5 Cause and Effect

What is the nature of cause and effect? More specifically, how can we identify and represent linguistically-relevant, recurrent, schematic elements of cause-effect actions? In this section I explore the possible embodied basis of our understanding of cause-effect relations, and identify some key parameters of such actions. Following

[11] As stated in Chapter 2, the **evokes** keyword is used to indicate that the evoked schema is locally available, but does not impose a part-of or subtype relation.

this, I propose a CauseEffectAction schema that incorporates some of these additional parameters. As this schema illustrates, cause-effect actions can be analyzed and represented as complex processes involving two subprocesses. One subprocess, the 'causal action', is a force-application action. And the other subprocess is the 'affected process', which indicates the way in which the acted upon entity is affected by the causal action. Significantly, two of the participant roles in this schema – the causer and the affected – are defined such that they capture the properties associated with prototypical 'agents' and 'patients'.

5.5.1 Effects of force-application

When an actor performs a force-application action, he will presumably have direct experience of his force interaction with the other, acted upon entity. As discussed earlier, these experiences include changes in the amount of pressure, joint torque, and muscle tension. And, if the other entity has the necessary sensory capacity, it too will have some direct experience of the interaction. We might characterize such experiences as the 'embodied', direct effects of force-application actions.

However, the reasons actors typically perform such actions have to do with various secondary effects these actions bring about. Possibly the most common desired effect is one which relates to the entity to whom force is applied. For instance, we may apply force to a stationary object in order to initiate its motion and thereby change its location (as in *She pushed / threw the cup across the table)*. Or the intention may be to change the state of the acted upon object (e.g. *She crushed the paper cup*; *She cut the bread*).
And, in such cases, the actual application (transfer) of force serves as a 'means' to a larger end. Or, to put it another way, it serves as a causal action that brings about some consequent secondary effect. Furthermore, this effect is some state of affairs that presumably would not have occurred absent the forceful action.

Some of the elements of these cause-effect actions are similar to those present in non-agentive cause-effect scenarios. For instance, consider a commonly discussed causal scenario, in which one billiard ball moves and hits a second stationary ball, initiating the motion of this second ball. One way to conceptualize the cause and effect elements of this scene is to view the moving ball (the 'causer') as the supplier of a force that is transferred on impact to the stationary ball, leading to an outcome that would not have occurred absent the force transfer. In such a situation, the effect (the initiated motion of the second ball) is dependent on the transfer of force that occurs upon impact. However, the motion of the first billiard ball prior to its impact with the second one is not dependent on any post-impact effects. Thus, we can observe a unidirectional dependency relation: the effect is dependent on the cause, but the cause does not depend on the effect in any way.

Goal-directed cause-effect actions differ from 'billiard ball' types of cause and effect in several very important respects. In the action, but not in the billiard ball situations:

- Actor (causer) wants the effect to happen. That is, the actor performs the action with the intention of bringing about a particular effect.
- Actor is in control of one or more of the parameters of the causal action (e.g. the actor can choose which particular routine to execute, how much effort to exert).
- Actor directly experiences the immediate effects of the force application action (e.g. experiences changes in pressure, exertion), as well as observing secondary effects (e.g. observes changes in the acted upon entity).
- Perception of these effects can serve as feedback to the action, leading the actor in some cases to make adjustments to various parameters of the ongoing action.

In the context of goal-directed force application actions, then, the desired effect is the goal of the causal action, and influences the actor's selection of various parameter values for this action. Thus, the effect is an integral part of the action. Furthermore, the actor adjusts his action in accordance with the type of effect he is attempting to bring about. This is true for the initial selection of the causal action (e.g. deciding whether to push or throw an object to a desired location), the ongoing performance of the action (e.g. object isn't moving, so actor needs to exert more effort), and the termination of the action (e.g. when object is at desired location, actor can stop pushing it). Thus while the effect is dependent on the action, the performance of this goal-directed force-application action is itself dependent on the desired effect.

These are not the only types of motor-control actions in which the actor's actions depend to some extent on another entity's actions/processes. For example, when following a ball rolling across a field, we adjust our motion based on the motion of the ball. But it is not necessarily the case in such situations that our actions have any effect on that other process. What makes goal-directed cause-effect actions especially notable is that, at least from the perspective of the actor performing them, the action and the effect are <u>inter</u>dependent. Goal-directed 'cause-effect' actions thus differ in some significant ways from 'billiard ball' scenarios. Moreover, it is precisely these differences that suggest that these types of actions may well provide an embodied understanding of cause and effect that grounds other more abstract uses of these concepts.

5.5.2 Characterizing and representing the structure of cause-effect actions

As already discussed, not all forceful actions lead to an effect. Moreover, not all effects are brought about by agentive actions[12]. But, in cause-effect actions these two elements
are intertwined. Therefore, when defining a schema to represent these actions, we need to show how these two potentially dissociable elements fit together within a larger 'cause effect action' context. There are many different types of actions that can cause many different kinds of effects, however. How can we define a relatively general schema that captures schematic regularities that are present in different 'cause-effect' actions? To answer this question, it is necessary to take a closer look at these actions.

First, consider a simple story about how we may learn to correlate actions with outcomes, and thus conceptualize these actions as 'causes' with consequent 'effects'. When young:

- We perform (and observe others perform) various force-application actions
- We observe that various outcomes ensue from these actions
- We learn correlations between specific actions and their outcomes. E.g. when we do X, Y happens.

Such correlations might be observed in any cause-effect sequence, as when a ball hits a lamp, and the lamp falls over. But, for volitional (goal-directed) actions we have an especially strong motivation for learning the correlations between causes (actions) and effects: these correlations help us decide which action to perform in order to bring about a desired outcome.

Moreover, as indicated by our ability to imagine and make predictions about a variety of novel scenarios, we clearly have neural circuitry that does more than just capture correlations between very specific 'causes' and very specific 'effects'. Again, this is especially pertinent for goal-directed actions; it helps us determine which action to perform in order to bring about some desired effect. Consequently, even in situations where we haven't previously done X or caused Y to happen, we can still make predictions (what will happen if I do X?) and decide plans of action (if I want Y to happen, what is the best thing to do?). Especially important for the current analysis is the assumption that in addition to enabling us to plan and imagine various scenarios, such neural circuitry can also be utilized in the active simulation of situations described by language.

[12] Furthermore, in many cases the "effects" are ones that can also occur independent of the action (and, in some cases independent of any readily observable 'causer'). For example, a leaf may fall off a tree, a window may break in a storm, and we may feel a sudden pain in our leg and not know what caused it. Many of these effects can be described with (intransitive uses of) 'process verbs' like *break* and *open* (and *fall*). This will be discussed in the following chapter.

An actor's experience of situations in which he performs a 'cause-effect' action are potentially very rich and complex. However, an actor is presumably most likely to focus on elements of that situation that are relevant to his achievement of whatever goal he is trying to accomplish, and background or ignore other aspects of the these experiences. To illustrate, consider a situation in which a person has the goal of breaking a particular stick. To accomplish this goal, this person will have to take into account the spatial properties of the stick, such as its shape, location and orientation, in order to establish an initial grip on it. But, the actor will not necessarily need to consider the smell or color of the stick, and the specific details of the grip may vary. To actually break it, he will also have to consider the stick's likely reaction to various applications of force (i.e. its 'force-related' properties, such as hardness, elasticity, etc.). And he will use all this information to select an appropriate routine, and amount of effort to exert. Moreover, as he performs the routine, he will need to monitor the 'wholeness/integrity' status of the stick, and make appropriate adjustments to the routine. For instance, if the stick isn't broken after the initial force application, he may increase the amount of force applied. And, when the stick does break, he will terminate the routine.

For different goals, we may attend to somewhat different things. For example, if our goal is to pick up the stick, then its mass is more relevant than its rigidity. And if our goal is to push a cup sitting on a table to another person, then in addition to the cup's mass, we need to consider the roughness of table. Also, we will need to monitor the current location of the cup in order to determine when to stop pushing it.

In each case, the force amount the actor 'applies' has to be sufficient to initiate and/or maintain the particular desired process. And this amount will depend on the amount of 'resistance' the affected entity provides to this initiation/maintenance. For instance, the amount of force needed to start motion depends in large part on the mass of the thing being moved. So, when selecting appropriate routine and force parameters, the actor needs to consider not only the effect he is trying to achieve, but also the force-related elements of the situation in which he is trying to achieve this goal.

What implications does this have for how we define schemas to represent such actions?
For one thing, it is apparent that we can identify a set of elements that are particularly relevant to the successful performance of goal-directed 'cause-effect' actions. Some of these are the same as for other motor-control actions, e.g. the body part the actor is using, how this part is being used, and how much effort is being expended. Others are more specific to these particular actions, such as the force-related properties of the actor and acted upon entity (e.g. strength, mass, flexibility) and the effects the force has this other entity.

In addition, these different elements are interdependent: varying the value of one element affects the value of other elements. Furthermore, given the neural circuitry described above, if we know values for some of these variables, we can often figure out values for the others. This suggests that we can define a single general schema that includes these relevant 'focused on' elements, but does not specify particular values for them. This schema will thus represent schematic structure that recurs across many different cause-effect actions, not the specific details that vary from situation to situation. In the current grammar, this structure is represented in the CauseEffectAction schema, described in the following section.

Looking ahead, this schema can then be used to represent the meanings of various 'cause-effect action' verbs, with individual verb constructions specifying whatever specific values are appropriate. When these verbs are used in sentences that describe such actions, other co-instantiated constructions, context and world knowledge can provide further information about various values of the situation being described, such as the identity (and associated 'force-related' properties) of the actor and affected. Furthermore, via simulation we can then infer other values, as needed.

5.5.3 The CauseEffectAction schema

The CauseEffectAction schema represents structure associated with actions in which an actor performs a force-application action that brings about some change in the entity that is being acted upon. That is, the actor causes some effect to the entity he acts on. This schema is similar to ForceApplication in that it includes structure associated with the action itself, but differs in that it also includes structure associated with the consequent effects to the acted upon entity. Thus, this schema places 'force–application actions' into the larger 'cause effect' context in which they typically occur.

A given cause-effect action may actually result in several different effects, and there may be multiple contributing 'causes' to whatever effects occur. However, the CauseEffectAction schema is intended to represent the 'focused on' elements of an actor's experience of cause effect actions, not the full 'reality' of causal situations. Consequently, it only represents a single causal action and a single effect. For this same reason, this schema explicitly represents only the initial force that the actor transfers to the other entity, with the idea being that the actor will tend to background or ignore the return force that inherently accompanies it, as well as any consequent effects this return force has on him.

The ECG formal specifications used in this schema may at first glance seem rather cryptic. Therefore, it may help to first give a brief overview of what this schema specifies before describing these specifications in detail.

Overview

Cause-effect action is represented in CauseEffectAction as a complex process, involving a ForceApplication subprocess (the causal action) that produces a force transfer (the cause), which brings about some effect to another subprocess (of which the affected entity is protagonist). Thus, action and effect are represented as parts of a larger complex cause-effect gestalt. Note that in many cases, each subprocess (the action and the process affected by the action) can potentially occur independent of one another. Thus, it may only be within the context of the 'causal scenario' that a particular action is identified as a 'cause' and a particular outcome process as an 'effect'.

The two key participant roles are those of causer and affected. Within this gestalt, the causer of the larger cause-effect process is the actor of the action subprocess. And the affected participant is the entity that this actor acts on and (potentially) affects in some way. Via their bindings with ForceApplication roles, causer and affected are also bound to ForceTransfer roles: the causer is the supplier of the force, and affected is the recipient. These bindings indicate that the force supplied by the actor's action is transferred to the affected entity. Consequently, although these two participant roles are represented within this schema using simple names, these bindings serve to indicate that they are in fact internally complex semantic roles.

The ForceApplication schema represents one prototypical kind of process that 'supplies' a force that is received by another entity. In order to represent processes that receive this transferred force, we can define an additional schema: the ForceSink schema. The ForceSink schema does not itself specify where this force originates; there are various possible sources, including not only forceful actions, but also non-agentive events (e.g. falling objects) and general environmental circumstances (e.g. gravity, heat). When this schema is used as part of the CauseEffectAction schema, however, bindings indicate that the force that is received by this schema is supplied by a force-application action. The general idea here is that the ForceApplication action (the causal action) supplies a force to the ForceSink process ('affected process') that at least potentially brings about changes in the way the ForceSink process 'unfolds'.

CauseEffectAction also includes an x-net role, which is constrained to be a 'cause effect action' x-net. This x-net can be defined such that it includes two subprocess x-nets (for force application and the force sink process), with a 'force transfer' relation between them. Within the simulation model, execution of such an x-net should indicate that the transferred force affects the execution of the force sink process in some way

As Talmy (2000a) and others have observed, a received force may potentially 'cause' many different kinds of effects. These can be characterized in terms of how they affect the ‘unfolding’ of some force-sink process associated with the affected entity. For instance the received force may:

- initiate a process that would not have otherwise been initiated (e.g. cause entity to start moving, despite tendency to stay still)
- maintain a process that might otherwise have finished (e.g. cause X to keep moving, despite tendency to stop)
- inhibit a process that would have otherwise started (e.g. prevent X from moving, despite tendency to start moving)
- terminate a process that would have otherwise kept going (e.g. cause X to stop, despite tendency to keep moving)

Since CauseEffectAction is intended to represent the structure common to these different situations, the x-net in this schema is necessarily specified at a very general level, one which does not indicate differences as to the aspectual relations between the two subprocesses, nor as to how the force sink process is affected by the reception of force.

Schema details

With this background in place, we can now look at the various specifications of the CauseEffectAction schema (figure 5.5) in more detail. The first thing to note about CauseEffectAction is that it is a composite schema that integrates the structure of two more primitive schemas into a single, complex structure. Accordingly, this schema is specified to be a subcase of a ComplexProcess schema. As such, it inherits two subprocess roles: process1 and process2. Within CauseEffectAction, the first subprocess is the (goal-directed) force application action the actor is performing, an action that transfers force to another entity. For that reason, process1 is constrained to be ForceApplication. The second subprocess is associated with the affected entity. Various types of effects may potentially ensue from a force application action, each associated with some process of which the ‘force receiver’ is the protagonist. To maximize the applicability of this schema, this subprocess is relatively underspecified, constrained only to be some kind of ForceSink process, a process that receives and is potentially affected by some sort of force. Note that this constraint can work two ways. If a process is already conceptualized as a ‘force sink’ (e.g. one that needs some input of force to be initiated), then it will readily compose with this role. But, absent such an initial conceptualization, by composing a process with this schema, we are likely to -- after the fact, so to speak – construe it as a ‘force sink’. Many kinds of process can potentially be conceptualized as force sink processes, including motion and various kinds of state changes. This will be discussed at greater length in the following chapter.

The relatively simple ForceSink schema shown below (figure 5.4) is a subcase of the very general Process schema (figure 2.12). The inherited protagonist role is bound to the recipient role of an evoked ForceTransfer schema.[13]

```
schema ForceSink
  subacase of Process
  evokes ForceTransfer as ft
    roles
        protagonist
        xnet: @ forceSink
    constraints
        protagonist < -- > ft.recipient
```

Figure 5.4 The ForceSink schema.

Both subprocesses (i.e. ForceApplication and ForceSink) are constrained to be schemas that evoke ForceTransfer. In the context of cause-effect actions, though, these are the same ForceTransfer. That is, the force supplied by ForceApplication is the force received by ForceSink. To specify this, CauseEffectAction evokes ForceTransfer and binds it to the force transfer schemas evoked by each of its subprocesses (ft ↔ process.ft; ft ↔ process2.ft).

The two participant roles of causer and affected are defined in relation to these two subprocesses. The causer is bound to the protagonist role of the first subprocess (protagonist ↔ causer). Because this process is constrained to be one of ForceApplication, this protagonist is a force-application actor: thus, the causer role is bound to an actor role, and is constrained to be some kind of animate entity. We can view this in two different ways. We can say that, in the context of this larger 'cause-effect' action, the force-application actor is also a causer. That is, the person who is acting is also causing some effect. But we can also say that in this central case of cause-effect, the causer is an actor. That is, the entity that is bringing about the effect is performing some force application action. Either way you look at it, this schema defines causer as a complex semantic role. And, because actor is defined independent of cause-effect, these schemas capture the fact that actors may be causers in some, but not necessarily in all contexts.

The affected participant role is bound both to the actedUpon role of the first subprocess (process1.ActedUpon ↔ affected), and the protagonist role of the second subprocess (protagonist2 ↔ affected). This serves to specify that in the context of cause effect actions, the protagonist of the force sink process is acted upon by some actor/causer, and is affected in some way by this causal action.

[13] If needed, it would also be possible to define a somewhat more complex ForceSink schema that would include roles allowing us to specify at what particular stage in the process the force is received.

```
schema CauseEffectAction
  subcase of ComplexProcess
  evokes ForceTransfer as FT
    roles
          process1: ForceApplication
          process2: ForceSink
          causer
          affected
           x-net: @causeeffectaction
     constraints
          protagonist ↔ causer
          protagonist2 ↔  affected
          process1.actedUpon ↔ affected
          ft ↔ process.ft
          ft ↔ process2.ft
```

Figure 5.5 The CauseEffectAction schema.

To summarize, in CauseEffectAction, goal-directed causal actions are represented as complex processes, involving two different subprocesses, one associated with an action, and the other with a process that this action affects in some way.[14] This schema also includes the participant roles of causer (the performer of the causal action) and affected (the protagonist of the affected process). Furthermore, CauseEffectAction specifies that the causer performs an action that supplies a (causal) force, and the affected entity 'undergoes' a process that is affected in some way by the reception of this force. This schema thus shows how seemingly abstract concepts such as causation and affectedness can be analyzed and represented within the larger more directly 'embodied' context of goal-directed motor-control actions.

5.6 Verb Constructions

With these schemas in place, we can now consider how to use them to represent the meanings of the verbs discussed earlier in this chapter. Recall that I distinguished between two types of verbs that describe 'forceful actions'. For one of these types, the verb specifies something about an effect that is brought about through a forceful

[14] It would also be possible to include an 'effect' role that could be used to indicate the 'result state' of the affected entity. If process schemas include roles for various aspectual stages of the process (e.g. initial, ongoing, final), the effect role could be bound to the final stage of the affected process (effect < -- > process2.final).

action (e.g. *cut, crush, throw*). For the other type, the verb describes a forceful action, but does not specify any particular type of effect that this action is used to achieve (e.g. *slap, push, kick*). As discussed in the sections below, by defining verb constructions that identify their meaning with either the CauseEffectAction or the ForceApplication schema, we can capture important similarities and difference in the meanings of these verbs.

5.6.1 'Cause-effect action' verbs

To start, let us consider the first group of verbs (e.g. *cut*), which are consistently used to describe actions that cause an effect to the entity that the actor is acting upon. By defining verb constructions which identify their meanings with the CauseEffectAction schema, we can capture the causal structure common to the 'core' meanings of these verbs. Each of these constructions will indicate that there are two key participant roles associated with these verbs: a causer, and an affected participant role. The causer performs an action that transfers force to the affected, and the affected 'undergoes' a process whose unfolding is influenced by this force input. These verb roles thus have many of the properties commonly associated with prototypical 'agent' and 'patient' roles.

The nature of the effect to the 'patient' differs for different verbs. For instance, some verbs describe different types of motion-related effects, such as:

- Initiate projectile motion: *throw, toss*
- Cause ongoing motion: *carry, tow, haul*
- Stop ongoing motion: *catch*
- Prevent (independent) motion: *hold, grip, grasp*

Other verbs describe effects that involve a change in the state of the affected entity, e.g. *cut, chop, slice,* and *dice*.

As discussed earlier, the CauseEffectAction schema is defined at a very general level and does not specify details about the nature of the 'effect' subprocess. For each verb construction, however, specific details about effects can be specified using additional meaning constraints. For instance, for translational motion-related effects, the verb construction will have the added constraint that the 'affected process' is bound to the MotionAlongAPath schema described in Chapter 3 (figure 3.6). In some cases, the situations described by verbs differ as to the aspectual relation between the action, force transfer, and effect. For instance, for *throw*, force is received at initial stage, and motion continues after force input stops. Whereas for *carry* (as in *He carried the cup)*, the force transfer continues throughout the time the object is being moved. And for *catch*, force transfer starts after motion is already ongoing. One way to represent these differences is through the specification of different types of cause-effect x-nets within each of these verb constructions.

A given construction does not necessarily specify values for all of the CauseEffectAction roles, however. Additionally, the strengths of particular value specifications vary; we might consider a particular value to be a default, or even just a possible value, rather than an absolute. The construction for *cut*, for instance, can indicate a particular type of effect (e.g. division) that is brought about by some kind of action[15]. But, there are many kinds of different actions that may potentially bring about such an effect. If we want to cut some salami, for example, we might do so by dragging a knife across it, by dropping it on a very sharp blade, or by sending it through a slicing machine. And to cut the grass, we might snip it with scissors, drive a rider-mower over it, etc. In order to define a verb construction that can be used in the description of these different specific situations, we can specify the properties of the effector at a very general, schematic level (e.g. it is a sharp object), but would not want to specify details about other aspects of the action, such as the specific motor-control routine or the amount of effort involved.

```
construction Cut1
  subcase of Verb
  form
    constraints
      self.f.orth ← "cut"
  meaning: CauseEffectAction
    constraints
      self.m.x-net ← @cut
      self.m. process1.effector.shape  ← 'sharp'
      self.m.process2: StateChange
```

Figure 5.6 The CUT1 construction.

Richer meanings

A question arises at this point: How is it that, given only this 'general' verb meaning we are able to make much more specific assumptions about the likely values for various 'unspecified' elements? For instance, if we hear the sentence *She cut the bread*, we are likely to assume that she used a particular motor-control action in which she held a knife and moved it back and forth across the bread. And for different sentences we will make different assumptions; hearing *She cut the lawn*, we are likely to infer that she used a lawnmower that she pushed around the lawn. Thus, our assumptions about the specific instrument used, and the motor-routine involved will differ for different uses of this verb. How can we get rich sentence

[15]In the Cut1 construction shown in figure 5.6, this effect is very generally constrained to be one of 'state change'. One way to indicate a more specific type of effect would be to use a more specific constraint on the affected process (e.g. 'change in boundary integrity'). Another would be to use a different constraint for the causal action (e.g. an action that involves motion of an effector through the boundary and/or interior of the affected entity). Forceful actions that include motion are discussed in Chapter 7.

understandings such as these without specifications of rich verb meanings? In the earlier discussion on cause-effect actions, I indicated that this is possible because there are additional sources of information and because we are able to infer further values via simulation. Below, I expand upon this brief answer.

The first thing to recognize is that while the verb and argument structure constructions instantiated in a given sentence will be the main source of information about the process(es) described by that sentence, other sources of information may also be relevant. The other constructions instantiated in a given sentence are one main source. For instance:

- NP constructions describe the referents that 'fill' the causer and affected roles in a particular situation. Based on our general world knowledge about these participants, we are likely to make various assumptions about their properties, including the 'force-related' properties discussed earlier, such as strength and mass.
- Adjectives may provide explicit specification of relevant properties of role fillers (e.g. A <u>strong/weak</u> person cut the <u>soft/hard</u> bread)
- Adverbs may indicate more about the processes involved, for example, the amount of force (e.g. gripped tightly/loosely)

So, several different types of co-instantiated constructions may potentially supply relevant information about the situation described by a given sentence. Additionally, the larger context in which the sentence occurs, e.g. prior discourse and/or the discourse setting, may serve as another source of information. For instance, we may know from prior discourse that the bread that is being referred to by the sentence *She cut the bread* is a long, hard baguette.

The full SemSpec for a sentence is a therefore a product of the composition of the meanings supplied by the instantiated constructions and contextually supplied information. Furthermore, we may make various assumptions based on 'world knowledge' about the participants and the type of situation being described. Thus, the verb and A-S constructions are by no means the sole source of information relevant to the type of action being described.

But how might language-specified information about some elements of the described situation affect our understanding of other, unspecified elements of this situation? For instance, how does our knowledge about the nature of the acted upon entity affect our inferences about the amount of force needed to affect that entity? The short answer is that many of these assumptions, expectations and inferences about the specific situation being described arise through the simulation process. Because this is a very important point, it bears further elaboration.

Consistent with NTL's simulation-based theory of language understanding, one key assumption is that the neural circuitry used to understand descriptions of events is closely related to that used to execute, plan, and/or imagine these events.

Accordingly, simulation of cause-effect actions taps into rich neural circuitry that we have developed through repeated experiences of such actions. As discussed earlier, one presumed feature of this circuitry is that it supports our ability to use known values for some parameters of a situation to determine values for other parameters. For instance, given the mass of an object, we can make predictions about how much effort it will take to throw it to some particular location. Similarly, given a specific type of action, and a particular type of entity being acted upon, simulation allows us to predict a likely effect. Thus, the structure used to understand (simulate) descriptions of cause-effect actions enables us to draw further inferences about unspecified elements of such actions.

A very important consequence of this assumption is that the constructions themselves need not specify all the expectations and inferences associated with our understanding of a given 'cause-effect action' sentence. Instead, the instantiated constructions will supply some of the relevant parameters of the event. Additional information may be supplied by context and through assumptions based on world knowledge (e.g. how much we think something weighs). And simulation will give rise to various additional expectations and inferences. As a result, our understanding of a sentence is likely to include expected values for parameters that are not directly specified in the description itself. Thus, our full understanding of a sentence is typically much richer than what is overtly specified by the instantiated constructions.

This means that we can handle differences in understanding of different sentences (such as *She cut his hair / the lawn*) without necessarily positing different verbs senses. Instead, we can define a relatively sparse 'core' meaning for the verb, and then handle differences in assumptions and inferences via composition of information from various sources plus simulation.

5.6.2 Force-application verbs

Next, let us consider the second group of verbs, which also describe forceful actions, but which are not consistently used to specify any particular effect these actions may accomplish. This group includes verbs such as push, *pull*, *shove*, *nudge*, *squeeze*, *kick*, *hammer, slap*, and *tap*.

These verbs are often used to describe situations in which a particular action results in some effect to the acted upon entity, as in *She pushed him off his chair*; *She kicked the table to pieces*; and *She hammered the metal flat*. And, even when a particular effect is not specified (e.g. *She pushed him*, *She kicked the table*, *She hammered the metal*), we are still often likely to infer that one occurred.

These same actions may be performed to accomplish many different kinds of goals. For instance, an actor might kick or push something to cause it to move or to change shape. If the acted upon is a person, the intention might also be to cause pain, get that person's attention, etc. And any effects we infer for a particular description of such an action will depend in large part on the nature of the different fillers (compare *She kicked the ball / wall.*). Moreover, our inferences about this effect are typically defeasible (*He pushed her, but she didn't move*).

In addition, whatever effects the action has may not be ones that directly relate to the acted upon entity. For instance, the action may affect the actor himself (*He kicked the table but all that happened was that he hurt his foot*). And that might even be the actor's intention for performing the action (*He pushed / shoved off the dock*). Or, the objective may be to produce some other kind of effect, such as noise (*He hammered / tapped on the table to get everyone's attention*).

Thus, while these verbs such as *push*, *kick*, *hammer*, etc. are consistently used to describe actions in which an actor contacts and applies force to another entity, they are not consistently used to describe situations in which this force has some particular type of effect on this other entity. And in fact, in some cases the action may be performed without even having the objective of producing any effect to this other entity.

There is more than one way we might analyze and represent the meanings of these verbs. I discuss two possibilities, with the second one being the alternative I prefer. One approach is to analyze verbs such as these is as having a 'core' meaning of 'cause-effect' action, in which a forceful action results in some unspecified effect. This meaning would best be represented using the CauseEffectAction schema. Each verb construction would include specifications about the type of causal action, but wouldn't have any further specifications about the effect this action has on the acted upon entity. Thus, these verb constructions would be similar to the ones for the previous set of verbs, but rather than specifying effect and not specifying causal action, these constructions would do the opposite, specifying action but not effect.

Such an approach would capture the fact that the actions described by these verbs are very often (maybe even prototypically) used to bring about some effect in the acted upon entity. In addition, it would be consistent with the meanings of the transitive examples in which such an effect is specified or inferred. However, as shown by the examples above, only some aspects of this meaning are consistently present across different uses of these verbs. Specifically, in all cases the actor performs an action involving contact and transfer of force to another entity. But, while the force applied may bring about some effect to the acted upon entity, this is not always necessarily the actor's primary objective for performing this action.

Consequently, an alternative approach is to define these verbs as having a core meaning of force-application action, without any specification with respect to what larger purposes and/or effects such actions might have. Following this approach, constructions for these verbs identify their meanings with the ForceApplication schema rather than the CauseEffectAction schema. And, as in the approach above, individual verb constructions specify further details about the nature of this action (e.g. motor-control routine, amount of force, etc.).

This second approach thus captures the meaning that is consistently present across different types of uses. However, it raises questions about how to analyze sentences in which there is a specification or strong inference that the 'acted upon' entity is indeed affected by this action. E.g. *He kicked the ball (across the field)*. The answer I propose lies once again in composition plus simulation. Briefly, the story is as follows.

As will be discussed in the following chapter, the grammar includes transitive A-S constructions whose meaning is represented using the CauseEffectAction schema. In the central case, the verb constituent has the same schematic structure as the transitive A-S construction. Therefore, 'cause-effect' verbs (such as *cut*) may serve as a constituent in the central case transitive A-S construction, while 'force-application' verbs (such as *push* and *kick*) may not. However, transitive A-S constructions also include extensions to this central case, in which a <u>portion</u> of the A-S construction's meaning is the same as its verb constituent's schematic meaning. One extension specifies that its verb constituent meaning is identified with ForceApplication. Analysis of sentences that instantiate an 'force-application' verb and this second transitive A-S construction will produce a SemSpec that indicates that the type of event being described is a 'cause-effect action'. The instantiated verb serves to elaborate the causal action subprocess of this event. And the noun phrases in the sentence serve to describe the entities that fill the roles of causer and affected in a particular situation. SemSpecs for these transitive sentences thus not only support simulation of the action described by the verb, but also support simulation of the effect that action has on the 'acted upon' entity. Moreover, inferences about the nature of that effect will depend not only on the nature of the action that the actor is performing, but also on assumptions we make about the actor, the acted upon, and other aspects of the situation being described.

One important consequence of this analysis is that verb meanings don't necessarily need to include cause-effect structure in order to describe cause-effect situations. Instead, this cause-effect structure can be supplied through constructional composition. Additionally, this model of language understanding helps explain how it is possible to infer various effects without the verb construction having to specify them. For instance, we don't need to posit different senses of *kick* in order to get the following different inferences:

(8) a. She kicked the boy – the boy hurts
b. She kicked the ball – the ball moves
c. She kicked the wall – the wall is unaffected, but her foot hurts.

Instead, it is possible to posit a single core meaning of *kick*. The transitive A-S construction indicates that we should conceptualize this as being an action which at least potentially brings about some effect to the acted upon entity, And, through simulation, we can derive further inferences about what effects this action is likely to have on different objects (i.e. people, balls, and walls).

Furthermore, as discussed in later chapters, other 'non-transitive' sentences can be analyzed as instantiating A-S constructions that describe different types of events. Composition of the 'force-application' verb meaning with these different event types will lead to different types of simulations and support different types of inferences. Crucially, these won't necessarily include a simulation of the 'effect' to the entity that the actor is acting upon.

In sum, with this second approach we can analyze and represent these verbs as having a core meaning of 'force-application action'. And, given the larger framework being used here, it is possible to capture the differences in specified and inferred meanings of sentences such as the ones described in this section without necessarily positing additional verb senses.

Verb constructions

The details about the constructional representations of these 'force-application' verbs are as follows. For each of these verb constructions, overall meaning is identified with a ForceApplication schema. Each will therefore have actor, effector, and actedUpon roles. Each construction will also include additional information. For one thing, they will specify a particular x-net that may indicate the nature of the motor-control routine performed by the actor. In addition, they may specify default values for other ForceApplication roles. Constructions for *push, nudge*, and *shove* may be similar with respect to the general routine they specify, but they will differ as to the amount of effort (and force): for *nudge* the value of effort is 'low', for *shove* it is 'high', and for *push* it is unspecified. Constructions for other verbs may differ in differ in several respects from these other constructions. For instance, the construction for *squeeze* will specify a fairly different type of x-net for routine, one that will model the application of a compressive force. Additionally, it may have the default constraint that the effector is the actor's hand. Similar to *push*, the amount of effort will be unspecified.

```
construction Push1
  subcase of Verb
  form
    constraints
      self.f.orth ← "push"
  meaning: ForceApplication
    constraints
      self.m.x-net ← @push
```

```
construction Shove1
  subcase of Verb
  form
    constraints
      self.f.orth ← "shove"
  meaning: ForceApplication
    constraints
      self.m.x-net ← @push
      self.m.effort ← 'high'
```

Figure 5.7 The Push1 and Shove1 constructions.

The ForceApplication schema also provides much of the key schematic structure of the actions described by verbs such as *kick, slap*, *tap*, *hit*, *punch, hammer, pat*, etc. However, as will be explored more fully in later chapters, these are actually complex actions, which have a spatial component that precedes the force-application component of the action. Specifically, these verbs describe actions in which the actor first has to move an effector (e.g. his hand or foot) towards an entity prior to contacting and transferring force to this entity. As we will see, some uses of these verbs focus on this spatial component (e.g. *She slapped her hand on his leg*). Therefore, rather than identifying their meaning directly with ForceApplication, constructions for these verbs identify their meaning with a more complex schema that integrates ForceApplication with spatial schematic structure. This more complex ForcefulMotionAction schema and constructions for verbs such as *slap* and *kick* are discussed more fully in Chapter 7.

5.7 Summary

Consistent with the overarching framework provided by NTL, one key premise made in this chapter is that our understanding of concepts such as force causation and affectedness are grounded in direct physical experiences, particularly those in which we forcefully interact with other people and objects with the objective of affecting them in some way. Within the context of such experiences, causal action and consequent effect are interdependent and form a rich and complex gestalt. Significantly, some elements of this gestalt are at least partially dissociable from the situation as a whole. We can for example, apply force to another entity with no intent of affecting that entity (e.g. pushing off from a wall). And entities can change or move without an actor necessarily acting on them (e.g. a boulder rolling down a hill). This potential dissociability indicates that is useful to decompose cause-effect actions into more primitive components. At the same time, it is important to keep in mind that these elements are conceptualized differently when they are part of this gestalt than when they are not. That is, it is the presence of a consequent 'effect' that leads us to conceptualize a forceful action as a 'cause', and it is the presence of a 'cause' that prompts us to conceptualize a given change as an 'effect'. Therefore, while it is important to recognize the componential nature of these cause-effect actions, it is also important to recognize that the gestalt whole is more than just an aggregation of its component parts.

To help capture the internal complexity of these actions, and their relations to other types of actions and experiences, the schemas described in this chapter are defined as part of a larger lattice of 'process' schemas. Figure 5.8 shows the schemas in this lattice that have been discussed thus far.

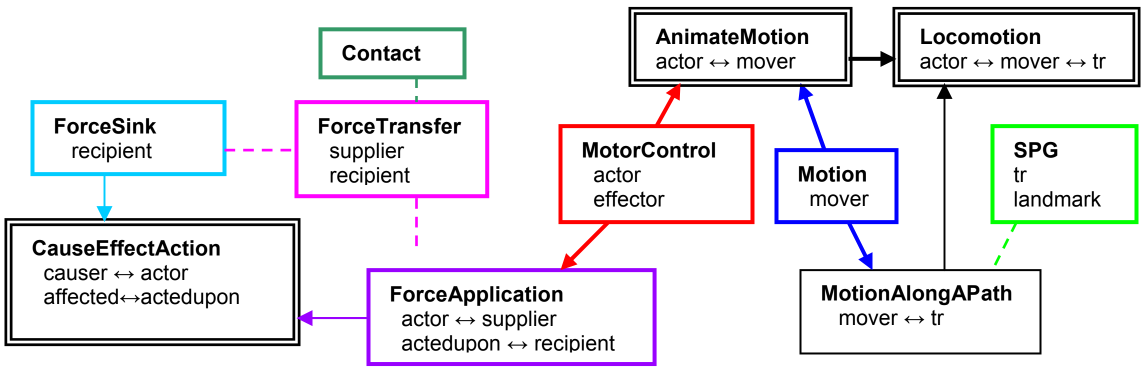

Figure 5.8   A portion of the Process schema lattice.

This lattice includes various types of schemas and relations. In the diagram above:

- Thicker arrows indicate subcase relations.
- All schemas which have a double-line box are subcases of ComplexProcess. The thinner arrows pointing at the complex process originate at each of its subprocess schemas.
- Dotted lines indicate an 'evokes' relation

As I've shown in this chapter, the CauseEffectAction and ForceApplication schemas can be used in the representation of the meanings of various 'action' verbs, such as *push, pull, cut, throw*, etc. One significant difference between these verbs concerns affectedness: some verbs (e.g. *cut*, *throw*) are consistently used to describe situations in which the 'acted upon' entity is affected in some relatively specific way, while others (such as *push* and *pull*) are not consistently associated with any particular effect. By using separate, but related schemas to represent the meanings of these two types of verbs, we can capture both commonalities and differences in their meanings.

These schemas will also play a key part in many of the sentence analyses presented in the following chapters. Two aspects of the CauseEffectAction schema are especially relevant for these analyses, one of which concerns the roles within this schema, and the other of which concerns the schema's process-related structure.

The CauseEffectAction schema defines two central participant roles: the causer and the affected. Both of these roles are internally complex ‘composite’ roles, as indicated by their bindings to other roles. The causer is an actor, a supplier of force, and a causer of some effect. The affected is acted upon by an actor, a recipient of force, and the undergoer (protagonist) of some effect. Via these bindings, the roles of causer and affected capture many of the properties commonly associated with prototypical ‘agents’ and ‘patients’. An important benefit of defining these as complex composite roles is that it facilitates recognition of similarities and differences to the roles in other schemas. For instance, it is readily apparent that causer and various actor roles have some structure in common, as do affected and various undergoer/’theme’ roles (e.g. mover and ‘state change’ roles). Or, to put it somewhat differently, causer (prototypical ‘agent’) is similar to but also different than other actors, and affected (prototypical ‘patient’) is both similar to and different than other ‘themes’.

CauseEffectAction is defined as complex process, with two inter-related subprocesses. One subprocess (the ‘causal action’) is a ForceApplication process, and the other subprocess is a ForceSink process (a process that receives and is affected by an externally-supplied force). Thus, CauseEffectAction has complex internal structure that integrates the structure of other schemas. By defining CauseEffectAction in this way, it is possible recognize various partial matches of schematic structure between this and other schemas. As noted above, this supports comparison of meaning of constructions of similar kind (e.g. between ‘force-application’ and ‘cause-effect action’ verbs). Moreover, it also facilitates recognition of commonalities of schematic structure associated with A-S constructions and their verb constituents. As we will see, this plays an important part in the analysis of transitivity presented in the following chapter.

Chapter Six

Transitive and Related A-S Constructions

6.1 Introduction

The current grammar includes many different A-S constructions that support analysis of a wide range of sentence examples. In Chapter 4, I described 'translational motion' A-S constructions instantiated in examples such as *She walked / slid into the room*. In this chapter, I focus on A-S constructions instantiated in examples such as (1a-d).

(1) a. She cut / pushed / slid the bread.
b. The bread was cut / pushed / slid.
c. The (falling) shard of glass cut the bread.
d. She / The bread slid.

As these examples illustrate, the same verb can often occur in sentences which differ both as to form and overall meaning. By defining A-S constructions to represent these different general form-meaning patterns, it is possible to analyze these different types of sentences without positing multiple constructions for a given verb. Significantly, these A-S constructions enable a compositional analysis that captures important differences in event conceptualization associated with these different sentences.

As with the 'translational motion' A-S constructions described in Chapter 4, each of the A-S constructions instantiated in the examples above specify a pattern in which a set of constituents in a default order is paired with a description of some type of event. As discussed in that chapter, there are various types of distinctions in argument realization patterns that merit the definition of different specific A-S constructions. This includes differences with respect to:

- the specific number and type of constituents
- the (prototypical) order of the constituent forms
- the particular type of humanly relevant scene the A-S construction is used to describe (i.e. the specific 'process' schema the A-S construction identifies its meaning with)
- the meaning of the A-S construction's verb constituent (i.e. the schema associated with the 'core' meaning of the verb)
- the semantic relations between the A-S construction and its constituents.
- the focal participant within this scene (from which event participant's perspective this event should be simulated).

Transitive examples such as (1a-b) above exhibit A-S construction form-meaning patterns that are similar at a general level (e.g. the same general type of constituents, in the same general order, used to describe the same general type of event). But, looking at a range of different transitive examples, it is apparent that they exhibit differences with respect to the meaning of the verb constituent, the type of event the A-S construction describes, and the semantic relation between these two constructions. For this reason, the transitive examples examined in this chapter are analyzed as instantiating various different – but related -- 'transitive' A-S constructions. With respect to the passive examples, even though the verb constituent meaning and specific event type may be the same as in their transitive 'counterparts', differences in form and simulation perspective prompt definition of A-S constructions that are distinct from, though semantically similar to transitive A-S constructions. As with passives, the event associated with the intransitive examples is described (and conceptualized) from the perspective of the 'undergoer'. Unlike passives, however, this event is not necessarily conceptualized as including causal structure. In terms of simulation, we can say that these examples support a simulation in which the verb-designated process can be simulated without necessarily also simulating another process that causes or is caused by it. Thus, differences in form, event type, and perspective each prompt definition of different A-S constructions.

As I will show, by defining A-S constructions that capture the distinctions listed above, and by representing the meaning of these A-S constructions and their verb constituents using schemas from the Process schema lattice, we can capture the sometimes subtle differences in how the verb-designated process is conceptualized in each of these examples. Furthermore, the analysis of cause-effect actions presented in the previous chapter plays an important part in the identification of the relevant event types associated with these A-S constructions.

<u>Chapter Road Map</u>

In the next section, I outline some of the challenges presented by examples such as those above. Following that, I provide a general overview of my analysis of these examples and the A-S constructions they instantiate. Then I take a more detailed look at the specific A-S constructions instantiated in various sentence examples, and discuss the SemSpecs associated with analyses of these sentences. To conclude, I discuss how composition with different A-S constructions indicates different conceptualizations of the process designated by a given verb construction.

6.2 Transitivity: generalizations and challenges

The concept of transitivity is typically associated with a particular usage pattern, in which a verb occurs with a direct object. Additionally, a basic semantic generalization can be drawn: this transitive pattern is typically associated with descriptions of two-participant scenes. Various semantic analyses have identified some basic characteristics of such scenes and the participants themselves (e.g. Hopper and Thompson 1980; Slobin 1985; Dowty 1991; Langacker 1991). Prototypically, these characteristics include the fact that one of the scene participants (the 'agent') performs an intentional action, and that the other participant (the 'patient') undergoes some change of state or location. Moreover, the agent's action is what brings about this change in the patient; more specifically, this is because the action involves a transfer of energy from the agent to the patient.

Languages differ as to the means they use to 'mark' transitivity, and also differ as to what range of meanings are marked in this same way. In English, transitivity is associated with a particular pattern of argument expression: the agent participant is expressed by the 'subject' NP, and the patient participant is expressed by a 'direct object' NP.

It would be a fairly simple matter to define an ECG A-S construction that would formally represent a basic, general characterization of the transitive argument realization pattern. In terms of form and constituency, such an A-S construction would include a 'direct object' NP constituent whose form canonically follows that of the verb constituent. In terms of meaning, the 'prototypical' transitive event would be represented using the CauseEffectAction schema described in the previous chapter. This A-S construction would specify that the affected role of CauseEffectAction is bound to its 'direct object' constituent, and that causer role is bound to profiledParticipant (indicating that in declarative sentences it will be bound to the subject NP). This A-S construction is similar to the Transitive Construction proposed by Goldberg (1995: p. 117), in which a 'proto-agent' is linked to the subject NP and a 'proto-patient' is linked to direct object. One advantage of this formal representation is that it more precisely defines roles like 'agent' and 'patient', and indicates their embodied grounding in cause-effect actions.

However, while such an A-S construction captures the general characteristics of transitive sentences, is not by itself sufficient to fully address many of the challenges associated with the analysis of transitivity in English. One issue that needs to be dealt with is that many 'transitive verbs' (verbs that exhibit transitive argument realization pattern) may also appear in sentences with other types of meanings and argument realization patterns (Fillmore 1970; Dixon 1991). For instance, many motion verbs, such as *slide*, *spin*, *roll*, etc, can appear in transitive sentences, such as *He slid / spun the box (into the room*). But such verbs also quite commonly appear in intransitive sentences, such as *The box slid / spun (into the room)*. These examples differ as to their expression of participant roles. In the transitive examples, a mover/ 'patient' role is expressed by the direct object NP, whereas in the intransitive examples, the mover role is expressed by the subject NP. Moreover, the intransitive examples do not express a second, 'agent' participant. Significantly, these examples differ not only with respect to argument realization patterns, but also with respect to what type of event is being described by that pattern. The transitive examples describe a 'transitive' event, in which the mover's motion is affected by the actions of another entity: an 'agent'. The intransitive examples also describe events that involve the movement of some entity, but this motion is not necessarily caused or affected by the actions of any other entity. Thus, the transitive and intransitive examples not only differ as to the expression (or non-expression) of an agent participant; they differ as to whether such a participant is even a conceptually necessary part of the event being described.

Other verbs, such as the 'force application' verbs discussed in the preceding chapter (five) exhibit some different patterns. Verbs such as *push, pull, slap* and *kick* often occur in transitive sentences, such as *She pulled / slapped his arm*. In such uses, the entity that the actor is acting upon is expressed by the direct object NP, and can be characterized as a 'patient' (i.e. an entity that is affected in some way by the actor's actions). But, this same 'acted upon' participant may also be expressed in other ways. This is seen in examples such as *She slapped at his arm* and *She slapped her hand on his arm*, in which the acted upon participant is expressed by the NP in a prepositional phrase, rather than as direct object. Moreover, accompanying these differences in role expression are differences in how the role played by this entity is conceptualized. Specifically, unlike the simple transitive example, in these other two examples, the 'acted upon' entity is not necessarily conceptualized as an affected patient.

In sum, while both of these types of verbs occur in sentences of prototypical transitive form and meaning, in which an 'agent' acts on and affects a direct object 'patient', they may also occur in other sentences that differ both as to overall form and meaning. Consequently, a simple characterization of these verbs as 'transitive verbs' whose meaning is a more specific instance of the basic transitive scene clearly does not adequately explain the different uses and meanings that these verbs can be used to convey. That is, we cannot simply characterize these as 'transitive verbs': we also need to account for their use in other types of situations.

As discussed in previous chapters, for both 'motion' and 'force application' verbs, it is possible to recognize a core meaning that is consistently present across these different uses (and patterns of argument realization). In the case of motion verbs, this core meaning is one of motion (without the necessary presence of an external agent or 'causer' of this motion). And in the case of verbs like *push* and *slap*, the core meaning is one of a force-application action in which an actor transfers force to another entity, but not necessarily with the objective of causing some specific effect to that entity. In both cases, then, the core meaning is something different than that of the 'prototypical' transitive scene.

In order to analyze transitive uses of these verbs, we have the same two options as for many other verb 'alternations'. One option involves positing additional verb senses. In this particular case, this would include a second, 'cause-effect' sense of these verbs. For instance, in addition to a core 'intransitive' motion meaning for *slide*, we could posit a second sense that includes the causal structure present in *She slid the box*. The alternative approach, pursued here, is to analyze transitive sentence meaning as a constructional composition of a verb's core meaning with the 'cause-effect' meaning of a transitive A-S construction. This approach will require definition of more than one transitive A-S construction, but will reduce the number of verb senses that we are required to posit. It will also require recognition and representation of various semantic relations between these transitive A-S constructions and their verb constituents. As we will see, use of schemas from the process schema lattice to represent the meanings of these different constructions will greatly facilitate this course of action.

Passives present another type of complication to the analysis of transitivity. Many passive sentences describe a scene that seems quite similar to the one described by their active transitive 'counterparts'. In particular, the same participants seem to be conceptually necessary parts of the scene. But, the sentences differ as to how these participants are expressed (or not). For example, *He cut the bread* and *The bread was cut by him* both seem to have the same set of participants and describe the same scene, but these participant roles are expressed differently. Specifically, for passives, the 'patient' is expressed as subject, and the 'agent' is the optional object of a *by*-phrase. In addition to needing to formalize this different argument realization pattern (with different constraints on the verb constituent), we also need to account for whatever differences in meaning are associated with active vs. passive. As we will see, the profiledParticipant role plays a key part in the analysis of passives in the current grammar.

Yet another challenge is presented by the fact that not all clauses with transitive syntax necessarily have prototypical transitive meaning. That is, in some cases they describe scenes that differ in some important respects from the 'prototypical' transitive scene. These deviations include:

- Causation without intentionality and/or agency (*The falling branch broke the table*)
- 'Agent' is an animate entity which experiences some stimulus; stimulus is not typically affected (*I smelled the flower*)
- Mover moves in relation to some other entity, but this entity is not necessarily affected by the mover's motion (e.g. *I followed my dog*; *I entered the room*).

What semantic relation do these transitive examples have to the more prototypical ones? We could expand the definition of transitive meaning to include these additional types of situations, but would end up with an overly general meaning. Alternatively, we could assume that while these examples all exhibit a similar syntactic pattern, they are expressing distinct, unrelated meanings and that we therefore should not try to draw any generalizations over the group as a whole. As will be shown here, the constructions in the current grammar result from taking a third, somewhat different approach.

6.3 Overview of analysis

In this section, I discuss how the challenges described above are handled, and present an overview of how the sentences examined in this chapter are analyzed. More detailed descriptions of the specific constructions and schemas used in these analyses are presented in the sections that follow this one. Many of the insights incorporated into this analysis are not new; the contribution lies in showing how these insights can be formalized, integrated and extended.

ECG grammars are usage-based, designed to capture both relatively local and broader generalizations. Accordingly, rather than attempting to define a single very general transitive A-S construction, this chapter describes a different strategy, in which several different transitive A-S constructions are defined, each of which captures relatively local (though not lexically-specific) generalizations over constituency, form and/or meaning.
At the same time, these constructions are defined in such a way that we can recognize relations and similarities between them.

As discussed in the chapter introduction, specific A-S constructions in the current grammar are defined such that they capture similarities and distinctions with respect to the following elements: (1) the specific number and type of constituents; (2) the (prototypical) order of the constituent forms; (3) the particular type of humanly relevant scene the A-S construction is used to describe; (4) the focal participant within this scene (i.e. from which participant's perspective this scene should be simulated), and; (5) the semantic relations between the A-S construction and its constituents (particularly the verb constituent). A difference with respect to any one of these elements provides a basis for positing two or more separate A-S constructions. The A-S constructions presented in this chapter capture distinctions with respect to the type of event, the perspective taken on that event, and relations between verb and A-S construction meaning (i.e. how verb meaning is related to event meaning). A brief description of each is given below.

<u>Type of event.</u>

The 'prototypical' transitive scene can be characterized as one in which one entity (an 'agent') acts forcefully on another entity (a 'patient'), with the intended result that this second entity is affected in some way by this action. But, not all sentences of transitive form describe this type of event, differing as to the presence/absence of basic concepts such as agency, intentionality, causation and affectedness. Rather than trying to define a very general schema that is applicable for all these different situations, I identify several different types of 'transitive' events and use a different schema to represent each one. In this way, it is possible to define different 'families' of A-S constructions, each of which differ as to the type of event they describe, as indicated by the use of different schemas to represent their meaning. One family of A-S constructions is defined for the prototypical transitive scene, and other A-S constructions are posited for other kinds of scenes (e.g. non-agentive causation, perception of a stimulus, changes in spatial relations). The main focus of this chapter will be on sentences that describe prototypical transitive events, which, as will be discussed more fully below, are represented using the CauseEffectAction schema introduced in the previous chapter.

<u>Relations between verb and A-S construction meaning.</u>

Each A-S construction specifies constraints on the semantic class of verbs that can serve as its verb constituent, as well as specifying the semantic relation it has to this verb constituent. For A-S constructions that describe prototypical transitive events, I examine three different groups of verbs, each of which differs as to the semantic relation it has to the A-S construction as a whole. In keeping with the assumptions made in Chapter 4, I view the 'central case' relation to be one in which the verb and the A-S construction share the same schematic structure. This is indicated in constructional representations by the fact that both identify their meaning with the same schema. In extensions to this central case, the A-S construction and its verb constituent have some schematic structure in common, but the two differ in some respects. As Goldberg (1995) observes, while verb meaning is often a more specific instance of the general type of event designated by the A-S construction, other types of relations are also possible, including 'means', 'manner', and 'result'. One contribution of the current analysis is to show how different types of relations can be explicitly and precisely specified within A-S constructions using the schemas in this ECG grammar.

Perspective

In addition to specifying a type of event and a relation between the meaning of its verb constituent and that scene, specific A-S constructions specify from which participant's perspective a given event is conceptualized (and therefore from which participant's perspective the scene should be simulated). This information is specified within the A-S construction by a binding between an event participant role and the EventDescriptor schema's profiledParticipant role. The main focus in this dissertation is on an analysis of active sentences. But, in this chapter I also look at passive sentences that describe prototypical transitive events. Difference in perspective plays a crucial part in the analysis of passives presented here. In this analysis, active sentences and their passive 'counterparts' are seen as describing the same type of event, but describing it from different perspectives. For example, *Jack cut the bread* describes a 'transitive' (CauseEffectAction) event from the perspective of the causer (Jack), while *The bread was cut (by Jack)* is described from the perspective of the affected entity (the bread). Passives are analyzed in the current grammar using a separate hierarchy of A-S constructions that are semantically related to the active family of transitive argument structure constructions.

Summary

The current grammar contains several different specific A-S constructions that differ with respect to their particular specifications of: (1) the type of event they describe, e.g. a prototypical transitive event, or some other type of event; (2) their semantic relation to their verb constituent, and; (3) simulation perspective, which is correlated with differences between active and passive A-S construction differences. By defining these individual specific constructions as part of a larger hierarchy of A-S constructions, the grammar also captures many of the commonalities between these and other A-S constructions.

6.4 Prototypical transitive A-S constructions

6.4.1 Event type: the prototypical transitive scene

As already noted, the basic scene prototypically described by transitive A-S constructions is one in which a person forcefully acts on some object or other person, with the outcome being that this 'acted upon' entity is affected in some way (e.g. changes state, moves, experiences pain, etc.). In English transitive sentences, this is usually – but not always -- an intentional action: the reason the actor performs this particular action is to bring about some particular desired outcome.

As discussed in the previous chapter, one characteristic of such events is that they involve two entities, each of which is associated with some process. Significantly, in at least some cases it is possible for each of these processes to occur -- and be conceptualized -- independent of one another. For example, a person can perform a motor-control action, even one that involves force, without (perceptibly) affecting another entity and perhaps without any intention of doing so. This is reflected in sentences like *He pulled on the rope, but it didn't budge*. And in many cases, any "effects" that do occur are ones that can also occur independent of the action and, in some cases independent of any readily observable 'causer'. For example, not all motion is initiated by an external agent (e.g. *The leaf (spontaneously) fell off the tree*). Neither are all painful experiences (e.g. feeling a sudden unexplained pain in your leg), nor all changes of state (e.g. a branch may spontaneously break). Thus, the two processes seem to be dissociable to some extent.

However, the fact that these two processes are described by a single transitive clause suggests that we are able (and likely) to conceptualize the actor's action and the effect to the patient as parts of a single coherent event. [1] Why might this be the case? As hypothesized in the previous chapter, the answer may lie in the nature of the goal-directed, forceful motor-control actions that are described by 'prototypical' transitive sentences. In such actions, these two processes are tied together in two key ways. Firstly, there is a causal relation between them: there is a presumption that the particular process that the patient undergoes is the consequence of the actor's actions. More specifically, we can view the force 'transferred' from the actor to the patient as the causal element that leads to some effect in the patient (e.g. initiates a process that would not otherwise have started). Secondly, in goal-directed actions, the 'affected process' provides important feedback to the actor, both in terms of planning and execution of the action. For instance, the specific routine and amount of force that the actor chooses to use are largely based on what type of effect he hopes to bring about. Moreover, the actor needs to monitor the ongoing action and effect with respect to this goal, adjusting the action if needed and performing it until the he perceives that the desired effect has been accomplished. In such situations, then, the actor's causal action is itself influenced by the effect. Therefore,

[1] It is also possible to describe them using separate clauses, especially when the 'causer' is inanimate. E.g. *The branch landed on the table. The glass top shattered.* vs. *The branch shattered the glass table top*.

such actions are inherently complex, involving two closely coordinated, inter-related 'processes'.

Thus, prototypical transitive events appear to be conceptualized as a single gestalt, but one which has complex internal structure. The structure of such scenes can be represented using the CauseEffectAction schema (Figure 5.5). This schema has two integrated subprocesses. The first subprocess is the action being performed by the actor, and is constrained to be some sort of force-application action. The second subprocess is the 'effect' that the patient undergoes.[2] Two key participant roles are defined by this schema, each of which is identified as the protagonist of one of the subprocesses: the animate causer performs the action, and the affected is acted upon and (potentially) affected in some way by this action. This schema also specifies that there is a transfer of causal force from the causer to the affected. The participant roles defined by this schema thus capture many of the same properties as typical Agent and Patient roles. Significantly, though, the ECG representation and underlying conceptualization of these roles is semantically complex, and they are defined relative to embodied gestalt schemas, rather than just being names whose meaning is not explicitly specified.

For each member of the family of 'prototypical' A-S constructions discussed here, the meaning of the A-S construction is therefore identified with the CauseEffectAction schema. And, since A-S construction meaning is bound to the eventType role of the EventDescriptor schema, this indicates that these A-S constructions are used to describe events that have the schematic structure represented by CauseEffectAction. These A-S construction meanings indicate the general schematic structure that recurs in a variety of different transitive scenes. Consequently, they do not specify details about the nature of action, the force transfer, or the effect present in specific scenes (e.g. they don't specify a particular motor-control routine that the actor performs, what body part or instrument the actor uses, nor the specific type of effect that results from some particular causal action.)

For each of these prototypical A-S constructions, the verb constituent has some schematic meaning in common with the A-S construction. But, in addition to having a core schematic component, each verb construction also typically has more lexically-specific meaning specifications. When a specific verb composes with one of thee transitive A-S constructions, these more specific elements serve to elaborate facets of the 'cause-effect action' event described by sentence. But, as we will see, the particular facets they elaborate differ for different groups of verbs.

[2] While the prototypical transitive situation is one in which the actor is acting volitionally, with intention to bring about an effect, the CauseEffectAction schema presented here represents a somewhat more general 'cause-effect' situation, in which the actor's actions result in a transfer of force to the patient, but the actor is not necessarily acting volitionally and/or with the intent to bring about any specific effect. Therefore, this schema does not include structure and bindings relating to volition or intent.

6.4.2 A radial category of transitive A-S constructions

In the sections which follow, I examine three different 'prototypical' A-S constructions, each of which differs as to which semantic 'class' of verbs can serve as verb constituent, and which, accordingly, also differ as to the semantic relation between the A-S constructions and its verb constituent. For each, the basic procedure is to examine a specific sentence containing a verb from that semantic class, and to describe the A-S construction instantiated in that sentence. Following this, I present a full constructional analysis of that sentence and describe the SemSpec this analysis yields. For the first example, these elements are each described in some detail. Then, following examples are described in terms of their differences and similarities to the first example.

6.4.2.1 Central case.

Let us start by examining the sentence *He cut the bread*. We can characterize the meaning of this sentence in terms of the type of scene it describes, e.g. one in which a (male) actor performed a forceful 'cutting' action on another entity (bread). Furthermore, the sentence specifies that this action resulted in some sort of effect on the bread, as indicated by the fact that it doesn't make sense to say *He cut the bread, but nothing happened to it*. But the effect is underspecified: at a minimum we might assume that the bread surface is 'severed', but further details are only defeasible inferences. The constructions instantiated in this sentence, when unified, should produce a SemSpec that supports simulation of such a scene.

The event described by this sentence is a more specific instance of the prototypical transitive scene described above. Consequently, the meaning of the A-S construction instantiated in this example, TransitiveCEA1, is identified with the CauseEffectAction schema. In addition, this construction has an (inherited) constraint that its meaning is bound to the eventType role of an evoked EventDescriptor schema. Together, these constraints indicate that the eventType has the causal structure of the CauseEffectAction schema.

As discussed in Chapter 5, the core schematic meaning of *cut* can also be analyzed and represented using CauseEffectAction, as can verbs such as *crush*, *chop*, etc. Thus, in this case, the schematic conceptual structure associated with the verb is the same as that associated with the A-S construction itself. This similarity of schematic structure is indicated in TransitiveCEA1's semantic constraint that the meaning of its verb constituent is identified with a CauseEffectAction, schema. Because this constraint is not lexically-specific, TransitiveCEA1 can be used to analyze a variety of transitive sentences that include 'cause-effect action' verbs, such as in (2).

(2) He cut / crushed / sliced/ sawed the bread.

In such examples, while the verb and A-S construction may have the same schematic meaning, the verb provides additional more specific meaning, thus serving to 'elaborate' or profile certain aspects of this cause-effect event. This function is indicated by the inherited constraint that the meaning of the verb constituent is bound to the profiledProcess role of an evoked EventDescriptor schema.

In addition to its inherited verb constituent, TransitiveCEA1 has an np constituent. Form ordering constraints specify that the form of this constituent canonically follows that of the verb. Meaning constraints specify that the meaning of this np constituent is bound to the affected role of the CauseEffectAction schema. Thus, this construction indicates that the entity expressed by the 'direct object' np constituent is acted upon and potentially affected by the causer's action.

Recall that A-S constructions are not defined as clause-level constructions (as discussed in Chapter 4). Consequently, TransitiveCEA1 does not include a 'subject' NP. It does however specify that the causer of the CauseEffectAction is the profiledParticipant. This specification indicates that the event should be simulated from this participant's perspective. In addition, for the current example, unification with the instantiated Declarative construction will result in the causer role being bound to the referent described by Declarative's subj NP constituent.

As shown in 6.1 below, TransitiveCEA1 is defined as a subcase of the general ArgStructure construction (Chapter 4, 4.3). TransitiveCEA1 IntransitiveLocomotion1 shares all the structure of this general ArgStructure construction 'parent', but also has the following additional specifications (shown in black in the figure below):

- In addition to a verb constituent, it also has a noun phrase constituent (np)
- Form constraints indicate that the form of the verb canonically precedes that of the np constituent.
- A-S construction meaning is identified with a more specific subcase of Process (the CauseEffectAction schema).
- Bindings indicate the semantic relations between the A-S construction and its constituents (thus indicating how their meanings are integrated).
- A meaning constraint indicates which event participant role is 'profiled' (the causer).

```
construction TransitiveCEA1 // central case
  subcase of ArgStructure
   constructional
    constituents
       v: Verb
       np: NP
   constraints
      self.features <--> v.features
   form
     constraints
       v.f before np.f
  meaning: CauseEffectAction
     evokes EventDescriptor as ed
     constraints
       self.m <-->ed.eventType
       v.m  <--> ed.profiledProcess
       self.m.causer  <--> ed.profiledParticipant
       self.m <--> v.m
       self.m.affected <--> np.m
```

Figure 6.1 The TransitiveCEA1 construction instantiated in examples such as *He cut the bread* (inherited structure in gray).

Sentence Analysis and the SemSpec

Using the current grammar, the example *He cut the bread* is analyzed as instantiating the following constructions:

- Lexical constructions for each of the words, including a CutPast construction for 'cut' (see Chapter 5, 5.6)
- NP constructions for 'He' and 'the bread'
- TransitiveCEA1 A-S construction
- Declarative clause construction (see Chapter 4, 4.1)

When these instantiated constructions unify, they produce a SemSpec (6.2) that supports simulation of the event described by this sentence.

The SemSpec includes an EventDescriptor schema, which provides many key simulation parameters. EventDescriptor's eventType role is bound to the meaning of the TransitiveCEA1, which is identified with CauseEffectAction. In this 'central case' transitive construction, the meaning of the verb constituent is closely similar to that of the A-S construction. Accordingly, the profiledProcess role is also bound to CauseEffectAction, the schema with which CutPast identifies its meaning. .
Additional meaning specifications in the verb construction may provide further information about this process, including details about the nature of the effector (a sharp thing of some kind) and the effect. In this way, the A-S construction supplies information

about the general type of event being described, and the verb provides additional information about the specific processes involved in this event.

In addition, unification of TransitiveCEA, CutPast, Declarative and instantiated NP constructions results in several bindings associated with each of the participants of this event. Specifically, the Causer role of CauseEffectAction is bound to:

- protagonist of CauseEffectAction
- actor and protagonist of ForceApplication (which is process1, the causal action of CauseEffectAction)
- referent described by 'he' (male animate)
- profiledParticipant

And Affected is bound to:

- protagonist of CauseEffectAction's process2 (the effect)
- actedUpon of ForceApplication
- referent described by 'the bread'

This SemSpec will support a simulation of an event in which a male animate causal actor performs some kind of forceful 'cutting' action on some bread, with the result that this bread is affected in a particular way (e.g. is cut / divided into smaller units). This event is described from (and should be simulated from) the perspective of this actor/causer. Simulation of this event can give rise to some additional inferences concerning, for example, how much energy the actor expended, what sort of instrument he used, and what may have motivated his actions.[3]

The SemSpec shown in 6.2 was produced on the ECG workbench utilizing the Constructional Analyzer. As with other SemSpecs, this SemSpec consists of a set of semantic schemas, value constraints and bindings. For the other SemSpecs described in this dissertation I will use the reduced notation above that shows sets of roles which are bound together (shown as co-indexed roles in 6.2).

[3] A specific language understander may draw many additional inferences that depend on variable factors such as the context this sentence is uttered in, the language user's past experiences with cutting bread and other substances, etc. But the constructions in this grammar are intended to provide the 'core' conceptual structures likely to be consistently utilized by a range of language users in a variety of different utterance contexts.

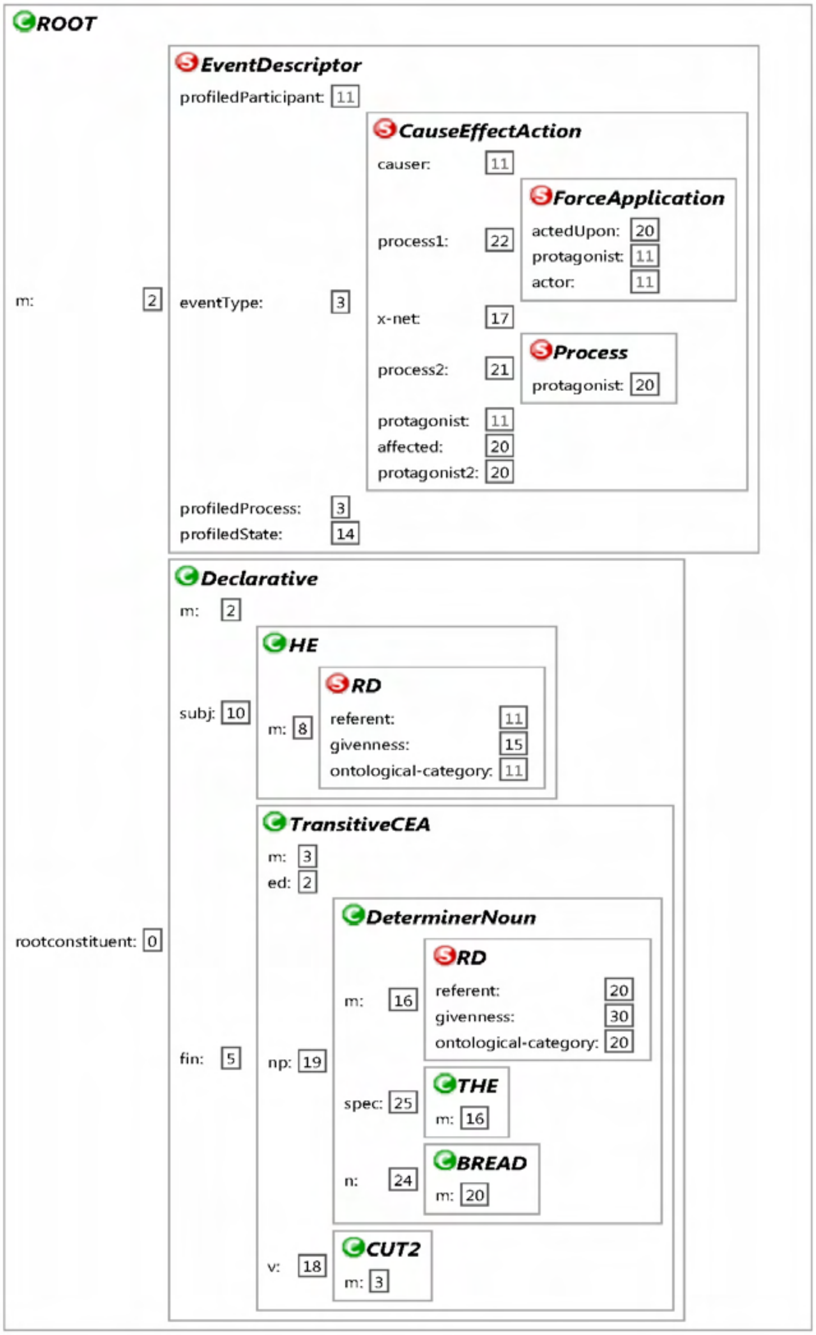

Figure 6.2 SemSpec for *She cut the bread*. Bindings in this figure are indicated via co-indexation. Thus, two roles that are bound to one another will have the same boxed number following the role name.

6.4.2.2 Profiled cause

Next, consider the example *He pushed the bread*. As in the previous example, this sentence can be used to describe a situation in which an (animate, male) actor acts forcefully on another object (*bread*). Unlike the previous example, however, no particular effect is specified, though there are many different possible effects that we might infer (e.g. the bread might move or fall apart).

As discussed in the previous chapter, the core meanings of verbs such as *push*, *shove*, *nudge*, etc. are represented in the current grammar in constructions which identify their meaning with a ForceApplication schema. This schema represents the structure associated with forceful actions but, unlike CauseEffectAction, the forceful action is not necessarily causally linked to an effect. This is consistent with the idea that these verbs are used to describe actions which do not always bring about an effect to the entity that force is applied to, and may not even be performed with that goal in mind. For example, someone might slap their hand on their leg as an expression of emotion, or push against a table with the intent of moving oneself, not the table.

This means that the schematic structure associated with these verb constructions differs from that of the prototypical transitive event, which is represented using the CauseEffectAction schema. However, because of the way CauseEffectAction is defined, we can easily recognize that the schematic structure associated with these verbs is the same as part of this event structure. Specifically, it is the same as the 'causal action' subprocess of CauseEffectAction (as indicated by the specification that this subprocess is some kind of ForceApplication action).

By defining a transitive a-s construction that indicates this relation, we can capture the fact that transitive uses of these verbs (such as *He pushed the bread*) are used to describe events in which the actor's force-application is conceptualized as leading to (or at least potentially leading to) some effect to the acted upon entity. For this reason, the current grammar includes another transitive A-S construction, TransitiveCEA2, that specifies that the meaning of its verb constituent is bound to the 'causal action' subprocess of the CauseEffectAction meaning of the A-S construction as a whole.

As was discussed in Chapter 4, the prototypical situation may be one in which an A-S construction has the same schematic structure as its verb constituent. This is the relation present in TransitiveCEA1, discussed in the previous section. However, it is also possible to identify and represent extensions to the central case in which the verb's schematic structure is related to -- but not the same as – that of the A-S construction. Consistent with this view, TransitiveCEA2 is defined as a minimally different extension to TransitiveCEA1.

The crucial difference between this extension and the central case concerns the meaning of the verb constituent and its relation to the event described by the A-S construction. TransitiveCEA2 indicates that its verb constituent has 'force-application' meaning, and that this constituent provides information about the causal process of the CauseEffectAction (process1), but does not elaborate the effect (process2). This is specified by defining TransitiveCEA2 as a subcase of TransitiveCEA1, and then: (1) specifying that the inherited constraint that verb meaning is the same as A-S construction meaning should be ignored, and (2) binding the 'causal action' subprocess, (process1, which is constrained to be ForceApplication) to the verb constituent meaning. Because these meaning constraints are not lexically-specific, they will be met by many different verbs which identify their meaning with ForceApplication.

The sentence *She pushed the bread* can be analyzed as instantiating many of the same constructions as for *She cut the bread*. The key differences concern the verb and A-S constructions instantiated. Rather than instantiating CutPast and TransitiveCEA1, *She pushed the bread* instantiates PushPast and TransitiveCEA2. The SemSpecs for these examples are also very similar. The main difference involves the profiledProcess role. This role is still bound to the meaning of the verb, but in this case verb meaning is ForceApplication rather than CauseEffectAction. However the verb meaning is still related to that of the transitive A-S construction, as indicated by the binding between ForceApplication and process2 of CauseEffectAction.

Also, for this example, while the A-S construction specifies that the event has cause-effect structure, neither it nor its verb constituent specify what type of effect results from the causal action. However, the SemSpec will provide parameters for a simulation which may give rise to various inferences, with the particular effect inferred depending largely on the particular fillers of the causer and affected roles. Compare: *The baby/weightlifter pushed the feather / chair / car*. The simulation of effect will also depend on the specific ForceApplication action described by the verb. For instance, substitute *nudged*, which specifies a low amount of force, in the examples above.

Thus, when force-application verbs such as *push* occur in transitive sentences such as *She pushed the bread*, the best-fitting interpretation of the sentence produces a SemSpec that supports simulation of some effect to the acted upon entity, even though the verb construction itself doesn't necessarily include this structure. In other words, when used in transitive sentences such as these, we get a cause-effect conceptualization of the process described by these 'force-application' verbs.

6.4.2.3 Profiled Effect

Now let us examine the sentence *He slid the bread*, which includes a verb (form) that can also be used intransitively, as in *The bread slid*. Both of these examples describe a situation in which the bread is moving. But, in the transitive example the sliding motion is conceptualized as being the effect of some unspecified causal action, while in the intransitive use this is not necessarily the case.

As discussed in Chapter 3, the verb *slide* is consistently used to describe motion which is accompanied by changes in the mover's overall location. The grammar therefore includes a SlidePast construction that identifies its meaning with MotionAlongAPath (Figure 3.6), a motion schema with a mover that is also a trajector in an SPG (source-path-goal) schema. The meaning of this verb construction thus does not include causal structure (though it doesn't specifically preclude it, either).

As in other verb 'alternation' situations, one approach to analyzing transitive uses of *slide*, such as *He slid the bread*, is to posit an additional sense of this verb, in which the motion is an effect of a causal action. Under such an approach, the transitive example above would be analyzed as instantiating the transitive verb construction, which would unify with the central case TransitiveCEA1 A-S construction. Other verbs that also exhibit these same two argument realization patterns e.g. *bounce*, *break*, *open,* etc. could also be analyzed in a similar fashion. We could posit 'intransitive' senses in which constructional meanings are represented using schemas for processes that involve a change in state or location, but which are agnostic as to whether that state change is initiated, maintained, and/or terminated by some other entity. And for each verb we could also posit a second 'transitive' sense in which this process is caused by some external causal agent.

However, the current grammar also includes another transitive A-S construction extension whose verb constituent meaning is related to the effect subprocess of the 'cause effect action' event. When an 'intransitive' verb construction such as SlidePast unifies with such a construction, it serves to elaborate the effect that is caused by some (unspecified) causal action. Or, to look at this in a somewhat different way, unification with such a transitive A-S construction indicates that the process associated with the 'core' meaning of the verb should be conceptualized as being caused by some external agent. Given such an A-S construction, it is not necessary to posit a second 'caused' meaning of *slide* to analyze the sentence *He slid the bread*.

This additional A-S construction is named TransitiveCEA3. This construction is very similar to TransitiveCEA2 (used to analyze *He pushed the bread*), except that the meaning of the verb constituent is bound to process2 (the affected subprocess) of CauseEffectAction rather than to process1 (the force application subprocess). Thus, when SlidePast unifies with this A-S construction, it serves to elaborate the effect, but not the causal action. As with other A-S constructions, because these meaning constraints are not lexically-specific, this same A-S construction will also potentially unify with many other verbs, which in this case includes verbs such as *move, break*, etc..

While the verb and A-S constructions instantiated in this example differ from those of the previous examples, the other instantiated constructions are the same. The SemSpec is also the same in most respects, with the main difference again involving the profiledProcess role: for the current example this is bound to MotionAlongAPath rather than CauseEffectAction, or ForceApplication. In addition, MotionAlongAPath is bound to process2 of CauseEffectAction, indicating that the meaning of the verb construction serves to elaborate the effect of the cause-effect action.

This binding between processes results in an additional role binding that was not present in the previous examples. In addition to affected being bound to the actedUpon role of ForceApplication and to the referent described by 'the bread', it is also bound to the Mover role of MotionAlongAPath. Thus, the SemSpec for this example indicates that the bread is an 'affected-mover' who is acted upon by a causer.

6.5 Passives: a different perspective on prototypical transitive scenes

While passive is typically analyzed in relation to active, the exact relation remains a topic of continuing linguistic research. In the analysis sketched here, actives and passives are treated as different families of constructions which are related through common semantics. The general idea is to have passive constructions use the same meaning schemas as their active counterparts, while having different constituents, form constraints, and bindings that they inherit through the passive hierarchy.

Passives examples such as *The bread was cut/ pushed / slid (by him)* are semantically similar to the examples that were examined in the previous section: all describe prototypical transitive scenes with two main participants that can be characterized as playing the roles of 'causer' and 'affected'. But, there is a crucial difference between these examples concerning the patterns by which these two participants are expressed. Specifically, in active transitives, the causer is expressed as subject NP, and the affected entity as direct object NP, whereas in passives, affected is expressed as subject NP and causer is optionally expressed as the object of a 'by phrase'.

Constructionally, passive A-S constructions differ from active transitives in terms of their constituents. Unlike the active transitive A-S constructions, passive constructions do not have an NP constituent, though they may have an optional prepositional phrase. In addition, passives have different verb constituent constraints, including the fact that the verb form is that of past participle. The current grammar includes a general Passive construction which specifies these constraints. More specific passive subcases inherit these constraints, but differ in their meaning specifications.

Using this grammar, the examples above can be analyzed as instantiating passive A-S constructions which identify their meaning with CauseEffectAction. This indicates that, like the transitive A-S constructions discussed above, these constructions are used to describe 'prototypical transitive' events. But, as noted above, the passive constructions express the participants of this event differently than do the active ones. This difference is handled by binding the profiledParticipant to the affected role, rather than the causer role. As a result, when these passive constructions unify with the other constructions instantiated in the utterance, the affected role will be bound to the 'subject' NP constituent of Declarative. Binding profiledParticipant to a different event participant role signals a difference in perspective as well, with the passive constructions specifying that the cause-effect event is described from the perspective of the affected entity, whereas in active voice the event is described from the perspective of the causer.

As with all A-S constructions, these passive A-S constructions also need to specify the semantic relation the verb constituent has to the A-S construction as a whole. In other words, they need to specify what semantic class of verbs can serve as the verb constituent for a given passive A-S construction, and how the meaning of this verb is integrated with that of the A-S construction. This can be handled the same way as it was for the active transitive constructions. In the central case construction, the meanings of the verb and A-S construction are closely similar, In one extension the verb elaborates the causal action, and in another extension it elaborates the effect. The end result is a radial category of passive constructions that is semantically similar to active transitives, but is constructionally similar to other passives.

As with the active examples, these passive examples also instantiate the clause-level Declarative construction and an NP construction for 'the bread'. When these constructions are unified, the SemSpecs for passive examples are very similar to their active counterparts. For instance, the SemSpec for *The bread was cut* is very similar to the one for *He cut the bread.* Both indicate that the sentence describes a 'cause-effect action' event, which involves both a causer and an affected participant. The key difference is one of perspective, as indicated by differences as to which participant is bound to profiledParticipant. In addition, while the causer is a conceptually necessary participant in the events described by both examples, it is not directly expressed in this passive example. Moreover, even in passive sentences in which it is expressed (e.g. *The bread was cut by him*), the causer is not attentionally foregrounded the way it is in active transitive sentences.

6.6 Less Prototypical 'Transitive' events

The family of A-S constructions described above can be used in the analysis of many different clauses that describe prototypical transitive events, in which an actor performs an action that affects another entity in some way. However, there are many sentences that exhibit similar 'form' (i.e. V > NP), but which describe events that differ in some significant ways from this prototype. Consider two such deviations:

- The event has cause-effect structure, but the cause is not necessarily associated with an actor's actions. E.g. *The (falling) shard of glass cut the bread*

- The event has an intentional actor, but does not exhibit cause-effect structure. E.g. *He smelled the bread.*

In both types of events there are two salient entities involved, but they play somewhat different roles in the event than do the entities in 'cause-effect action' events. In the first type of event, we can still characterize the two roles as 'causer' and 'affected', but the 'causer' is not necessarily an animate actor. The second has an animate actor, but the other entity is not necessarily affected by the actor's actions/experiences.

Because the transitive A-S constructions presented in the previous section identify their meaning with CauseEffectAction, their meaning specifications are not consistent with the type of event described by these other examples. This could be taken as a sign that the meaning specifications of these transitive constructions need to be changed so as to broaden their application. However, in a usage-based grammar such as this, the objective is not to identify only the broadest generalizations possible. Consequently, 'nonprototypical' transitive examples such as these are instead handled by positing additional transitive A-S constructions. In terms of constituency and form constraints, these constructions are similar to the ones described in the previous section. Crucially, though, they differ as to the types of events they are used to describe. As discussed below, these different events bear some important similarities to 'cause-effect action' events, though the relations are not the same in each case.

6.6.1 Non-agentive causation

First, consider the sentence *The (falling) shard of glass cut the bread*. This sentence can be used to describe a two-participant event in which the 'action' of one participant (the falling glass) results in the other participant being affected in some way (being cut). But, unlike earlier examples, this 'causal action' doesn't necessarily involve motor-control; not only is the causer not necessarily an actor, it may not even be an animate entity.

To represent this type of event, we can define a CauseEffectProcess schema (not shown), a schema that is similar to CauseEffectAction, but which has looser constraints on the type of causal subprocess involved. Specifically, while this causal subprocess 'supplies' a force that is transferred to another entity, it doesn't necessarily involve a motor-control action. This is consistent with scenarios such as the one described above, in which force is transferred from the (non-agentive) moving causer to the other entity upon impact.

A more detailed account of how to formally represent this difference is as follows. CauseEffectProcess has all the same specifications as CauseEffectAction except for its constraints on process1 (the causal subprocess). Specifically, this subprocess constrained to be a type of ForceSupply (not shown), rather than a ForceApplication. ForceSupply is a subcase of Process that binds the protagonist role to the supplier role of an evoked ForceTransfer schema. CauseEffectProcess thus has a causal subprocess that supplies force, but which is not constrained to be a motor-control schema of some kind, and a causer role that is a force supplier but is not constrained to be an animate motor-control actor. As with CauseEffectAction, CauseEffectProcess has an affected role that is the recipient of the transferred force. Thus, while CauseEffectProcess doesn't share the motor-control elements of CauseEffectAction, it does share its 'force transfer' structure.[4] And both schemas have one role that is the supplier of this force, and another that is its recipient.

This CauseEffectProcess schema can then be used to represent the meaning of a family of A-S constructions that are used to describe 'cause-effect' scenes that don't necessarily involve agentive causation. As with the transitive A-S constructions presented previously, this can include a central case construction in which verb meaning is the same as that of A-S construction, and subcases in which their meanings differ.

The question may arise as to why we can't use the more general schema to represent the prototypical transitive scene as well, and therefore only have one set of transitive 'cause-effect' constructions, rather than separate ones for agentive and non-agentive causation. One important point is that if we don't have transitive A-S constructions that identify their meaning with CauseEffectAction, we will need some other way to specify the presence of agency, when relevant. That is, if the A-S construction doesn't specify agency, then the verb construction may need to. This might be a reasonable analysis for some verbs (e.g. *hit, strike, cut*).[5] However, for many other verbs, such as *slide, break*, *close*, etc., positing an agentive causal sense would run contrary to the current analysis, which utilizes constructions for these verbs that don't necessarily specify any causal structure at all, agentive or not.

Another important point is that just because a more general meaning has been identified, this doesn't mean that the more specific one needs to be 'eliminated'. This is especially true here, since the more specific schema better captures all of the elements associated with the type of scenes that are prototypically associated with transitive marking. This is true cross-linguistically, in that not all languages allow transitive marking for non-agentive 'causers'. And also within English, since transitive A-S constructions seem to be

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[4] Also, because CauseEffectProcess doesn't include motor-control, it doesn't include an effector that can potentially be conceptualized as an intermediary in a force transmission 'chain'.

[5] If separate agentive and non-agentive constructions are posited for such verbs, it will be necessary to determine which of them is most likely instantiated in a given example. This will involve consideration of various 'best-fit' factors, one of which is the nature of the entity that fills the causer role. If this entity is not animate, it will meet the constraints on CauseEffectProcess's causer role, but not those of CauseEffectAction. If it is animate, it will meet the constraints of both schemas, but since the constraints on CauseEffectAction are more specific, this schema will be considered a better fit. Additional information within utterance, or as part of context may also come into play as well, as in, e.g., (*When the boy fell on it) he crushed the paper cup.*

used relatively infrequently to describe non-agentive scenarios. Instead, such scenarios are quite often described in other ways using, for instance, intransitive A-S constructions that specify a path of motion (*The falling rock broke through the glass table top*) or separate clauses (*The rock fell on the table, and the glass top broke*).

Therefore, in addition to having a family of ‘cause-effect action’ transitive A-S constructions, the grammar also contains a family of non-agentive ‘cause-effect process’ transitive A-S constructions. There is, however, clearly a semantic relation between these two families. This relation is captured here by having both families identify their meaning with closely related schemas which both include force transmission and cause-effect structure, elements that are commonly viewed as central defining features of transitive events.

6.6.2 Non-causative transitives

While the examples examined thus far can all be analyzed as including some sort of cause-effect structure, not all examples of transitive form necessarily describe situations in which these kinds of structure are present. For instance, consider examples (3) – (5).

(3) He saw / smelled / heard the cow.
(4) He followed / tailed his dog.
(5) He entered / exited the room.

In each of these, the entity expressed as subject is associated with some process (e.g. a perceptual experience or motion). But, there is no specification – or even necessarily an inference – that this process leads to the transmission of force and/or causes some effect to the other participant.

For each set of examples, it is possible to make some generalizations about the type of event being described, and to define a schema that represents the schematic structure present in the event. For instance, sentences such as those in (3) can be all be analyzed as describing an event that involves one entity who undergoes some perceptual experience, and another entity that provides the content of this experience. And this event can be represented with a schema containing, at a minimum, these two roles. Sentences such as those in (3) and (4) can also be seen as describing two-participant events, though each would be represented by a schema containing a pair of somewhat different roles. Using these schemas, A-S constructions can then be defined to analyze each of these types of examples.

But, are such constructions semantically related to the other transitive A-S constructions? And if so, how? If we only look at the prototypical transitive scene in terms of its ‘objective’ properties, such as force transfer and contact, these may seem like the only possible basis for recognizing similarities. In which case, any similarity we recognize is likely to be quite abstract (e.g. see Langacker 1991)[6]. However, if we have a richer, more embodied view of the nature of such scenes, we can recognize other possible bases of comparison.

As discussed in Chapter 5, cause-effect actions can be analyzed as having two different types of relations between the participants (and the processes associated with them). One is the causal relation, which involves a flow of force and which is also present in non-agentive 'cause-effect' scenarios. But there is also another relation; the actor, in order to successfully perform the action, needs to 'attend to' various properties associated with the entity he is acting on (and attempting to affect). Thus, in these cases, there is also an asymmetrical experiential/perceptual relation between the causer and the affected.

A similar experiential/perceptual relation is present in the scenes described by the current set of examples. The situation described by examples such as *He saw / smelled / heard the cow* is one in which the experiencer's perceptual experience depends on the particular properties of the object being perceived (with relevant properties depending on what mode of perception the experiencer is using).

This relation is also evidenced in the situations described by sentences such as *Jan followed / tailed her dog*. In these situations, Jan's path and possibly also her speed of motion depend on her perception of the motion and changing spatial locations of her dog. And to simulate Jan's motion, we need to simulate the motion of her dog. But, the dog's motion is not necessarily affected by Jan's actions. A similar situation also holds for examples like *He entered/exited the room*. However, in these cases, the mover's path of motion depends on the configuration and/or orientation of another object, not its motion. So, to successfully perform these actions, the actor/mover has to attend to these properties.

Thus, analysis of the prototypical transitive event as a complex embodied process helps us to recognize different types of similarities with these other events. In one case, there is a similarity with respect to the presence of force transmission and causation. In other cases, the similarity is related to the actor's need to monitor certain aspects of another entity in order to successfully perform a given action. In each case, these similarities provide motivation for extending the use of the transitive argument realization pattern to the description of these other events.

In addition to recognizing the motivations for such extensions, the grammar also needs to specify which extensions English actually makes. Therefore, to analyze examples such as

[6] Langacker (1991: 221) suggests that there is an abstract similarity here involving contact and interaction. In both cases the agent or experiencer initiates some kind of interaction with another entity. In the prototypical case, this interaction involves contact and the transmission of energy. But in the other situations, there may be some kind of mental 'contact' with the other entity, but is not any transmission of energy.

(1-3) above, the grammar needs to include additional transitive A-S constructions for each of these different types of events. Each of these A-S constructions would have the same constituents and form constraints as does the central case TranstiveCEA1. But, they would identify their meanings with schemas that have similarities to, but are different than CauseEffectAction, indicating that these A-S constructions are used to describe other types of events (albeit ones which can be viewed as semantic 'extensions' of CauseEffectAction). Full definitions of these schemas and their relations to one another is a topic left for future work.

6.7 Same process, alternative conceptualizations: intransitives, transitives, and passives

At the beginning of this chapter, I listed several sentence examples that contain the same verb, but differ as to their overall form and meaning, such as:

(6) The bread slid / spun /rolled (into the room)
(7) He slid / spun / rolled the bread
(8) The bread was slid / spun / rolled (by him).

The main point of this section is to compare how the verb-designated process is conceptualized in these different types of examples. One key meaning difference relates to event type: is the verb-designated process conceptualized as being part of a single participant, 'autonomous process' event, or a two participant causal event? The other difference relates to event perspective: from which participant's perspective is a given event conceptualized / described?

We have already examined A-S constructions for two of these different argument realization patterns: (active) transitives and their passive 'counterparts' (e.g. *He slid the bread*; *The bread was slid*). But, in order to compare all three types of examples, we first need to examine the intransitive pattern (e.g. *The bread slid*) and the A-S construction such examples instantiate.

6.7.1 Intransitive A-S construction

In Chapter 4, I presented analyses of various 'motion-path' descriptions, including examples such as *The box slid into the room*. The analysis of intransitive examples such as *The box slid* is similar in many respects to the analyses of these 'motion-path' examples. However, rather than instantiating a relatively specific IntransitiveMotionAlongAPath A-S construction, the simple transitive examples can be analyzed as instantiating a simpler and more general IntransitiveProcess construction (6.3).

The central case IntransitiveProcess construction is very similar to the general ArgStructure A-S construction (see 4.3, Chapter 4). However, IntransitiveProcess has two key specifications not present in ArgStructure. One is a constraint found in other central case A-S constructions: a binding between the meaning of the A-S construction and that of its verb constituent (self.m <--> v.m). Because the meaning of the A-S construction is identified with the single participant Process schema, this binding indicates that the meaning of the verb constituent construction is (and/or should be conceptualized as) a single participant process of some kind. The second constraint indicates that the profiledParticipant role of the evoked EventDescriptor schema is bound to the protagonist of this process.

```
construction IntransitiveProcess
    subcase of ArgStructure
    constructional
      constituents
          v : Verb
    meaning: Process
      evokes EventDescriptor as ed
      constraints
          self.m <-->ed.eventType
          v.m  <--> ed.profiledProcess
          self.m <--> v.m
          self.m.protagonist <--> ed.profiledParticipant
```

Figure 6.3   The IntransitiveProcess A-S construction.

Using this IntransitiveProcess A-S construction, analysis of the sentence *The bread slid* results in a SemSpec that indicates that the mover (protagonist of the verb's motion schema) is the profiledParticipant, and is bound to the referent described by the subj constituent of the Declarative construction. Thus, this analysis captures the fact that in intransitive uses, the 'mover' role associated with a motion verb is expressed by the 'subject' NP. Additionally, the SemSpec indicates that this motion should be simulated as a single participant process from the perspective of the mover.

The sentence *The bread slid* is thus analyzed as prompting a simulation in which we focus on the motion of the bread. For a given use of this sentence, this described motion may in reality have been caused by some external actor (e.g. when he pushed it, the bread slid). And/or the sentence may be describing a situation in which the motion of the box caused some effect to another entity (e.g. the bread slid, hit the lamp, and knocked it over). The important point is that in this particular event description, the motion of the bread is <u>conceptualized as</u> (and therefore simulated as) an autonomous, single participant event.

6.7.2 Comparison of examples

Given this analysis of the intransitive example, we are now in a position where we can compare the three types of examples shown in (6) – (8).

As discussed in Chapter 3, the core meanings of motion verbs such as *slide*, *spin*, and *roll* are represented using a motion schema. These schemas include a role for a mover (and may also include a LM role), but do not include an additional role for another entity that may serve as the 'external causer' of this motion. Thus, the meanings of these verb constructions do <u>not</u> include causal structure such as that represented in the CauseEffectAction schema.

Each set of sentence examples that contain a given verb form can all be analyzed as instantiating a verb construction with the same core meaning. Consequently, in each case, the sentences are analyzed as describing events that include basic motion-related structure. Significantly, though, the A-S constructions instantiated in these different types of examples support analyses that indicate differences as to how this motion-related process is conceptualized in each of these descriptions. Focusing on the *slid* examples:

- *The bread slid* -- motion is conceptualized as an autonomous process, without any specified causal relations to any other processes. The event should be simulated from the perspective of this single participant: the mover.
- *He slid the bread* – motion is conceptualized as the affected process within a cause-effect event. This event should be simulated from the perspective of the causer (not the mover).
- *The bread was slid (by him)* – as with the transitive example, motion is conceptualized as a 'caused' process. However, as with the intransitive example, the event should be simulated from the perspective of the mover.

Thus, each argument realization pattern signals a different conceptualization of a given verb-designated process. And, A-S constructions in the current grammar capture these differences.

6.7.3 Extending this analysis to other verbs

Motion verbs are not the only types of verbs which designate processes which can at least potentially be conceptualized either as being caused or as being autonomous (i.e. one that is not necessarily affected by an external 'causer'). We can, for instance, make a similar analysis of sentences that include various verbs that describe changes in the 'state' of some object, such as *shatter*, *burst*, *break*, *open*, *melt*, etc. For instance:

(9) The door opened / She opened the door / The door was opened.
(10) The branch broke / She broke the branch / The branch was broken.

We can analyze each set of sentences as instantiating a core verb construction whose meaning is that of a single participant process. Intransitive examples support simulation of this specified process from the perspective of the 'undergoer', without requiring accompanying simulation of some other (causally related) process.[7] Active transitive examples support simulation of a causal action that affects the 'unfolding' of the verb-designated process, with this causal event simulated from the perspective of the causer. And passive examples also indicate that the verb-designated process should be conceptualized as being the effect of some other process, but this event should be simulated from the perspective of the affected entity (i.e. the 'undergoer'), not the causer.

Note that the processes designated by different verbs vary as to how amenable they are to autonomous vs. caused conceptualizations. For instance, *sneeze*, *yawn*, *pant*, and *sing* describe actions which are not typically conceptualized as the 'affected process' in a cause-effect action scenario (or even a non-agentive cause-effect scenario). It is for this reason, presumably, that such verbs are not used in transitive sentences such as *Sandra / The pepper sneezed him* (with the meaning that Sandra / the pepper caused him to sneeze). In some cases, though, we can conceptualize these actions as having a direct effect on some other entity, as indicated by sentences such as: *She sang him to sleep*; *She sneezed oatmeal on the dog*; and *The dog panted hot stinky dog breath on me*.[8] Similarly, the process described by *rot* is also typically conceptualized as autonomous (e.g. *The pumpkin rotted*). This process seems to resist an agentive causal conceptualization. For instance, if we heard a sentence like *Jan rotted the pumpkin*, it would be hard to imagine how Jan's actions may have directly affected the pumpkin's process of decomposition. But, as attested sentences such as *The leak rotted the hardwood floor*[9] indicate, we can conceptualize a rotting process as being directly affected by some other non-agentive process. Thus, even processes which are typically conceptualized as being autonomous can in some cases be conceptualized as affecting or being affected by another process.

To a large extent, we can view the range of different possible conceptualizations as being a function of the process itself. But, it is also the case that our notions about what type of process a particular verb designates will themselves be affected by the types of sentences we typically encounter these verbs in. For instance, if we only heard *break* used transitively, we might well assume that it describes a cause-effect action (or non-agentive causal process) that causes a loss of integrity of some object, similar to the verb *cut*. Whereas if we also encounter *break* in intransitive uses such as *The branch suddenly broke*, then we can draw the conclusion that the verb (consistently) refers more specifically to the loss of integrity itself, a change in state which is often – but not always – brought on by a force transferred from some other entity.[10]

[7] Note that the phrase 'all by itself' can be used to underscore the autonomy of the process, especially in situations where we might expect otherwise. E.g. "My bedroom door just opened all by itself**.** Creepy." (https://m.twitter.com/itallstarted)]. Similarly, "THIS TIME, i didnt even do ANYTHING and the camera broke, all by itself**!"** (shopper.cnet.com/digital-cameras/casio-exilim-ex-s500/4014-6501_9-31416644.html)

[8] The last two of these are attested sentences uttered by a member of the author's family.

[9] google search, accessed 6/20/10 (www.kudzu.com/m/Southside-Plumbing-Co-1349658/reviews/)

[10] See Lemmens (1998) for a similar analysis of 'transitive' and 'ergative' English 'suffocation' verbs.

Independent of language, we have the ability to conceptualize many types of processes in more than one way. For instance, a given process may be conceptualized as an 'autonomous' single participant process, as an action that affects another entity in some way, and/or as a process that is itself affected by another entity's actions. Language gives us the ability to communicate these different conceptualization patterns to others. One important way different conceptualization patterns are signaled in English is via the use of different argument realization patterns. By defining A-S constructions that pair these different argument realization patterns with different event conceptualization 'templates', the current grammar supports a compositional analysis that captures differences in event conceptualization in sets of sentences such as the ones examined here.

6.8 Summary

In this chapter, I described A-S constructions associated with three general, basic patterns of argument realization: transitive, passive, and intransitive.

Based on recognition of differences with respect to the type of event they are used to describe, and their semantic relations to their verb constituent, the A-S constructions instantiated in the transitive examples examined here are defined as a 'family' of several different, inter-related transitive A-S constructions.

Some of these transitive A-S constructions are used to describe what can be characterized as a prototypical transitive scene, in which a person forcefully acts on some object or other person, thereby affecting this entity in some way. The meanings of these A-S constructions are represented using the CauseEffectAction schema. This schema indicates the interdependence of cause and effect within agentive causal actions: the causer's actions affect how the 'affected process' unfolds, and the way the process unfolds may affect the causer's actions. A radial category of 'prototypical transitive' constructions is defined. In the central case, the verb constituent's schematic structure is the same that of the A-S construction. This is A-S construction is instantiated in examples such as *She cut the bread*, in which the instantiated verb's meaning is identified with the CauseEffectAction schema. In extensions to this central case, the verb's schematic structure is identified with some part of the A-S construction's event structure. Specific meanings associated with a given verb will serve to 'elaborate' the schematic event structure associated with the A-S construction. For instance, 'force-application' verbs like *push* will elaborate the causal action subprocess, whereas motion verbs like *slide* will elaborate the effect. From the viewpoint of the verb, in both of these extensions the A-S construction serves to add causal event structure to the verb's core meaning. That is, in transitive uses, pushing is viewed as a causal action that may bring about some effect to the acted upon entity, and sliding is viewed as being affected by some causer's actions.

Other A-S constructions of transitive 'form' describe events that are different than but show some similarities to the prototypical transitive scene. In the case of non-agentive causation (e.g. *The glass cut the bread*), there is a commonality of causal structure: as with prototypical transitive events, one causal process affects how another process unfolds. For other cases (e.g. *He smelled / followed the dog*) the commonality relates to the attention-related structure present: as with prototypical transitive events, an actor attends to the process associated with another entity.

Passive sentences are analyzed in the current grammar using a separate hierarchy of A-S constructions that are semantically related to their transitive 'counterparts' in terms of verb constituent meaning and event type. However, these passive A-S constructions differ from the active transitive A-S constructions with respect to their constituent and form specifications. Semantically, the crucial difference between these constructions concerns the specification of which event participant is the profiledParticipant.

Given these different active transitive and passive A-S constructions, sentences such *Jan pushed the bread / The bread was pushed* are both analyzed as describing the same type of event (a cause-effect action), but indicating that this event should be simulated from different perspectives. For *Jan pushed the bread*, the event should be simulated from the perspective of the causer (Jan), while for *The bread was pushed (by Jan)*, the event should be simulated from the perspective of the affected entity (the bread).

Intransitive examples such as *The bread slid* are analyzed as instantiating an IntransitiveProcess A-S construction. This A-S construction supports simulation of what is conceptualized as being a single-participant event. In some intransitive examples, the process designated by the verb is typically conceptualized as being an autonomous, single participant process (e.g. sneezing, rotting). But, in many cases, the verbs designate processes that can potentially be conceptualized in more than one way. However, when any of these verbs are used intransitively, unification with the IntransitiveProcess results in a SemSpec that supports simulation of a single-participant process: the process of which the profiledParticipant is protagonist. Furthermore, the SemSpec will indicate that this process should be simulated without necessarily simulating processes associated with other entities. For instance, analyses of examples such as *The branch rotted / slid / broke* specify that the process 'undergone' by the branch should be simulated as a single participant event, without necessarily simulating a 'causal' process. And for *She sneezed/yelled/ pulled*, the actions performed by the actor should be simulated, without necessarily simulating processes that may have caused or been affected by these actions. Thus, for verbs that designate processes which potentially have a direct relation to another process, intransitive uses will only focus on (actively simulate) the process related to one participant (which will be the profiledParticpant in these intransitive uses).

One broader generalization that we can make is that each A-S construction can be viewed as a paring between a particular 'verb plus arguments' pattern and an event conceptualization 'template'. This template indicates, for a particular semantic class of verbs:

- The type of event structure that should be simulated (i.e. which type of event the described situation is conceptualized as being?)
- From which event participant's perspective this event should be simulated (i.e. the event participant which is the primary focus of attention)
- How verb meaning is related to event structure (A-S cxn meaning). That is, what schematic structure the verb has in common with the A-S construction.

By representing the meaning of these A-S constructions and their verb constituents using schemas from the Process schema lattice, it is possible to explicitly represent various relations between verb and A-S constructions. Significantly, different relations indicate sometimes subtle differences in how the verb-designated process is conceptualized in various sentences, as described above.

In each case, the relation is based on some commonality of schematic structure of the A-S construction and the verb. When these two constructions unify, we can view the composition of meaning in two complementary ways. On the one hand, we can say that the verb 'elaborates' (e.g. specify values for) the schematic event structure that the A-S construction has in common with the verb. On the other hand, we can say that the A-S construction serves to focus attention on (support active simulation of) whatever portion of schematic structure that the verb has in common with the A-S construction. Different possible types of part /whole relations lead to the following possibilities:

- **Whole-whole**. Schematic structure of each is the same: verb elaborates A-S construction-specified event structure, and all of the verb-designated process is simulated (e.g. 'central case' situations like *She cut the bread* and *The bread slid*).
- **Whole-part.** Verb schematic structure is the same as <u>part of</u> the A-S construction event structure: verb will elaborate a <u>portion</u> of the event structure, and all of the verb-designated process will be simulated (e.g. *She pushed the bread*, *She slid the bread*).
- **Part-whole.** <u>Part of</u> the schematic structure associated with the verb-designated process is the same as the A-S construction event structure: the verb will elaborate this event structure, and <u>part of</u> the verb process will be foregrounded/simulated (e.g. *She pushed* and, as discussed in the next chapter, *She slapped at the bread*).
- **Part-part.** <u>Part of</u> the verb schematic structure is the same as part of the A-S construction structure: the verb elaborates a portion of the event structure, and part of the verb process is foregrounded/simulated (e.g. *She slapped the bread*, discussed in the next chapter).

Thus, when verbs occur with different A-S constructions, we get different 'construals' of the verb-designated process. In the following chapters, I look more closely at verbs such as *slap* and *kick*, and the various types of A-S constructions which they co-occur with. As we will see, because of the multi-faceted nature of the actions designated by these verbs, various types of relations to A-S construction meaning are possible, each of which indicate somewhat different conceptualizations of these actions.

Chapter 7

Conative A-S constructions: Different conceptualizations of complex motor-control actions

7.1 Introduction

In this chapter I show how many additional new cases can be analyzed using the basic groundwork established in the preceding chapters. As this chapter underscores, the recognition (and representation) of the depth and complexity of many constructional meanings is a critical element in the compositional analysis of the examples being examined here. In addition, this chapter further demonstrates the value of a radial category analysis of many A-S constructions.

As noted in the previous chapter, several verbs that appear in transitive sentences also occur in what are commonly termed 'conative' constructions. For instance:

(1)a. She slapped his hand b. She kicked the door

(2)a. She slapped at his hand b. She kicked at the door.

One readily apparent distinction between these examples is that the conative examples (2a) and (2b) include the preposition *at*, whereas the transitive examples (1a) and (1b) do not. Furthermore, we can analyze this difference as indicating that the entity that is expressed by the 'direct object' NP in the transitive examples is expressed as a prepositional object in the conative examples. Accompanying this difference in form is a difference in meaning. The general intuition is that in transitive examples, the actor (*she*) performs an action which affects the other entity (*his hand, the door*) in some way. In the conative examples, however, this affectedness is not a necessary entailment. Thus, while this entity's role in both situations seems to be similar in some respects (e.g. actor is acting with respect to this other entity), it differs with respect to 'affectedness'. In transitive examples, this entity plays the role of a typical 'patient' which is affected by the actor's actions. In conative examples, it role is more aptly characterized as a spatial 'goal'.

Due to these differences in form and meaning, 'conative' examples should clearly be analyzed as instantiating a different A-S construction than the transitive examples. But, what type of event does this 'conative' A-S construction describe? How is the meaning of the verb related to this event type? And, crucially, how can the meanings of the verb and A-S constructions instantiated in conative examples be defined such that their composition captures both similarities and differences to the meanings of similar transitive examples?

In this chapter I address these questions, showing how we can build upon the insights Goldberg and other linguists have had about conatives, and integrating these ideas into the current framework. One key element of the analysis presented in this chapter concerns the recognition and formal representation of the composite, internally complex nature of the actions designated by the verbs that occur in this conative construction. Another key element is the idea that, as with other A-S constructions, the conative A-S construction serves as an event conceptualization 'template' that indicates how the process designated by its verb constituent should be conceptualized (and simulated).

My basic analysis is as follows. The verbs being examined here, such as *slap*, *kick*, *tap*, etc., describe actions which involve both a 'force-application' and a 'spatial' action component. For instance, for slapping actions, the actor first moves her hand towards some entity, then contacts and applies force to that entity. This means that this other entity is both a spatial 'target' and a force-recipient. Schemas which represent the meanings of these verbs should these are essentially composite actions with both spatial and forceful components.

In a given sentence, the instantiated verb will have some schematic meaning in common with the instantiated A-S construction. Based on this commonality, their meanings will compose. The A-S construction will serve to indicate what type of event should be simulated. And, the verb-designated process will be conceptualized as being part of that event. In cases where the verb only has <u>part</u> of its meaning in common with the event type specified by the A-S construction, unification with that A-S construction will essentially serve to focus attention on that portion of the verb's meaning. That is, the SemSpec produced by sentence analysis will support active simulation of that portion of verb meaning.

In transitive uses of the verbs being discussed here (e.g. *She slapped his hand*), the instantiated A-S construction specifies that the event being described is a 'cause-effect action' event. In this case, both the verb and the A-S construction meanings include force-application structure. This commonality motivates their compositional relation: the force-application component of the action described by the verb is bound to the 'causal action' subprocess of the 'cause-effect action' event specified by the A-S construction. This relation is similar to the one evidenced in *She pushed him*, except that in the current case force-application is only a <u>portion</u> of the verb's meaning. The resultant SemSpec supports simulation of effects to the entity that force is applied to (*his hand*). Thus, in transitive uses, the action designated by the verb is conceptualized as being the causal action within a 'cause-effect action' event. In this conceptualization, the focus is on the force-application components of the verb-designated action.

The ‘conative’ A-S construction describes a ‘spatial action’ event. Therefore, when these verbs occur in ‘conative’ examples (e.g. *She slapped at this hand*), the common meaning is spatial in nature. Sentence analysis in these cases produces a SemSpec that supports a simulation in which the ‘prepositional object’ (*his hand*) fills the role of spatial target. This simulation does not, however, support simulation of force transfer and possible effects to this target. Thus, in conative uses, the action designated by the verb is conceptualized as being the part of a ‘spatial action’ event. In this conceptualization, the focus is on the spatial elements of the verb-designated action.

To be considered successful, the compositional constructional analyses of sentence examples should produce a SemSpec that is consistent with our intuitions (and linguistic analyses) of what such sentences mean. Therefore, before describing the details of my constructional analyses of these ‘conative’ examples, it is important to first consider in more depth what sorts of meanings these examples may have. To this end, I examine a range of different ‘conative’ examples in the next section, and identify meaning generalizations that integrate insights other linguists have had about the meaning of the conative construction. Following this, I discuss how this general meaning can be characterized and represented within the context of a simulation-based model of language understanding. Then, with this background in place, I provide a more detailed description of my analysis and the schemas and constructions involved.

7.2 ‘Conative’ meaning

The ‘conative’ construction, also referred to as the ‘verb-*at*’ or just the ‘*at* construction’ (e.g. Broccias, 2001), has been the subject of many different theoretical studies [list some refs]. While it is well beyond the scope of the current work to survey the different frameworks used and conclusions reached in these studies, a brief look at a few selected approaches will serve to indicate some of the main aspects of ‘conative’ meaning that have been recognized by other linguists.

The meaning of the ‘conative’ construction is often characterized in terms of an actor’s intent and/or attempt to act purposefully. Levin, for instance, states that when *slap, kick* and various other verbs of ‘contact by impact’ are used in this construction they “… describe an ‘attempted’ action without specifying whether the action was actually carried out” (1993: 42). Similarly, Goldberg suggests that when these verbs are used in this construction they “…designate the *intended result* of the act denoted by the construction.” (1995: 63). Thus, both of these characterizations focus on the idea that a sentence like *She slapped at his hand* entails that the actor intended and/or attempted to perform the action designated by the verb, but does <u>not</u> entail that this action was actually successfully completed. In this respect, the conative use contrasts with transitive uses such as *She slapped his hand*, which entail that the actor did in fact (successfully) perform this action.

Dixon (1991) views sentences such *He kicked at the ball* as marking a deviation from an 'ideal' transitive event, with the deviation being one of relative emphasis. His analysis is not limited to '*at*- phrase' constructions; he makes the more general observation that:

> … a preposition can be inserted before the object NP of a transitive verb to indicate that the emphasis is not on the effect of the activity on some specific object (the normal situation) but rather on the subject's engaging in the activity. (1991: 280).

Dixon thus views '*at*-phrase'(and other 'prepositional phrase' constructions) as being used to describe situations in which the focus is on the actor's performance of the verb-designated action. This focus differs from that of transitive uses, in which focus is on the effects this action has on another object.

Broccias (2001) suggests that there are different types of scenarios described by '*at* constructions'. Sentences such as *She kicked at the wall* are analyzed as describing a schematically-defined 'allative' scenario in which an 'emitted entity' moves towards another object. For instance, in *She kicked at the wall*, the 'emitted entity' is the actor's leg, which moves towards the wall. Broccias' analysis of these examples thus suggests that for this allative scenario, attention is focused on the motion-related elements of the actor's actions. Consistent with the analyses of the conative construction described above, Broccias notes that affectedness of the other object is a possible, but not necessary, element of this scenario.

As I show below, if we look at a range of 'conative' examples, it becomes apparent that while each of these characterizations capture some relevant elements of the meaning associated with these examples, no single characterization quite captures all the relevant elements and how they fit together.

7.2.1 Examination of a variety of 'slap at' and 'kick at' examples

The first thing to note about sentences such as *She slapped / kicked at X* is that they entail that the actor in this action moved some part of her body. Consequently, it doesn't make sense to say *She kicked at X without moving her foot.* Moreover, this body part needs to move in the general direction of this other entity. So, for instance, we wouldn't use the sentence *She kicked at the ball* to describe a situation where the actor knows where the ball is, but moves her foot in a direction away from the ball. Therefore, at a minimum, 'conative' example such as these entail that the actor moved an 'effector' in the general direction of some 'target'. That is, in addition to have the intention of acting, the actor did in fact actually perform at least some portion of the verb-designated action.

Given this effector motion towards a target, it seems reasonable to assume that the actor is acting with the intention of contacting this object. But, such contact does not necessarily occur, as indicated by examples such as the following:

(3) <u>She slapped at the annoying fly</u>, but missed.

(4) Pushing himself off the wall, he grabbed at it, missed, and nearly fell.[1]

In these cases, then, we can assume that the actor did in fact move an effector towards a target, but failed to actually contact this target. Without contact, no force transfer can occur, so we are not likely to infer that this 'target' entity was physically affected in any way. The situations described by examples such as these are thus consistent with Goldberg's analysis of the meaning of conative, in which an actor performs an action with the intended result of affecting another entity, but does not necessarily succeed. In other words, for *She slapped at X*, the actor's intent was to 'slap X', but the actor did not achieve this objective.

As examples such as (5) and (6) indicate, examples of this form can also be used to describe situations in which the actor does seem to contact the target object.

(5) She slapped at her T-shirt, hitting herself, wanting only to get the bug off her.

(6) And she kicked at the gravel in the driveway of their temporary Decatur home, scuffing her new Weejuns.[2]

In (5), the actor seems to have successfully made contact with the target (her T-shirt), as indicated by the later phrase 'hitting herself'. Similarly, in (6) the actor contacts the gravel, consequently 'scuffing her new Weejuns'. Despite this presumed contact, though, these sentences do not seem to support the same sort of expectation (and simulation) of affectedness as do similar transitive examples such as *She slapped her T-shirt / kicked the gravel*. We could speculate that this is due to lack of a sufficient amount of force to affect this other entity, similar to the situation described by *She kicked the tree but nothing happened*. From this, we might conclude that the actor may have achieved part – but not all – of her intended result. That is, the actor successfully contacted the other entity, and transferred some amount of force, but did not perceptibly affect this other entity. Accordingly, one way to view the situations described by 'conative' examples such as these is as ones in which the actor intended to affect the other entity, but did not fully achieve this intended result.

However, some examples of this form suggest that the actor did not necessarily perform the action with the intent of affecting the 'acted upon' entity in the first place. In example (6), above, the actor may have been acting aimlessly, with no particular intent at all. And in example (5) the goal may actually been to contact and affect the bug, not her shirt. Such is also the case with the following example:

(7) In one swift motion he slapped at her hand and squashed a mosquito that was sitting on the outside of her thumb

For examples such as these, the intention seems to be to affect some other entity, not the target. Examples such as the following are similar:

[1] Accessed from BNC

[2] muse.jhu.edu/journals/southern_cultures/v014/14.1orr.html

(8) <u>She slapped at her clothes</u> to shake off the powdered concrete and ash.

(9)<u>She kicked at the narrow iron footrest</u> to knock the snow and mud off her boots.

The situations described in (8) and (9) are ones in which the actor forcefully contacts another entity (her clothes, the footrest). However, this contact is only a subgoal within some larger intentional action; the actor's larger goal here is to remove some sort of substance from her apparel. In other words, to accomplish her objectives, the actor needs to forcefully contact another object. But, the actor does not perform this action with the objective of affecting this object. Consequently, any effects that may result from this forceful contact are not particularly salient to this actor. The important point here is that what seems relevant is not whether any effects did or did not 'actually' occur, but whether any effects which did occur are conceptualized as being salient.

7.2.2 Generalizations

Given these different examples, what generalizations can we make about the type of events that are described by the 'conative' A-S construction? One thing that seems to be consistently true is that these different 'conative' examples all describe situations in which an actor acts, and moves an effector towards a 'target'. Contact may occur, but not necessarily so. This is consistent with Broccias' characterization of conative as having 'allative' schematic structure, in which there is translational motion toward a target and possible but not necessary contact with this target.

Commonly, conative examples describe situations in which: (a) the actor's intent is to affect the target, and; (b) the actor's actions do not result in any actual effect. Based on examples such as these, it may seem appropriate to characterize the conative construction as being used to describe situations in which an actor intends/attempts to affect another entity but does not necessarily succeed. But, looking at a wider range of examples indicates that sentences of this same form can also be used to describe situations in which (a) the actor may not have acted with the intent of affecting the target entity, and/or; (b) it can be inferred that the target was affected by the actor's actions. Therefore, this 'intended/attempted affectedness' characterization only seems appropriate for some, not all of these 'conative' examples.

We can, however, make a broader generalization: in all of these conative examples, the affectedness of the target entity is not a prominent part of (our conceptualization of) the described event. There are several reasons affectedness might not be prominent, including the following:

- Actor missed target, as in example (3). Since no contact or force transfer occurred, target was not affected.
- Actor was acting out of frustration or boredom and did not care what happened to target, as in example (6).

- Actor's intent was to affect some other entity. While actor needed to contact the target to achieve this larger objective, he was not concerned with how this target was affected by his actions, as in (7), (8) and (9).

For all of these situations, while the actor performs an action that at least potentially affects another entity, effects to this other entity are not a salient part of the actor's experience of that action.

Consequently, rather than characterizing the meaning of conative examples as one in which the actor intends to affect another entity, but is not necessarily successful, a more broadly applicable characterization seems to be that the effects that actor's action has on the 'target' entity, if any, are attentionally backgrounded. Thus, these conative examples clearly contrast with their transitive 'counterparts', in which affectedness is a prominent part of the event conceptualization. This is consistent with Dixon's characterization of conatives.

While this characterization tells us something about what these conative examples do <u>not</u> mean, the question that then arises is what they <u>do</u> mean. That is, what elements of the situations described by these conative examples are <u>prominent</u>? As noted above, the 'conative' examples above all entail that the actor moved an effector in the general direction of some 'target'. Based on this, we can say that these examples foreground the spatial elements of the action described by the verb. Furthermore, the entity described by the NP in the '*at* phrase' is conceptualized as a spatial target, while its possible role as an affected 'patient' is backgrounded or inhibited.

7.3 Overview of current approach

The compositional constructional approach to the analysis of conative examples that I outlined at the beginning of this chapter captures this meaning of 'conative' uses of these verbs. In the second half of this chapter, I provide a more detailed description of this approach and the schemas and constructions involved.

The approach I take builds on Goldberg's (1995) hypothesis that the conative construction instantiated in examples such as *She slapped at X* is related to the A-S construction instantiated in examples such as *She looked / aimed at X*. More specifically, Goldberg suggests that in both cases, the meaning of the A-S construction is associated with a 'direct action at' scene. For the looking and aiming examples, the verb designates an 'instance of' such a scene, while for the conative construction examples (with verbs like *slap* and *kick*) the verb designates the 'intended result' of the directed action.

Translating this premise into the current framework, the *look* and *aim* examples can be viewed as instantiating a central case A-S construction, in which the A-S construction meaning has the schematic structure of a 'direct action at' event, and the verb constituent meaning is also identified with this same schematic structure. The 'conative' A-S construction can then be defined as an extension to the central case. This extension has the same event type as the central case, but has different constraints on verb meaning and, consequently, a different semantic relation between the A-S construction and its verb constituent. When verbs such as *slap* and *kick* unify with this conative A-S construction, the resultant SemSpec supports a simulation that is consistent with the characterization of conative meaning presented above.

To actually implement this approach, the grammar needs to include several additional schemas and constructions. Below, I briefly describe the several steps necessary for the definition of these schemas and construction. Fuller descriptions are then provided in the sections which follow.

One necessary step is to define a schema for the 'direct action at' event type. As I show, this can be done by using a similar methodology as employed in previous chapters. To start, I examine prototypical 'directed action' verbs such as *look*, *point*, and *reach*, and the actions they describe. Based on various types of evidence about the grammatically-relevant elements that recur in such actions, I define schemas for actions in which an actor orients and/or changes the location of an effector in relation to a spatial 'target'.
These schemas are used to represent the meanings of the verbs and 'central case' A-S constructions instantiated in examples such as *She looked /pointed at the bread* and *She reached for the bread*.

Another necessary step is to analyze and represent the meanings of verbs such as *slap* and *kick* that occur in 'conative' examples such as those above. As mentioned in Chapter 5, the actions designated by these verbs include a force-application component, in which the actor contacts and transfers force to another person or object. However, this force-application component is preceded by a spatial component, in which the actor moves an effector (e.g. his foot or hand) towards this other entity. This spatial component is similar in many ways to actions like pointing and reaching. Consequently, the schematic structure of actions such as slapping is represented using a complex schema that integrates ForceApplication with the 'effector motion' schema described above. By using this schema to represent the meanings of verbs such as *slap* and *kick*, we can formally represent the [+motion, + contact] features that are commonly recognized as being relevant to these verbs' use with the conative construction.[3]

A third necessary step involves the definition of A-S constructions. Given the assumption that central case A-S constructions have the same schematic structure as their verb constituent, we can represent the meanings of the A-S constructions instantiated in sentences such as *She looked at the box* and *She reached for the box* using the same

[3] While motion and contact are features that are commonly recognized as being relevant to 'transitive' verbs participation in a 'conative' construction, some note that not all verbs that appear in constructions of this form have these constraints (e.g. Broccias 2001, others). But, the assumption here is that, like transitives, there are several different A-S constructions of this same form which vary as to event type and/or constraints on their verb constituent.

schemas as are used to represent the meanings of *look* and *reach*. The 'conative' A-S construction is analyzed as an extension to one of these central case A-S constructions. This extension is used to describe the same basic type of event as the central case. Consequently, the same schema that is used to represent the meaning of the central case A-S construction can also be used to represent the meaning of this 'conative' construction. The conative extension has different constraints on the meaning of its verb constituent and its semantic relation to this constituent, however. As with other extensions, there is a commonality of schematic structure that motivates the composition of the verb and the A-S construction. In this particular case, this shared structure is spatial in nature: the spatial component of actions like slapping matches the spatial event structure associated with the 'conative' A-S construction.

With the inclusion of these schemas and constructions in the grammar, analysis of conative examples such as *She slapped at the bread* produces a SemSpec that supports simulation of the spatial elements of the verb-designated action (e.g. motion and change of location of effector). In contrast, analysis of transitive examples such as *She slapped the bread* yields a SemSpec that supports simulation of the force-application components of this action, and on the consequent effects this action may have on the 'acted upon' entity. Thus, these analyses indicate that these different uses of the same verb each focus attention of different elements of the verb-specified action.

7.4 Spatial actions: actions 'directed at' another entity

The first step is to examine and represent the schematic conceptual structure associated with 'spatial' actions, in which an actor acts in relation to some spatial target. Verbs such as *look*, *point,* and *reach* all describe what can be reasonably be considered prototypical spatially-directed actions, in which an actor acts in relation to some spatial target. One way to gain insights into the schematic conceptual structure associated with 'spatial' actions is to examine sentences these verbs are used in. And we can also gain further insights by more closely examining the actions themselves.

Typically, descriptions of these actions include explicit mention of both an actor and a spatial 'target', with the target typically being expressed as a prepositional object, as in *She pointed at the tree / She reached for her trusty calculator*. Even when this target is not expressed, it is still 'conceptually present'. We wouldn't, for example, use the words *reach* or *point* to describe an action if we didn't think that action was directed towards some specific location (and/or an entity at that location).

Unlike force-application and 'cause-effect action' verbs (such as *push*, *slap* and *cut*), these verbs describe actions in which the actor's relation to the second entity is primarily spatial. As indicated by examples such as (10) and (11), these verbs are commonly used to describe situations in which the actor does not contact this other entity.

(10) She looked / pointed at the cup, but didn't touch it.

(11) She reached toward the cup, but didn't touch it.

And we do not expect the spatial 'target' to be (physically) affected in any way by the action. Consequently, it seems odd to imply that we might have expected otherwise, as in *She pointed at the cup, but it didn't break*. And it seems even odder to state that in fact the pointing did cause this object to break, as in *She pointed at the cup and it broke*. Thus, unlike 'forceful action' verbs, these verbs designate actions which do not typically involve any contact or force transfer with another entity and, as a result, there is not any expectation that the other entity will be physically affected by these actions.[4]

In some cases, uses of these verbs may include an (optional) mention of a body part or other instrument used in the action. For instance:

(12) He reached for / towards the cup (with his left hand / the pliers).

(13) She pointed (her finger / a stick) at / towards the cup.

In each case, the actor controls the orientation and/or location of this effector in relation to 'target'.

Looking a little more closely at the nature of the actions that these verbs are used to describe can yield further insights. As discussed in Chapter 5, I hypothesize that when attempting to identify additional types of recurrent schematic elements that may be present in motor-control actions, it is especially important to recognize and represent elements that are related to the objectives the action is being used to accomplish. More specifically, we need to consider what main things the actor needs to attend to in order to achieve a particular kind of objective. Reaching and pointing actions both prototypically involve arm/hand motions that are performed in relation to some specific location (and/or an object at such a location). For instance, in pointing, the actor orients an extended finger in relation to this object. And in reaching, the actor moves his hand towards the object. In order to successfully perform such actions, the actor needs to attend not only to the orientation and/or shape of the hand (or other effector), but also its spatial relation to the relevant 'target' entity/location. Thus, like locomotion actions, these are motor-control actions in which motion is used to accomplish a spatial goal. But, unlike locomotion, the relevant motion concerns only some part of the body, not the whole body.

What sorts of neural structure might be active during the performance of such actions? Research on visually-guided arm reaching indicates that brain areas active during the performance of such actions show sensitivity to several types of information, including the following: (1) arm movement-related activity (probably linked to muscle output); (2) hand/arm position; (3) position or direction of eye gaze; and (4) target location, which can be coded in different frames of reference (Burnod et al. 1999; Battaglia-Mayer et

[4] Note too that these 'spatial action' verbs don't occur in sentences in which this spatial participant is expressed as direct object. E.g. we don't encounter *Jan pointed the tree*, with the meaning that Jan's pointing action cause some effect to the tree.

al.2003; Medendorp et al., 2005). Furthermore, another study (Fagioli et al. 2007) indicates that preparing to reach primes location information (whereas preparing to grasp primes size information).

Based on these various forms of evidence, we can conclude that there are three 'participant roles' that are especially salient for actions such as looking, pointing, and reaching. One is the person performing the action (the actor). To successfully perform these actions, this actor needs to attend to some location or landmark entity (the 'target'). The actor also needs to attend to the relevant part of the body (the effector[5]), particularly its spatial relation to the target[6]. For reaching, the actor actually moves the effector closer to the target, while for pointing and looking this is not necessarily the case. Therefore, for reaching actions, the effector's motion and location in relation to the target are important, whereas for pointing and looking actions, it is the effector's orientation in relation to the target that is especially salient. For both types of actions, there is not necessarily any physical contact with this target.

Schemas for these actions, described below, include these different participant roles. To capture the distinctions between the pointing and reaching types of actions, I define two different – but closely related – schemas.

Schemas for spatially-directed actions

The EffectorSpatialAction schema (Figure 7.1) represents the schematic structure associated with pointing and looking actions, in which the actor orients the effector (e.g. hand, eyes) in relation to 'target'.

EffectorSpatialAction integrates motor-control and spatial relations structure: it is defined as a subcase of MotorControl, and also evokes TL (a trajector-landmark schema). In addition to its inherited actor and effector roles, EffectorSpatialAction includes a target role. To indicate the spatial relations relevant to these actions, the effector is bound to the trajector role of the evoked TL schema, and the target is bound to TL's landmark role.

[5] Effectors are not necessarily restricted to body parts. Research on space perception indicates that the space within hand reaching distance (peripersonal space) can be extended when the actor is using a tool, (Berti & Frassinetti 2000; Berti et al. 2001), indicating that the tool essentially functions as an extended effector.

[6] The shape/orientation of this effector may be relevant as well, but in many cases relates to the larger intent of the action (e.g. will be different for pointing, reaching that precedes touching, and reaching that precedes grasping).

```
schema EffectorSpatialAction
  subcase of MotorControl
  evokes TL as tl
  roles
     actor
     effector
     effort
     x-net: @effectorspatialaction
     target
  constraints
     effector ↔ tl.trajector
     target ↔ tl.landmark
```

Figure 7.1 The EffectorSpatialAction schema.

The EffectorMotionAlongAPath schema (Figure 7.2) represents structure associated with actions in which the actor moves and changes the location of the effector in relation to the target. For actions such as reaching, this typically involves motion toward the target (often accompanied by the actor's further intention of contacting the target). But, EffectorMotionAlongAPath is defined more generally, such that it also covers actions that involve other various possible spatial relations between an effector and a target including, for example, motion 'into' or 'over' the target.

EffectorMotionAlongAPath is defined as a complex process that integrates the structure of EffectorSpatialAction with that of translational motion. As a subcase of ComplexProcess, it includes two inherited 'subprocess' roles. In this schema, process1 is constrained to be of type EffectorSpatialAction, and process2 to be MotionAlongAPath. The key constraint in this schema is the binding between the effector role of the first subprocess, and the mover role of the second subprocess. This binding indicates that the actor is in control of the effector's orientation as well as its motion and location in relation to the target.

```
schema EffectorMotionAlongAPath
  subcase of ComplexProcess
  roles
     process1: EffectorSpatialAction
     process2:  MotionAlongAPath
     x-net: @effectormotion
     protagonist
     protagonist2
  constraints
     process1.effector ↔ process2.mover
```

Figure 7.2 The EffectorMotionAlongAPath schema.

Actions like reaching are similar in some respects to locomotion actions such as walking; both involve an actor executing a motor-control routine which involves motion and change in location. Reflecting this similarity, both EffectorMotionAlongAPath and Locomotion (Figure 3.11) are defined as complex processes that incorporate MotorControl and MotionAlongAPath structure. The key difference between these actions concerns what is moving. For actions like walking, the actor as a whole moves and changes location, whereas for actions like reaching, the motion and change of location concerns only a part of the actor's body. This difference is captured in these schemas by different bindings to the mover role of the MotionAlongAPath schema: in Locomotion, mover is bound to actor, while EffectorMotionAlongAPath binds mover to effector.

7.5 More complex actions

'Spatial' actions such as reaching do not necessarily involve contact with and/or the application of force to another entity. To achieve some goals, though, an actor needs to combine a 'spatial' action with one which involves physical interaction with another entity. For example, if your cup is falling off your desk, you will first reach towards the cup (a type of spatial action) before grasping it (a type of force application action). More generally stated, you will move your hand towards the object before applying force to it. So in some cases, rather than being a complete, self-contained action, spatial actions are part of a larger more complex action that also involves physical interaction with another entity.[7]

Actions such as slapping, tapping and kicking also involve motion towards and contact with another entity, followed by a transfer of force to that other entity. Unlike grasping, though, the transfer of force occurs primarily at the moment of contact, and is at least in part a function of the mass of the effector and its speed at the time of impact. So, the motion that precedes contact is an especially salient part of these actions.

Complex actions such as these can be analyzed as involving two distinct but inter-related components: (1) a spatial component, in which the actor moves an effector towards another entity, and; (2) a force-application component, in which the actor physically contacts and transfers force to this entity.

The schematic structure of this spatial component is represented by the EffectorMotionAlongAPath schema, described above. And the force-application component is represented by the ForceApplication schema (Figure 5.3). Consequently,

[7] Other types of relations between motion and force-application are also possible. E.g. if you want to pick up the coffee cup, you will need to grasp the cup and move your arm upward at the same time. Therefore, such actions also include both a motion component and a forceful component but, unlike the previous examples, the motion and force-application are concurrent. Fuller analysis and representation of a variety of such actions is left for future work.

to represent the full structure of complex actions such as these, we can define a more complex ForcefulMotionAction schema (Figure 7.3) that integrates the structure of these two schemas. This schema is specified to be a subcase of ComplexProcess, and therefore has two subprocess roles. Its process1 role is constrained be of type ForceApplication, indicating that this role represents the force-application component of these actions. The other process (process2) is constrained be of type EffectorMotionAlongAPath, indicating that this role represents the spatial component of these actions.[8]

Both of the schemas for these subprocesses include actor and effector roles.[9] In the constraints section, the corresponding roles in each of these subprocesses are bound together. One binding indicates that the actor of the force-application action is also the actor of the 'effector motion' action (protagonist ↔ protagonist2). Another binding indicates that the same effector is used in both of these subprocesses (process1.effector ↔ process2.process1effector).

In these actions, the entity to which the actor applies force to (i.e. the actedUpon) is also the target of the spatial action. This is specified as a binding between these two roles (process1.actedupon ↔ process2. target). The complex role that results from this binding thus incorporates some properties typically associated with 'patients' (e.g. receives force from an actor), as well as some properties associated with 'goals' (e.g. is a spatial target). As we will see, the dual nature of this role helps explain why it may potentially be conceptualized in more than one way.

```
schema ForcefulMotionAction
  subcase of ComplexProcess
  roles
     process1: ForceApplication
     process2: EffectorMotionAlongAPath
     routine: @forcefulmotionaction
   constraints
     protagonist ↔ protagonist2
     process1.actedupon ↔ process2. target
     process1.effector ↔ process2.process1.effector
```

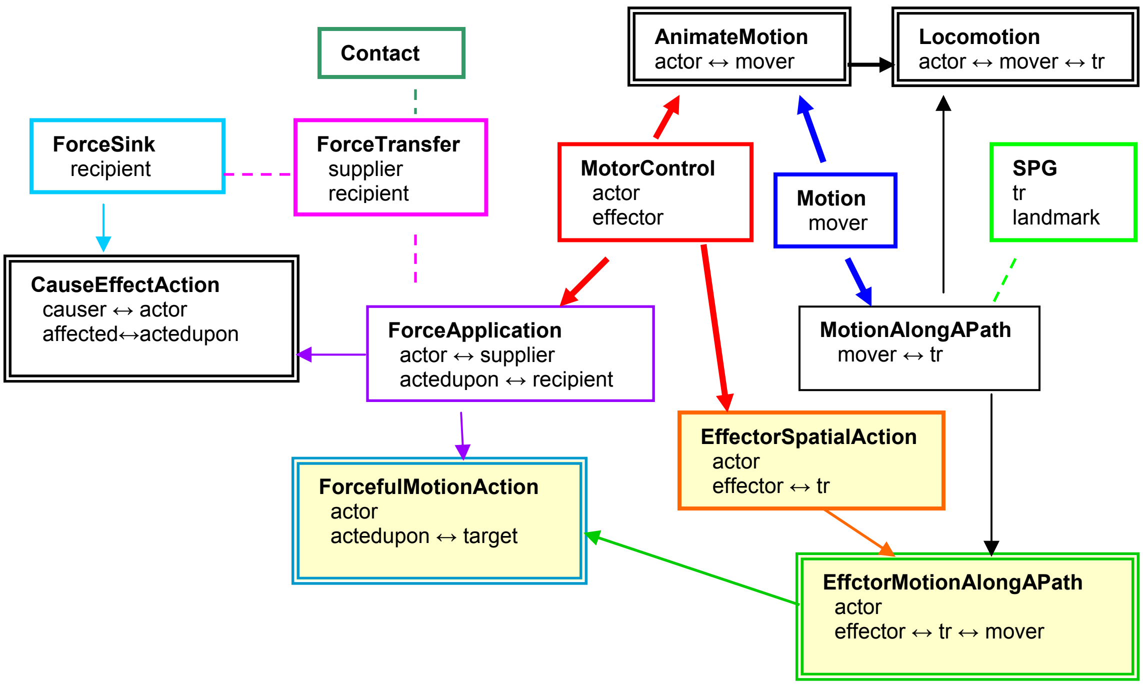
Figure 7.3 The ForcefulMotionAction schema.

[8] Process numbers do not specify anything about the ordering of these subprocesses.

[9] Note, though, that the set of roles bound to actor and effector differ for each of these schemas. For instance, the ForceApplication actor is bound to the supplier role of ForceTransfer. And the EffectorMotionAlongAPath effector is bound to the mover role of MotionAlongAPath. Thus, while the names of these roles are the same in each schema, and they have some structure in common, they are actually complex roles which differ in some respects.

The schema lattice, extended

All of the schemas described in the preceding sections are defined as part of a larger lattice of 'process' schemas. The various bindings and relations between the different schemas in this lattice reflect the interconnectivity of the embodied conceptual system that they represent. Figure 7.4 shows the schemas in this lattice that have been discussed in this and previous chapters (schemas discussed in this chapter have a shaded background).



In this diagram:

- Thicker arrows indicate subcase relations.
- All schemas which have a double-line box are subcases of ComplexProcess. The thinner arrows pointing at the complex process originate at each of its subprocess schemas.
- Dotted lines indicate an 'evokes' relation

Figure 7.4 Lattice of Process schemas, including 'spatial action' schemas.

7.6 Verb constructions

The schemas described above are used to represent the meanings of several different verbs in the current grammar. Verbs like *look* and *point* are used to describe spatial actions in which an actor orients an effector (e.g. eyes, finger) in relation to a target. These verb meanings are represented using the EffectorSpatialAction schema. The verb *reach* is used to describe actions which involve motion towards a spatial target. Accordingly, the grammar includes a Reach1 construction in which meaning is identified with the EffectorMotionAlongAPath schema. The Point1 and Reach1 constructions are shown in Figure 7.5, below.[10]

The meanings of various 'agentive impact' verbs are represented using the ForcefulMotionAction schema. These verbs include *slap*, *kick, pat, poke, tap*, and *rap*, all of which are used to describe actions in which the actor moves an effector toward and forcefully contacts another entity[11]. Individual verb constructions differ as to the particular meaning constraints they specify. For instance, they differ as to the specific motor-routine (x-net) involved, the effector used, and the amount of effort exerted, as illustrated by the Slap1 and Pat1 constructions (Figure 7.5). In addition, relatively schematic value specifications can be used to indicate the shape of the effector and the orientation of this effector at the time of contact. Slapping, for example, typically involves a flat, planar effector (typically an open hand), with the flat surface of the effector (e.g. the palm) contacting the 'acted upon'/target entity. Whereas poking involves a long thin effector (such as a pointed finger), with one end of this effector contacting the other entity.

```
construction Point1
  subcase of Verb
  form
    constraints
      self.f.orth ← "point"
  meaning: EffectorSpatialAction
    constraints
      self.m.x-net ← @point
```

```
construction Reach1
  subcase of Verb
  form
    constraints
      self.f.orth ← "point"
  meaning: EffectorMotionAlongAPath
    constraints
      self.m.x-net ← @reach
      self.m.effector ← hand //default
```

```
construction Slap1
  subcase of Verb
  form
    constraints
      self.f.orth ← "slap"
  meaning: ForcefulMotionAction
    constraints
      self.m.x-net ← @slap
      self.m.effector ← hand //default
```

```
construction Pat1
  subcase of Verb
  form
    constraints
      self.f.orth ← "pat"
  meaning: ForcefulMotionAction
    constraints
      self.m.x-net ← @slap
      self.m.effector ← hand //default
      self.m.effort ← 'low'
```

Figure 7.5 Constructions for *point*, *reach*, *slap* and *pat*.

[10] A fuller representation of Point1 could also specify the effector's shape (long thin thing) and orientation (axis of effector is aligned with path that connects effector and target).

[11] Note that none of these verbs have strong entailments as to the affectedness of the acted upon entity, and their meanings are therefore not represented using a CauseEffectAction schema. As noted in Chapter 5, *kick* is also used to describe leg motion actions that are not necessarily performed in relation to a target entity, as in *The baby / swimmer kicked her legs*. For these uses, we would want to define an additional Kick construction that identifies its meaning with an effector motion schema of some kind.

The ForcefulMotionAction includes both motion (as part of EffectorMotionAlongAPath, which represent the spatial component of the action) and contact (as part of ForceApplication, the forceful component of the action force-application process). Therefore, use of this schema to represent the meanings of verbs such as kick and slap explicitly captures the [+motion, +contact] features that are commonly recognized as being necessary in order for verbs to be used in the 'conative' construction. But rather than simply indicating the presence of motion and contact, this schema indicates what is moving (the effector), and what is being contacted (the acted upon/target).

Another important element of this representation is that it captures the multi-faceted, complex nature of the actions these verbs describe. As I discuss in the following section, this helps us to recognize and represent different ways we can conceptualize these actions and, correspondingly, alternative ways we can view the role played by the actedupon/target.

7.7 Argument Structure Constructions

Having defined schemas and constructions for verbs such as *point*, *reach*, and *slap*, we can now turn to an examination of the A-S constructions instantiated in examples such as:

(14) She pointed at the box

(15) She reached for the box

(16) She slapped at the box.

The A-S constructions instantiated in these examples are the same with respect to the general type and ordering of their constituents (i.e. they all have a verb and a 'path-pp' constituent, and the form of the verb canonically precedes that of the pp). In this respect they are also similar to the intransitive motion A-S constructions defined in Chapter 4 (instantiated in sentences such *as She walked / rolled into the room*).

However, as discussed above, the meanings of the verb constructions instantiated in these examples are represented using different schemas, reflecting the fact that the actions these verbs describe differ in some significant ways. This means that these A-S constructions differ as to what type of schematic meaning their verb constituent has. For this reason, these three examples are analyzed as instantiating three different A-S constructions that are similar in general form but have different constraints on verb constituent meaning.

Which schema should be used to represent the meanings of each of these A-S constructions? To answer this question, we need to consider what type of event is described by these different examples.

7.7.1 Central case A-S constructions

For examples (14) and (15), the type of event described by the sentence as a whole has the same type of schematic structure as the verb construction instantiated in that sentence. That is, the scene described by *She pointed at the box* (and by similar sentences, such as *She looked at the box*) can be characterized as one in which an actor orients an effector (e.g. eyes, finger) in relation to a spatial target (in this case, *the box*). This type of schematic structure is represented by EffectorSpatialAction, which is the schema that constructions for verbs such as *point* and *look* identify their meaning with.

The scene described by *She reached toward the box* not only involves a particular orientation of an effector in relation to a spatial target, but also its motion toward this target (i.e. she moves her hand toward the box). Thus, the schematic structure of this scene differs from that of the previous example. In this case, the appropriate schema is EffectorMotionAlongAPath, which is the schema with which Reach1 identifies its meaning.

In sum, the key difference these two A-S constructions is that they are used to describe different, though related types of events. Consequently, each of these A-S constructions identifies its meaning with a different, though related, schema. The IntransitiveESA A-S construction (not shown) instantiated in examples such as *She looked / pointed at the box* identifies its meaning with EffectorSpatialAction. And the IntransitiveEMAAP1 A-S construction (Figure 7.6) instantiated in example such as *She reached toward the box* identifies its meaning with EffectorMotionAlongAPath.

Both of these A-S constructions are similar, however, in that each has a prototypical semantic relation with its verb constituent, in which both share the same schematic structure. For this reason, both of these examples are analyzed as instantiating a 'central case' A-S construction whose meaning is bound to the meaning of its verb constituent.

These A-S constructions also each have a prepositional phrase constituent (pp) which is constrained to be of type Path-PP. The SPG meaning of this prepositional phrase should be identified with the SPG element of the A-S construction meaning. As seen in Figure 7.6, this is represented as a binding constraint (self.m.process2.spg <--> pp.m). As discussed in Chapter 2, Path-PP includes the specification that the landmark of its SPG schema is bound to the referent described by its noun constituent. And EffectorMotionAlongAPath specifies that the landmark of its SPG schema is bound to the target role. Therefore, when these two SPG schemas are identified with one another, the referent described by this noun phrase is bound to the target role.

```
construction IntransitiveEMAAP1
  subcase of ArgStructure
  constructional
    constituents
          v : Verb
          pp: Path-PP
   constraints
          self.features <--> v.features
 form
   constraints
          v.f before pp.f
 meaning: EffectorMotionAlongAPath
    evokes EventDescriptor as ed
    constraints
        self.m <--> ed.eventType
        v.m  <--> ed.profiledProcess
        self.m <--> v.m
        self.m.process2.spg  <--> pp.m
        self.m.actor <--> ed.profiledParticipant
```

Figure 7.6 The IntransitiveEMAAP1 A-S construction[12] (instantiated in examples such as *She reached toward the box*.)

7.7.2 'Conative' extension

My analysis of the conative A-S construction builds on Goldberg's basic hypothesis that the A-S construction instantiated in examples such as *She slapped at the box* is related to the A-S construction instantiated in examples such as *She looked /aimed at X*. Significantly, these constructions are considered semantically similar: Goldberg suggests that both of these types of examples describe the same kind of 'direct action at' scene.

As discussed in previous chapters, some A-S constructions have the same general form and are used to describe the same type of event as a central case A-S construction, but differ with respect to the semantic relation they have with their verb constituent. In such cases, these A-S constructions are defined as 'extensions' to the central case A-S construction. Accordingly, I define the conative as an extension to a central case construction, with the conative describing the same kind of 'direct action at' event as the central case, but having a different semantic relation with its verb constituent.

One complication for this approach is that I have identified two different kinds of events that might each be characterized as 'direct action at' scenes, and defined central case A-S constructions for each, as described above. Therefore, the question arises as to which of

[12] This A-S construction is similar to IntransitiveLocomotion1, instantiated in examples such as *He walked into the room* (discussed in Chapter 4). However, it differs with respect to event type and as to the nature of the role bound to profiled Participant (which is an actor but not a mover).

these should be viewed as describing the same type of event as the conative. In other words, if we define the conative as an extension to a 'central case' A-S construction, from which central case construction is it extended? An additional related question is, how is the meaning of the verb constituent related to that of the A-S construction?

When answering such questions, an important thing to keep in mind is that the A-S construction instantiated in the 'conative' examples should be defined such that analyses of these examples produce SemSpecs that support 'appropriate' simulation of each sentence. Based on the examination of conative examples presented earlier, the SemSpecs for these examples should capture the fact that these examples all entail that an actor moved an effector toward a target. For instance, *She slapped at the box* entails that she (the actor) moved her hand (the effector) towards the box (the target). More generally, the SemSpec should support a simulation which foregrounds the spatial elements of the verb-designated action (i.e. the effector's motion toward a target) and backgrounds the transfer of force (and therefore backgrounds or ignores any consequent effects we might infer based on this force transfer).

The EffectorSpatialAction schema only has structure relating to an actor orienting an effector in relation to a target, not structure related to translational motion of this effector in relation to the target. Therefore, to support the simulation of effector translational motion, the conative A-S construction I define here identifies its meaning with the EffectorMotionAlongAPath schema.

Thus, this 'conative' A-S construction has same event type as the IntransitiveEMAAP1 construction described above. However, its verb constituent has a different meaning and therefore has a different relation to A-S construction meaning. As with other A-S constructions in the grammar, the relation is based on commonality of schematic structure. But in this particular case, the A-S construction schematic structure is the same as a <u>portion</u> of verb schematic meaning. Specifically, the spatial subprocess of the verb's meaning has the same schematic structure as the A-S construction's event type, as indicated by the fact that both are represented using EffectorMotionAlongAPath. Given the nature of their relation, this 'conative' A-S construction is defined as an extension of IntransitiveEMAAP1, and is given the name IntransitiveEMAAP2.

As we will see in following section, sentences which are analyzed as instantiating this IntransitiveEMAAP2 construction will yield SemSpecs that support simulation of an actor's performance of a 'spatially-directed' action, thus focusing on the spatial component of the verb-designated action.

<u>Details of formal representation</u>

IntransitiveEMAAP2 is specified to be a subcase of IntransitiveEMAAP1, and therefore inherits constituents and form and meaning constraints. The key difference concerns the verb constituent's meaning. The inherited constraint that this constituent's meaning is bound to that of the A-S construction is ignored. Instead, IntransitiveEMAAP2 binds the meaning of the verb constituent to an evoked ForcefulMotionAction schema. To indicate the semantic relation the verb constituent has to the A-S construction, the spatial subprocess of the verb's meaning (process2 of ForcefulMotionAction) is bound to the meaning of the A-S construction as a whole (self.m <--> v.m.process2). This binding thus indicates that the A-S construction and its verb constituent share EffectorMotionAlongAPath schematic structure.

IntransitiveEMAAP2 also inherits a pp constituent, which is constrained to be of type Path-PP. It would be possible to more specifically constrain this to be an '*at*-phrase' constituent. But, this is not done in the current A-S construction for two principal reasons:

- The more general constraint makes this construction more broadly applicable, supporting analysis of examples that contain other prepositions (e.g. *She tapped on the box*).[13]
- The Path-PP type constraint captures the fact that when these prepositional phrases serve as a constituent in this A-S construction, they are used to describe a change in location rather than a static location. That is, the preposition indicates the spatial relation the trajector has to the landmark when the trajector is at its goal location (endpoint of its path).

[13] This would also support analysis of sentences that do not typically occur, e.g. *She slapped into the box*. Keep in mind that these constructions are defined to support language understanding. Therefore, possible problem of 'over-production' is not a central concern here. However, also note that other semantic factors are likely to constrain which prepositions are typically used.

```
construction IntransitiveEMAAP2
  subcase of IntransitiveEMAAP1
  constructional
   constituents
       v : Verb
       pp: Path-PP
   constraints
        self.features <--> v.features
 form
   constraints
        v.f before pp.f
 meaning: EffectorMotionAlongAPath
   evokes EventDescriptor as ed
   evokes ForcefulMotionAction as fma
   constraints
      self.m <--> ed.eventType
      v.m  <--> ed.profiledProcess
      ignore self.m <--> v.m
      v.m <--> fma
      self.m <--> v.m.process2
      self.m.process2.spg  <--> pp.m
      self.m.actor <--> ed.profiledParticipant
```

Figure 7.7 The IntransitiveEMAAP2 construction instantiated in examples such as *She slapped at the box*.

7.8 Analyses of sentence examples

With these schemas and constructions in place, we can now take a look at the sentence analyses they support. Crucially, we can see how the SemSpecs produced by these sentence analyses capture similarities and differences in meaning between conative and transitive examples such as those discussed at the beginning of this chapter.

7.8.1 *He slapped at the bread.*

First, let us look at the 'conative' example *He slapped at the bread*. Using the current grammar, this example can be analyzed as instantiating the following constructions:

- Lexical constructions for each of the words, including a SlapPast construction for 'slapped'.
- NP constructions for 'He' and 'the bread'
- Path-PP construction (for 'at the bread')
- IntransitiveMAAP2 A-S construction
- Declarative clause construction (Figure 4.1)

When these instantiated constructions unify, they produce a SemSpec that supports simulation of the event described by this sentence. As with other SemSpecs, this consists of a set of semantic schemas, value constraints and bindings.

One especially significant role in this SemSpec is the eventType role of the EventDescriptor schema. The schema bound to this role supplies important information about how the situation described by this sentence is conceptualized and, accordingly, indicates how it should be simulated. In the SemSpec for conative examples such as this, the eventType role is bound to EffectorMotionAlongAPath (which is the schema that IntransitiveMAAP2 identifies its meaning with). This indicates that the event structure to be simulated involves an actor's controlled translational motion of an effector in relation to a spatial target. [14] This SemSpec differs from the ones associated with transitive examples in that the event type to be simulated does not include causal structure.

The profiledProcess role of EventDescriptor is bound to ForcefulMotionAction, which is the schema with which SlapPast identifies its meaning. The fact that this is a different schema than the one bound to the eventType role is reflective of the fact that the schematic structure associated with the verb differs from the schematic event structure associated with the A-S construction.

Another significant element in this SemSpec is the binding between EffectorMotionAlongAPath (the event type and meaning of the A-S construction) and ForcefulMotionAction (the verb meaning). This binding effectively tells us how the verb-designated process should be conceptualized, and indicates which parts of this process should be actively simulated. In this SemSpec, EffectorMotionAlongAPath is bound to process2 of ForcefulMotionAction (i.e. the event type is bound to the spatial component of the verb-designated action). Thus, this binding indicates that the schematic structure associated with the A-S construction is the same as part of the verb's schematic structure. In this way, the SemSpec indicates that the spatial part of the verb's meaning that should be simulated. In other words, the spatial elements of the verb-designated action are foregrounded.

The meaning of the instantiated verb construction also includes conceptual structure related to contact and force transfer. This SemSpec does not necessarily specify that this structure should be inhibited, but neither does it specify that it should be actively simulated. Thus, this SemSpec is consistent with the fact that 'conative' examples such as this can be used to describe situations in which there is no contact or force transfer, but can also be used to describe situations in which these elements do occur (but are not foregrounded).

As reflected in the SemSpec, unification of IntransitiveMAAP2, SlapPast, Declarative and instantiated NP constructions result in several bindings associated with each of the

[14] Note that if conative were instead defined as an extension of IntransitiveESA (the A-S construction instantiated in examples such as *He looked / pointed at the bread*), the event type would support simulation of effector orientation, but not the effector's motion and change in location in relation to the target.

participants of this event. Specifically, the Actor role of EffectorMotionAlongAPath is bound to:

- protagonist of EffectorMotionAlongAPath
- actor and protagonist of ForcefulMotionAction
- referent described by ‘he’ (male animate)
- profiledParticipant

And Target is bound to:

- target of EffectorMotionAlongAPath
- actedUpon/Target of ForcefulMotionAction
- landmark of SPG
- referent described by ‘the bread’

This SemSpec will support a simulation of an event in which a male animate actor moves his hand toward a box (i.e. the goal location of the effector is in the vicinity of the box). This event is described from (and should be simulated from) the perspective of this actor. Since the eventType is MotionAlongAPath, the box’s role as a spatial target is foregrounded (and its potential role as an ActedUpon entity is backgrounded).

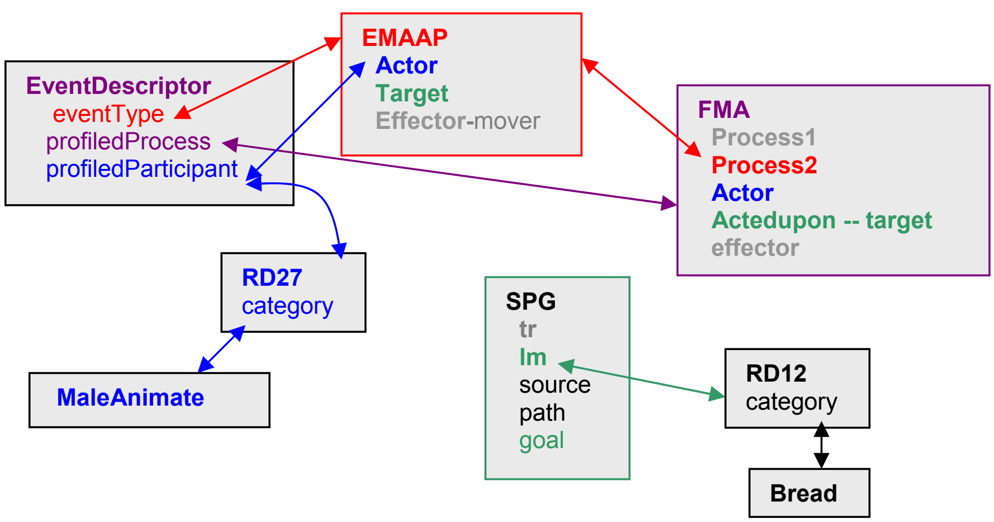


Figure 7.8 Schemas and bindings in SemSpec for *He slapped at the bread*.

7.8.2 *He slapped the bread.*

Having examined the conative example, *He slapped at the bread*, we can now turn to the examination of its transitive counterpart, *He slapped the bread*.

This transitive example is analyzed as instantiating the TransitiveCEA4 A-S construction (Figure 7.9). This A-S construction is similar in many respects to the

TransitiveCEA3 A-S construction instantiated in examples such as *He pushed the bread* (examined in Chapter 6). Both of these A-S constructions are used to describe events with agentive cause-effect structure. And in both cases, the verb constituent serves to elaborate the causal action subprocess of this event. However, the schematic meaning of the verb constituents differ. Constructions for *slap*, and verbs such as *kick*, *tap*, *punch*, etc. identify their meanings with ForcefulMotionAction, whereas the schematic meaning of the verb constituent in TransitiveCEA3 is identified with the simpler ForceApplication schema. It is these differences in verb constituent meaning (and the accompanying difference in the semantic relation this constituent has to the A-S construction) that necessitate the definition of two separate though closely similar A-S constructions.

```
construction TransitiveCEA4
  subcase of  TransitiveCEA1
  constructional
      constituents
          v : Verb
          np: NP
  form
      constraints
          v.f before np.f
  meaning: CauseEffectAction
      evokes EventDescriptor as ed
      evokes ForcefulMotionAction as fma
  constraints
          self.m <-->ed.eventType
          v.m  <--> ed.profiledProcess
          self.m.causer <--> ed.profiledParticipant
          self.m.affected <--> np.m
          ignore self.m <--> v.m
          v.m <--> fma
          self.m.process1<--> v.m.process1
```

Figure 7.9 The TranstiiveCEA4 A-S construction instantiated in examples such as *She slapped his hand* (inherited structure in gray).

TransitiveCEA4 is defined as an extension to TransitiveCEA1, the central case A-S construction instantiated in examples such as *She cut the bread*. As a subcase of TransitiveCEA1 (Figure 6.1), it inherits the structure and constraints of this 'parent' construction. However, it is different from this parent with respect to the meaning of its verb constituent and this constituent's relation to the meaning of the A-S construction as a whole. These differences are expressed via meaning constraints that specify that:

- the inherited constraint identifying the meaning of the verb constituent with that of the A-S construction is ignored (**ignore** self.m <--> v.m)
- the meaning of the verb constituent is bound to an evoked ForcefulMotionAction schema (v.m <--> fma)

- the ForceApplication portion of verb meaning should be identified with the ForceApplication portion of A-S construction meaning (self.m.process1<--> v.m.process1)

So, as with TransitiveCEA3, the verb constituent has ForceApplication structure in common with the A-S construction (i.e. the event type). But, unlike TransitiveCEA3, ForceApplication is only part of the verb's schematic meaning (i.e. a subprocess within a more complex composite process).

As illustrated in Figure 7.10, CauseEffectAction and ForcefulMotionAction both have a subprocess that is constrained to be ForceApplication (process1: ForceApplication). But these two complex schemas differ as to the nature of their other subprocess. Moreover, in ForcefulMotionAction, the same entity (the actor) is protagonist of both subprocesses, whereas CauseEffectAction involves two separate protagonists.

CauseEffectAction
process1: ForceApplication
process2: ForceSink
protagonist
protagonist2

ForcefulMotionAction
process1: ForceApplication
process2: EffectorMotionAlongAPath
protagonist < – > protagonist2

Figure 7.10 Similarities and differences with respect to subprocesses and protagonists in the CauseEffectAction and ForcefulMotionAction schemas.

Analysis of *He slapped the bread*:

Using the current grammar, the sentence He slapped the bread is analyzed as instantiating the following constructions:

- Lexical constructions for each of the words, including a SlapPast construction for 'slapped'
- NP constructions for 'He' and 'the bread'
- TransitiveCEA4 A-S construction
- Declarative clause construction (Figure 4.1)

This analysis and the SemSpec it produces are very similar to that of *He pushed the bread*, discussed in the previous chapter. The primary difference is related to the schematic meanings of the verb constructions instantiated in each example. In the SemSpecs, the schemas bound to the EventDescriptor schema's profiledProcess role reflect this difference: for the current *slap* example, profiledProcess is bound to ForcefulMotionAction, whereas in the *push* example, it is bound to ForceApplication.

As with the other examples that instantiate TransitiveCEA A-S constructions, this example is analyzed as describing an event in which an actor performs an action that transfers force to and potentially affects another entity. This is represented in the

SemSpec by a binding between the the eventType role of the EventDescriptor and the CauseEffectAction schema. In addition , the participant roles in the CauseEffectAction schema have many of the same bindings as in the SemSpecs for other prototypical transitive examples. The causer role of CauseEffectAction is bound to:

- protagonist of CauseEffectAction
- actor and protagonist of ForceApplication
- referent described by the 'subj' NP (in this case, *he*)
- profiledParticipant

And the affected role of CauseEffectAction is bound to:

- protagonist of CauseEffectAction's process2 (the effect)
- actedUpon of ForceApplication
- referent described by the 'direct object' NP (in this case, *the bread*)

However, in the SemSpec for the current example, these participant roles are also bound to ForcefulMotionAction roles:

- causer is bound to actor and protagonist of ForcefulMotionAction
- affected is bound to actedUpon/target of ForcefulMotionAction

This means that the meaning of the 'direct object' np (*the bread*) will be bound to the complex actedUpon/target role associated with the meaning of the verb (*slapped*).
Within the context of this event description, this referent is primarily being conceptualized as the affected participant in a CauseEffectAction type of event, i.e. as an entity which receives and is potentially affected by a force supplied by a causer event participant. Therefore, the force-reception 'acted upon' element of this complex role is foregrounded, and the spatial 'target' element is backgrounded.

The SemSpec for *He slapped the bread* thus indicates that this event has causal structure, and that the simulation of this event should include the actor's application of force to the bread, along with possible effects that may result from this force transfer. In such examples, then, the slapping action is conceptualized as a causal action which at least potentially brings about some effect to the thing that is contacted by the actor's hand. As with other transitive examples, specific effects can be inferred through simulation, utilizing additional information supplied by context and world knowledge.

<u>Comparison with conative SemSpec</u>

The main difference in the SemSpecs for these two types of examples involves the eventType role of EventDescriptor. Different bindings to this role indicate that these examples describe two different kinds of events. For the conative example, this role is bound to EffectorMotionAlongAPath

For the transitive example, this role is bound to CauseEffectAction (the schema with which TransitiveCEA4 identifies its meaning). Therefore, unlike the SemSpec for the 'conative' example, the specified event type here includes causal structure.

In both of the SemSpecs for these examples, the profiledProcess is bound to ForcefulMotionAction. But, for this transtivie example the verb meaning has a different relation to the eventType than in the conative example. Specifically, the shared structure is ForceApplication (process1, the forceful component of these actions) rather than EffectorMotionAlongAPath (process2, the spatial component of these actions).

7.9 Summary

To summarize, the story on 'conative' and transitive uses of verbs such as slap is as follows.

Verbs such as *slap, kick, punch, tap*, etc. are consistently used to describe actions that involve an actor moving an effector toward and then forcefully contacting some entity (e.g. a person or object of some kind). These actions thus involve both motion and changes in spatial relations as well as contact with and the transfer of force to another entity. The schematic structure of these actions is represented by the ForcefulMotionAction schema, a complex schema that integrates structure related to an actor's motion of an effector (represented by the EffectorMotionAlongAPath schema) with structure related to an actor's transfer of force to another entity (represented by the ForceApplication schema).

Sentences in which these verbs are used transitively (e.g. *He slapped the bread*) are analyzed as instantiating a TransitiveCEA4 A-S construction. This A-S construction identifies its meaning with a CauseEffectAction schema, indicating that this A-S construction is used to describe agentive causal events in which an actor's actions affect another entity in some way. As with other A-S constructions in the grammar, the meaning of this A-S construction and that of its verb constituent have some schematic structure in common, and it is this commonality of schematic structure motivates their semantic composition. In this particular case, both the verb and the A-S construction meaning include ForceApplication structure.

For conative uses of these same verbs (e.g. *He slapped at the bread*), sentences are analyzed as instantiating the same verb construction, but a different A-S construction: IntransitiveEMAAP2. This A-S construction identifies its meaning with an EffectorMotionAlongAPath schema, indicating that it is used to describe events in which an actor controls the motion and location of an effector in relation to a spatial target. In this case, the meaning common to both the verb and the A-S construction is the schematic structure associated with the A-S construction, represented by the EffectorMotionAlongAPath schema.

Thus, in both cases the verb (e.g. *slap, kick*, etc.) has some portion of its meaning in common with the A-S construction. But the particular portion differs for transitive and conative uses. This means that the SemSpecs for both of these types of examples include the schema associated with the verb's meaning (the ForcefulMotionAction schema). And this schema has bindings to the schema associated with the A-S construction (i.e. the schema bound to the eventType role). But the event types differ, as do the specific bindings.

To better understand the different types of sentence meaning indicated by these different SemSpecs, we have to consider the types of simulations they support. In each case, the SemSpecs provide parameters for a simulation of the event described by these sentences. But, the nature of the event differs and, consequently, the structure that is activated during the simulation process differs as well. One additional important assumption I make is that whatever elements of meaning the verb has in common with this type of event structure will be attentionally foregrounded and actively simulated.[15] Transitive and conative uses differ as to event type, as well as differing as to which portion of meaning the verb has in common with the event type. Transitive uses give rise to a simulation of a causative event that foregrounds the force application component of the verb-designated process. And conative uses give rise to a simulation of an 'effector translational motion' event that foregrounds the spatial/motion component of this verb-designated process.

Corresponding to these differences, the referent described by the non-subject NP is conceptualized as playing a different role in each of these events. In the causal event, this entity is viewed primarily as an entity which is at least potentially affected by the actor/causer's actions. In contrast, in the spatial event the actor controls the motion of an effector in relation to this entity; thus, its primary role is as a spatial landmark.

<u>Extensions</u>

Other sentences that differ as to the specific NPs and PPs they instantiate can also be analyzed as instantiating this same IntransitiveEMAAP2 A-S construction, including examples such as (17) and (18).

(17) The boy / My sister slapped at his hand
(18) He slapped at the light switch / a swarm of mosquitoes

There are many different verbs that can be used to describe complex actions in which the application of force is integrated with the motion of an effector. For example, in addition to slap, there are many other 'agentive impact' verbs such as *kick, punch, whack, tap,*

[15] Modulo aspect: some descriptions may not prompt active simulation of the event-related process schemas.

pound, thump, poke, and *peck*, to name a few. Constructions for these verbs which identify their meaning with ForcefulMotionAction schema will unify with the same A-S constructions that *slap* does. Therefore, this same 'conative' IntransitiveEMAAP2 A-S construction also can be used in the analysis of many other sentences, such as those in (19) and (20).

(19) He kicked / punched / whacked (at) the window
(20) He tapped / pounded / thumped / pecked (at / on) the table

As with the other specific A-S constructions in the grammar, IntransitiveEMAAP2 is defined as (indirect) subcases of the general ArgStructure construction. This means that this A-S construction meets the constraints on the fin constituent of the Declarative construction (discussed in Chapter 4), and can thereby be used in the compositional constructional analysis of declarative clauses such as those examined in this chapter. In addition, as with other A-S constructions, it will also meet the constraints on other types of clause constructions, thereby also supporting the analysis of other types of clauses. As described elsewhere (Bryant 2008; Feldman, Dodge and Bryant 2010), this includes constructions for questions and control. Thus, this A-S constructions can also be used in the compositional analysis of an even wider range of examples, including ones such as (20) and (21).

(20) Which tire did he kick?
(21) He wanted to tap on the door.

In sum, the schemas and constructions discussed in this chapter can be utilized in the compositional constructional analysis of a wide range of different sentence examples. One important element of the approach I have taken is to look past the verbs themselves and to recognize and represent the complex schematic conceptual structure associated with the actions these verbs describe. Another important element is to recognize that these actions can potentially be conceptualized in more than one way. For instance, in some cases, we may focus on some portion of the action, and in some cases we may view the action as part of a larger, more complex event. And, crucially, working within a simulation-based model of language understanding, we can define schemas and constructions that capture the ways we can use language to convey these different conceptualizations.

In Chapter 1, I used various 'slap' sentence examples to illustrate some of the challenges that a compositional analysis of sentence meaning needs to address. In this chapter, I have examined two types of these examples. In the next chapter, I show how many of the same elements used in the analysis of these examples can be utilized in the analysis of some additional types of 'slap' sentence examples.

Chapter 8

Further conceptual complexity: additional *slap* examples

8.1 Introduction

In this chapter, I further explore different uses of 'forceful motion action' verbs such as *slap*, *kick*, and *tap*. As discussed in the previous chapter, these verbs describe actions that involve both a forceful and a spatial/motion component. Due in part to the complexity and composite nature of their internal structure, these actions can potentially be conceptualized as being parts of different types of events. Furthermore, different conceptualizations can be communicated by using different patterns of argument realization. By representing the internal complexity of these actions, and by also representing the different event structures associated with these different argument realization patterns, I demonstrated that it is possible to support a compositional constructional analysis of different sentences that captures these differences in conceptualization.

In that previous chapter, I analyzed examples in which two event participants are expressed, such as (1a and b).

(1) a. He slapped the bread.
b. He slapped at the bread.

Each of these examples is analyzed as instantiating the same verb construction, but different A-S constructions. The transitive example (1a) instantiates an A-S construction with causal event structure, in which an actor affects some other entity. The SemSpec that results from analysis of this sentence indicates that in this event description, slapping is conceptualized as a causal action that may bring about some effect to the entity that the actor (*he*) is acting upon (*the bread*). In the simulation of this event, the forceful elements of the slap action will be foregrounded, and the spatial ones backgrounded. The 'conative' example (1b) instantiates an A-S construction with a different type of event structure, one which is associated with the spatial elements of motor-control actions. The SemSpec for this example indicates that it describes an event in which slapping is conceptualized as a spatial action, in which an actor (*he*) acts in relation to a spatial 'target' (*the bread*). In the simulation of this event, the spatial elements of the slap action will be foregrounded, and the forceful ones backgrounded. Thus, while both of these examples express two event participant roles, the events these examples describe and the roles the participants play differ in some significant ways.

Due to the compositional nature of the constructions in the current grammar, many other sentences can be analyzed in a similar fashion. For instance, the following examples (2a and b) can be analyzed as instantiating the same verb and A-S constructions as the examples above, but different noun and NP constructions:

(2) a. She / The girl slapped him /his hand / his leg.
b. She / The girl slapped at him / his hand / his leg.

And sentences of similar form with other semantically-similar verbs can also be analyzed as instantiating these same A-S constructions, as in (3 a and b) below.

(3) a. He kicked / tapped / rapped / whacked his leg.
b. He kicked / tapped / rapped / whacked at the door.

Thus, the analysis I have presented so far has begun to address a key question raised in the first chapter: how is it that the same verb (in this case, *slap*), often in conjunction with some of the same other words, can be used to express many different meanings?

In this chapter, I expand the analysis, examining some additional uses of *slap* and other semantically-related verbs, and showing how the complexity of the actions described by these verbs motivates additional patterns of constructional and conceptual composition. I focus on three types of sentences, each of which express three participants, as in the following:

(4) She slapped his hand off her leg.
(5) She slapped her hand on his leg.
(6) She slapped him on the leg.

While the forms of these sentences are very similar, their meanings differ in some significant ways. All have three constituents in the same order [V > NP > PP], and most of the word forms are even the same. But, the nature of the event being described differs in each case and, accordingly, there are differences in the nature of the event participant roles. Moreover, there are also significant differences in the relations between these event roles and those associated with the verb-designated action.

The events described by these different types of examples can be characterized as follows:

- *She slapped his hand off his leg*: An actor (*she*) performs an action that transfers force to another entity (*his hand*), thereby causing this entity to move and change location with respect to a spatial landmark (i.e. to move *off his leg*).
- *She slapped her hand on his leg*: As part of a slapping action, an actor (*she*) moves an effector (*her hand*) in relation to a spatial target (*his leg*).
- *She slapped him on the leg*: An actor (*she*) affects someone (*him*) by acting on a part of his body (*the leg*).

As I show, these examples can all be analyzed as instantiating the same verb construction for *slapped* that was described in the previous chapter. But, each type of example instantiates a different A-S construction. In each case, the A-S construction has some meaning in common with its verb constituent. However, the meaning of each A-S construction, as well as its semantic relation to its verb constituent differs.
As a consequence, the composition of verb and A-S construction meanings yields a different set of complex semantic roles for each of these different types of examples.

Each of these semantic roles is essentially a 'bundle' of roles from different schemas, with these different roles bound together to form a single internally-complex role. To compare roles in different examples, we can compare the roles within these different 'bundles'. In this way, it possible to recognize both similarities and differences between the semantic roles expressed in these different examples. For instance, the semantic role expressed by the 'direct object' NP in examples (4) and (5) are similar in that both include a 'mover' role as part of their 'bundle'. But, they differ as to which motor-control roles they include: in (4) this mover is also an 'acted upon' entity, whereas in (5) the mover is the 'effector' the actor is using to perform the action. Thus, this analysis captures both similarities and differences in the three semantic roles expressed by each type of example.

<u>Chapter Overview</u>

In the following sections, I examine each of the following types of examples in turn:
- 'Cause motion', e.g.: *She slapped his hand off his leg*
- 'Effector motion', e.g.: *She slapped her hand on his leg*
- 'Part-possessor', e.g.: *She slapped him on the leg.*

For each type of example, I do the following:
- Discuss the type of event described by the example.
- Define the A-S construction it instantiates. Each A-S construction differs as to event type, and as to the semantic relation the verb has to the A-S construction meaning. For the first two, the described events are similar to those in the examples described in the previous chapter. Therefore, the meanings of these A-S constructions are represented using schemas defined in previous chapters. The meaning of the third type of example, however, requires the definition of an additional schema.
- Discuss the constructional analysis of a sentence example, the SemSpec it produces, and the simulation which this SemSpec supports.
- Discuss similarities and differences with other types of examples.

As with other chapters, I focus on the examination of a few specific sentence examples. But, the A-S constructions instantiated in these examples are defined such that they can be used to analyze a wide range of other examples. This includes examples with other ‘forceful motion action’ verbs and different NPs (though not all of these verbs are equally felicitous in each type of example). For example:

(7) a. She poked the cup off the table.
b. She poked her finger into the mud.
c. She poked him in the eye.

(8) a. She kicked the ball over the fence.
b. She kicked her foot against the table leg.
c. She kicked him in the shin.

(9) a. She tapped the ball into the cup.
b. She tapped her finger on the table.
c. She tapped him on the shoulder.

Additionally, examples that instantiate different clause constructions (e.g. *She wants to tap him on the shoulder*; *Did she kick the ball over the fence*?) can also be analyzed as instantiating some of these same A-S constructions.

8.2 Cause Motion: *She slapped his hand off her leg*.

To start, let us consider the sentence *She slapped his hand off her leg.* The overall form and meaning of this example are similar in some respects to those of simple transitive examples (e.g. *She slapped his hand*). There are some significant differences, however, that provide the motivation for analyzing this example as instantiating a different kind of A-S construction: a ‘cause motion’ rather than a basic transitive A-S construction.

Goldberg (1995) describes Caused-Motion constructions that have several different but related senses, each of which occur with different types of verbs. The prototypical, central sense of this construction describes a basic scene in which a causal agent acts on some object, causing it to move along a path of motion. This central sense meaning is seen in the example above (*She slapped his hand off her leg*) as well as in examples such as the following:

(10) a. She threw the box on the floor
b. She slid the box across the floor
c. She pushed the box in the room.
d. She kicked the box at his leg.

As Goldberg points out, neither the meanings of the verb nor the preposition by themselves consistently provide a sufficient basis for predicting that their combined use yields a caused-motion interpretation. For this and other reasons she argues that the caused-motion meaning of such examples should instead be attributed to “a construction which combines the verb and directional preposition yielding a particular, conventionalized interpretation.” (Goldberg 1995: 159).

It is true that in some cases the verb can be characterized as having a caused motion meaning. In example (10 a), for instance, *throw* describes an action which causes some object to move along a path. But, for some verbs, the core meaning does not include this full caused motion structure. Such is the case for the verb *slide* in example (10 b). This verb is consistently used to describe translational motion. However, as evidenced by examples such as *The box slid down the ramp*, this motion is not necessarily conceptualized and described as being an effect of a causal action. This is also the case for verbs such as *push* and *kick* (in examples (10 c - d)), which describe actions that don't necessarily cause motion of the acted upon entity (e.g. *He pushed / kicked the box but it wouldn't budge*).

In all of these examples, the prepositional phrase elaborates the path of motion of the mover (*the box*). For instance, *She threw the box on the floor* indicates that at the end of motion, the box is on the floor. Furthermore, we can infer that the box was someplace else (i.e. not on the floor) when the motion started. Thus, within the context of this particular example, this phrase serves to indicate the endpoint location of a moving trajector.[1] However, 'on' and some of the other prepositions in the examples above can also be used to describe static spatial relations (e.g. *The box is on the floor, The UPS driver is standing at the door*). So, in and of themselves, not all of these prepositional phrases in these examples necessarily indicate a change in location.

Thus, independent of this particular phrasal context, neither the verb nor the PP necessarily describes causation and/or motion. But, we can identify larger conventionalized patterns in which these elements can be used to describe 'caused-motion' events.

In the sections which follow, I show how these patterns can be formally represented in an ECG grammar. A key part of this work concerns the analysis and representation of 'cause-motion' conceptual structure. Actions which cause the motion of another entity can be viewed as causal actions which have motion-related effects. Therefore, to represent the schematic structure of such actions, I define a schema that integrates a schema that has causal structure with one that has motion-related structure. Defining this 'cause motion' schema as a composition of other schemas has several benefits:

- It captures the semantic complexity of the 'affected-mover' participant role
- Similarities and differences to roles in other schemas are readily apparent (e.g. similarities and differences in the role 'the box' plays in *She slapped the box off the table* compared to the roles it plays in *She slapped the box* and *The box slid off the table.*)
- It aids recognition and representation of relations between 'cause motion' A-S constructions and various verb meanings (e.g. force-application, motion).

In the section below, I describe this 'cause motion' schema in more detail. Then, I describe some CauseMotion A-S constructions, each of which indicates how the

[1] Chapter 2 includes a fuller analysis of locative and 'path' uses of prepositions such as *at* and *in*.

meanings of its verb, NP, and PP constituents are integrated into this cause-motion event structure. Following that, I discuss sentence analyses supported by these constructions.

8.2.1 Schema: CauseMotionAction

The caused-motion scene described by examples such as *She slapped his hand off her leg* is similar in many respects to the prototypical transitive scene described in Chapter 6, in which one entity (an 'agent') acts forcefully on another entity (a 'patient'), with the intended result that this second entity is affected in some way by this action. However, in addition to being acted upon and receiving force from the actor, the patient moves and changes its location with respect to another object (in this particular example, *her leg*). Thus, there is a more specific kind of effect to the affected entity.

To represent the schematic structure of agentively-caused translational motion I therefore define a CauseMotionAction schema that integrates the structure of two schemas that were discussed in earlier chapters: CauseEffectAction (the schema used to represent the meaning of prototypical transitive scenes) [2] and MotionAlongAPath (a schema used to represent translational motion) [3].

CauseMotionAction (Figure 8.1) is defined as a subcase of CauseEffectAction, and consequently inherits the structure and roles of its parent. As described in Chapter 5, CauseEffectAction is a complex schema with two subprocesses, one of which is a causal action, and the other of which is an 'affected' process. CauseMotionAction differs from its parent in one crucial respect: it specifically indicates that the causal action results in the translational motion of the affected entity. This motion-related effect is represented within CauseMotionAction by constraining the affected subprocess (process2) to be of type MotionAlongAPath.

Because of the more specific type constraint on the affected subprocess, CauseMotionAction's roles differ in some significant ways from those of CauseEffectAction. Of particular importance, bindings to the inherited affected role indicate that this is a more semantically complex role than the affected role in CauseEffectAction. Within CauseEffectAction the affected participant role already has several bindings to other roles. It is bound both to the protagonist of the affected subprocess (i.e. protagonist2) and the actedUpon role associated with the causal action subprocess. Furthermore, this actedUpon role is itself bound to the recipient role of a ForceTransfer schema. CauseMotionAction inherits these role bindings. In addition, because the affected subprocess is specified to be MotionAlongAPath, its affected participant role is also bound to the mover role of MotionAlongAPath, a role that is itself bound to the trajector role of an evoked SPG schema. Together, these bindings indicate that the affected participant in this schema is acted upon and receives force from

[2] Chapter 5, Figure 5.5.
[3] Chapter 3, Figure 3.6.

an actor, and is thereby affected, with the specific effect in this case involving the motion and change of location of this participant.

There is also an additional participant role associated with CauseMotionAction that is not present in CauseEffectAction. This is the landmark role associated with the 'translational motion' subprocess (i.e. the landmark of the SPG schema evoked by MotionAlongAPath). This landmark role is not bound to any other roles within CauseMotionAction.

In addition, CauseMotionAction inherits a causer role. Within CauseMotionAction this causer role has the same bindings as it does in CauseEffectAction. That is, causer is bound to the protagonist role associated with process1 (ForceApplication), which means that it is also bound to ForceApplication.actor and ForceTransfer.supplier.

```
schema CauseMotionAction
   subcase of CauseEffectAction
   evokes ForceTransfer as FT
     roles
        process1: ForceApplication
        process2: MotionAlongAPath
        causer
        affected
         x-net: @causeMotionaction
     constraints
        protagonist ↔ causer
        protagonist2 ↔  affected
        process1.actedUpon ↔ affected
        ft ↔ process.ft
        ft ↔ process2.ft
```

Figure 8.1 The CauseMotionAction schema.

8.2.2 Constructions with CauseMotionAction meaning

The CauseMotionAction schema can be used to represent the meaning of verbs that describe actions which cause the translational motion of some object (e.g. *throw, toss, fling,* etc.). For each of these constructions, meaning constraints can indicate additional specifications regarding the nature of the motor-control routine, the amount of force involved, the path of motion the object follows, etc.

The CauseMotionAction schema is also used to represent the meaning of several different CauseMotion A-S constructions. All of the CauseMotion A-S constructions described in this chapter are of the form [V > NP > PP], and are used to describe basic 'cause motion' events in which an actor causes the translational motion of some other object. But, these constructions differ as to the meaning of their verb constituent and its relation to the A-S construction meaning. Consistent with the methodology employed in previous chapters, I define a central case A-S construction in which the verb constituent has the same schematic conceptual elements as the A-S construction, and extensions to this central case in which the verb constituent has other meanings and, therefore, different semantic relations to the A-S construction.

Central Case A-S construction

The central case CauseMotion1 A-S construction is instantiated in examples such as *He threw the box into the room*, in which both the A-S construction and its verb constituent identify their meaning with a CauseMotionAction schema.

```
construction CauseMotion1 // central case
 subcase of ArgStructure
 constructional
    constituents
       v : Verb
       np: NP
       pp: Path-PP
 form
    constraints
       v.f before np.f
       np.f before pp.f
 meaning: CauseMotionAction
    evokes EventDescriptor as ed
    constraints
       self.m<--> ed.eventType
       v.m<--> ed.profiledProcess
       self.m<--> v.m
       self.m.affected <--> np.m
       self.m.causer <--> ed.profiledParticipant
       self.m.process2.spg <--> pp.m.spg
```

Figure 8.2 The CauseMotion1 A-S construction (instantiated in examples such as *She threw the box on the floor*).

CauseMotion1 has three constructional constituents: v (of type Verb), np (type NP), and pp (of type Path-PP). Canonically, the form of the v constituent precedes that of np, which precedes that of pp. In other words, the verb precedes the ‘direct object’ NP, which in turn precedes the prepositional phrase constituent.

The meaning of CauseMotion1is identified with a CauseMotionAction schema. In addition, this construction specifies how its meaning is related to that of its constituents. In this central case A-S construction, the v constituent has the same schematic structure as the A-S construction (self.m <--> v.m). The meaning of its np constituent is bound to the affected role of CauseMotionAction (self.m.affected <--> np.m), indicating that the ‘direct object’ NP expresses the filler of the ‘affected-mover’ participant role. The pp constituent is constrained to be a Path-PP construction, and therefore identifies its meaning with an SPG (Source-Path-Goal) schema. This constituent serves to elaborate the path of motion that is followed by the affected participant. To indicate the semantic relation between the A-S construction and its pp constituent, the SPG meaning of the pp constituent is bound to the SPG structure associated with CauseMotionAction. More specifically, it is bound to the SPG schema evoked by MotionAlongAPath, which is the second subprocess of CauseMotionAction (self.m.process2.spg <--> pp.m.spg).

CauseMotion1also has bindings to an evoked Event Descriptor schema. As with other A-S constructions, this construction inherits the constraints that the meaning of the verb constituent is bound to the profiledProcess role of EventDescriptor, and the meaning of the A-S construction is bound to the eventType role. In addition, CauseMotion1 specifies that causer is bound to EventDescriptor's profiledParticipant role, indicating that this event should be simulated from the perspective of the actor who is causing the motion of the other object.

In many respects CauseMotion1 is similar to the central case TransitiveCEA1 construction described in Chapter 6 (Figure 6.1). However, it has the following differences:

- The type of event associated with CauseMotion1's meaning includes schematic structure related to motion and change in location.
- In addition to being an 'affected' entity, the referent described by CauseMotion1's np constituent is also a mover and an SPG trajector.
- CauseMotion1 includes a pp constituent that specifies details about change of location.
- The referent described by the np constituent of CauseMotion1's prepositional phrase is the landmark of the translational motion subprocess of CauseMotionAction (i.e. the affected-mover is a trajector that changes location with respect to this landmark).

Extensions to central case A-S construction

Similar to TransitiveCEA1, CauseMotion1 has various subcase 'extensions' that differ from the central case construction as to the meaning of their verb constituent and its relation to the meaning of the A-S construction as a whole. Consistent with how radial categories are represented elsewhere in the current grammar, these extensions are defined as subcases of the central case CauseMotion1 construction. Unlike the central case A-S construction, in these extensions the verb constituent does not have the same schematic structure as the A-S construction. Therefore, each of these subcases 'ignore' the inherited constraint that the schematic meaning of the verb constituent is the same as that of the A-S construction (**ignore** self.m <--> v.m). This ignored constraint is replaced by two others, one of which identifies the meaning of the verb constituent with that of some evoked schema, and another which specifies how the schematic meaning associated with this verb is related to the meaning of the A-S construction as a whole. In other words, each extension specifies what schematic structure the A-S construction and its verb constituent have in common, thus indicating how these constructional meanings compose with one another.

In the CauseMotion3 extension instantiated in examples such as *He pushed the box into the room*, the meaning of the verb constituent is bound to an evoked ForceApplication schema (v.m <--> fa). This constraint indicates that verbs such as *push*, *pull*, *shove*, etc., which are used to describe actions in which an actor 'applies' force to another entity, can serve as the verb constituent in this A-S construction. In this case, the schematic structure of the verb constituent is the same as the causal action subprocess of the CauseMotionAction event (self.m.process1 <--> v.m). This is the same semantic relation as the one specified in TransitiveCEA3, the A-S construction instantiated in examples such as *He pushed the box*.

As discussed in the previous chapter, the current grammar includes core constructions for verbs such as *slap* and *kick* that identify their meaning with a ForcefulMotionAction schema, indicating that such verbs are used to describe actions in which an actor moves an effector towards and forcefully contacts another entity. Accordingly, examples such as *She slapped his hand off her leg* and *She kicked the ball over the fence* are analyzed as instantiating a CauseMotion4 A-S construction (Figure 8.3), whose verb constituent's meaning is bound to an evoked ForcefulMotionAction schema. As with CauseMotion3, the CauseMotion4 A-S construction and its verb constituent both include ForceApplication schematic structure. But, for CauseMotion4, ForceApplication is only <u>part</u> of the verb constituent's schematic meaning (the forceful subprocess). This 'part-part' relation is specified within CauseMotion4 as a meaning constraint that binds the process1 role of CauseMotionAction to the process1 role of ForcefulMotionAction (self.m.process1 <--> v.m.process1). This constraint indicates that the ForceApplication component of the A-S construction should be identified with that of its verb constituent. This is the same semantic relation as the one specified in TransitiveCEA4 (the A-S construction instantiated in examples such as *She slapped his hand*).

```
construction CauseMotion4
  subcase of  CauseMotion1
  constructional
      constituents
          v : Verb
          np: NP
          pp: Path-PP
  form
      constraints
          v.f before np.f
          np.f before pp.f
  meaning: CauseMotionAction
      evokes EventDescriptor as ed
      evokes ForcefulMotionAction as fma
      constraints
          ignore self.m <--> v.m
          self.m.process1 <--> v.m.process1
          v.m <--> fma
          self.m<--> ed.eventType
          v.m<--> ed.profiledPorcess
          self.m.affected <--> np.m
          self.m.causer <--> ed.profiledParticipant
          self.m.process2.spg <--> pp.m.spg
```

Figure 8.3 The CauseMotion4 A-S construction (instantiated in examples such as *She slapped his hand off her leg*).

8.2.3 Sentence Analysis: *She slapped his hand off her leg*.

She slapped his hand off her leg can be analyzed as instantiating the following constructions:

- Lexical constructions for each of the words, including a SlapPast construction for 'slapped'
- NP constructions for 'She', 'his hand' and 'her leg'
- Path-PP construction (for 'off her leg')
- CauseMotion4 A-S construction
- Declarative clause construction (Figure 4.1)

When the constructions unify, the resultant SemSpec includes the various schemas and role bindings described below.

As with the SemSpecs for all the sentence examples examined thus far, the SemSpec for this example includes an EventDescriptor schema. In the current SemSpec, this schema's eventType role is bound to a CauseMotionAction schema. Thus, the type of event to be simulated includes structure related to an actor performing an action that transfers force to another entity, thus causing that entity to move. Accordingly, the entities described by the different sentence NPs will presumably be conceptualized primarily in terms of the roles they play within this 'cause motion' event (i.e. subject NP is causer, direct object NP is affected-mover, and prepositional object NP is a spatial landmark). The prepositional phrase in this example describes the path of motion of the affected-mover in relation to this landmark.

This SemSpec thus supports a simulation in which the force-related elements of the slapping action are attentionally foregrounded, while the 'effector motion' elements are backgrounded. Each event participant role is bound to other schema roles, as indicated below (attentionally backgrounded roles are shown below in square brackets).

The referent described by the 'subject' NP (*She*) is bound to the following roles:
- profiledParticipant of EventDescriptor
- causer of CauseMotionAction
- actor of ForceApplication
- supplier of ForceTransfer
- [actor of ForcefulMotionAction]
- [actor of EffectorMotionAlongAPath]
- protagonist of CauseMotionAction and ForceApplication
- [protagonist of ForcefulMotionAction and EffectorMotionAlongAPath]

The referent described by the 'direct object' NP (*his hand*) is bound to:
- affected of CauseMotionAction
- protagonist2 of CauseMotionAction
- actedUpon of ForceApplication
- recipient of ForceTransfer
- mover of MotionAlongAPath
- trajector of SPG
- [actedUpon < -- > Target of ForcefulMotionAction]
- [target of EffectorMotionAlongAPath] [landmark of a different SPG schema]

And, the referent described by the NP in the prepositional phrase (*her leg*) is bound to:
- landmark of SPG

Thus, this SemSpec indicates that each of the participants expressed in this example fills an internally complex semantic role, in which roles from different schemas are bound together.

8.2.4 Comparison with simple transitive examples

This analysis of *She slapped his hand off her leg* captures both its semantic similarity to and its differences from similar simple transitive examples such as *She slapped his hand.* More generally, the SemSpecs produced by analyses of these different types of examples support semantic comparisons between 'caused motion' and simple transitive uses of verbs such as *slap.*

For both kinds of examples, the instantiated A-S construction's meaning (eventType) includes agentive cause-effect structure. And for each, the event should be simulated from the perspective of the person performing the causal action (i.e. causer is bound to profiledParticipant). Additionally, both examples are analyzed as instantiating the same verb construction. Furthermore, the semantic relation between this verb construction and each of the A-S constructions is similar: in each case, the verb and the A-S construction have 'force-application' meaning in common. Consequently, for both types of examples, slapping is conceptualized as an action that causes some effect to the thing being slapped (*his hand*). And in both cases the force-related components of slapping action are foregrounded.

The key difference has to do with the type of effect caused by this forceful action. Each A-S construction meaning is identified with a different, though related schema. The A-S construction instantiated in the transitive example (TransitiveCEA4) identifies its meaning with a CauseEffectAction schema. This schema supports simulation of some effect, but the particular effect inferred for a given utterance will depend on various factors, such as the nature of the thing that is acted upon, and what intentions we think the actor may have for performing the action. The A-S construction instantiated in the cause motion example (CauseMotion4) identifies its meaning with a CauseMotionAction. This schema specifies that the effect is motion and change in location of the thing acted upon (i.e. his hand is initially on her leg, and her action causes his hand to move off her leg).

Reflecting these differences, the referent described by the 'direct object' NP (*his hand*) fills a richer, more complex semantic role for the 'cause motion' examples than for the simple transitive examples. This particular complex role includes a binding to the affected role associated with prototypical transitive examples, but also has a binding to a mover role. Moreover, this role has additional bindings to roles in other schemas: ForceApplication (actedUpon), ForceTransfer (recipient), and SPG (trajector). Together, these bindings capture greater role complexity than would be indicated by a single thematic-type role such as 'patient' or 'theme' alone. At the same time, this method of representation enables us to recognize both similarities and differences between the event participant roles in different types of events.

8.2.5 Verbs that co-occur with the CauseMotion4 A-S construction

English has many different verbs that are used to describe actions in which an actor moves an effector (body part or other instrument) towards and forcefully contacts another entity. In addition to *kick*, *slap*, and *tap*, there are verbs such as *hit, rap, punch, poke, jab, strike, clobber, beat, hammer*, and *pound*. For each of these verbs, we can define verb constructions whose meanings are represented using the ForcefulMotionAction schema. Specific verb constructions will differ as to specific constraints on things such as the typical effector used, the amount of force, etc.

These different verbs vary as to the frequency (and felicitousness) with which they co-occur with the CauseMotion4 construction. At least two factors affect the likelihood of their co-occurrence. The first is the forcefulness of the action, and the second is the effect of the action (which in turn is directly related to the actor's goal when performing the action). Very rough groups can be formed on the basis of these factors, although it might be better to think of these factors in terms of clines of values rather than seeing them as defining distinct categories.

Some types of 'agentive impact' verbs, such as *clobber, beat*, *pound,* and *strike* tend to be used to describe actions that result in non-motion effects. For example, when the acted upon entity is animate, the actions denoted by these verbs are usually carried out to harm this entity, not to cause it to move. Thus one reason these verbs tend <u>not</u> to occur with the CauseMotion4 construction is because the actions are not usually performed with a 'cause motion' intent. Note, however, that these verbs do co-occur with this A-S construction in descriptions of some sports-related events, in which the acted upon entity is inanimate (a ball) and the actor is trying to cause motion, often by using as much force as is possible[4]. In such cases, the verb seems to underscore the forcefulness of the action.

Other verbs, such as *pat* and *tap*, describe actions that do not typically involve enough force to actually cause something to move. Consequently, "low force" verbs such as these rarely co-occur with the CauseMotion4 A-S construction. However, there are uses of these verbs that can be analyzed as instantiating this A-S construction, such as *She patted her hair into place* and *He tapped the ball into the corner pocket*. In these cases, although the amount of force associated with the action is low, it is sufficient to cause the motion of some types of objects.

We can also imagine sentences that describe situations in which the particular action does <u>not</u> seem to produce sufficient force to cause the motion of a particular object, e.g. *He patted the ball across the room* or *He kicked the wall across the room.* These examples can still be analyzed as instantiating a CauseMotion4 construction, and this analysis will produce a SemSpec similar to other 'cause motion' examples. Thus, these examples can still be considered grammatically acceptable. However, although this SemSpec will provide parameters for a coherent simulation, this simulation may "crash" unless we change our force-related defaults, e.g. we know or imagine that the actor is extremely strong or that the acted upon entity is actually light and moveable. The infrequency with which some verbs or verb-object combinations occur in this construction is thus not due to grammatical prohibition, but to the infrequency of "cause motion" scenarios that they could aptly be used to describe.

---

[4] For example, a Google search provides the following examples:

- In the 5th inning Tony Clark <u>clobbered</u> the ball into Tokyo Dome's scoreboard, breaking it."
- "Presnal then <u>pounded</u> the ball across the goal line six plays later…"
- "…he inadvertently <u>struck</u> the ball towards his own goal."

In sum, the CauseMotion4 A-S construction captures a general pattern in which verbs with 'forceful motion action' meaning are used to describe 'cause motion' events. Meaning constraints within the CauseMotion4 A-S construction indicate that the semantic motivation for its composition with these verbs is provided by commonality of meaning: specifically, the 'force application' schematic structure that is part of the meanings of both types of constructions. However, this semantic similarity does not necessarily mean that all verbs with this type of meaning will co-occur with this A-S construction with equal frequency or felicity. Furthermore, as illustrated in the following sections, the actions described by these verbs bear other types of semantic similarities to other types of events, which motivates their composition with other types of A-S constructions. And, as we will see, these different compositions result in different sets of complex roles.

8.3 'Effector Motion' Events

Some examples with 'forceful motion action' verbs such *slap* and *kick* are very similar in general form to those discussed above but, in at least one reading, differ as to the type of event they describe and also differ as to what aspects of verb meaning are foregrounded. Consider examples such as the following:

(11) a. She slapped her palms against his desk.
b. She tapped her finger on the table.

One possible reading of these sentences is that they describe scenes in which an actor (*she*) acts upon another entity (*her palms, her finger*), causing this acted upon entity to move along a path described in relation to some landmark (*against his desk, on the table*). Under this reading, the meanings of these examples are similar to those in the previous section, and can be analyzed as instantiating the CauseMotion4 A-S construction. In terms of general cause-effect structure, these meanings are also similar to basic transitive sentences such as *She slapped her palms / She tapped her finger*, though there is an added specification that the action results in the translational motion of the affected entity.

However, a second, more likely reading of (11 a and b) is that they describe events in which an actor (*she*) performs an action using part of her body (*her palms / her finger*) and, as part of this action, moves this body part towards and contacts another entity (*his desk / the table*). Under this reading, the described event is similar to the ones described by 'conative' type examples such as *She slapped at his desk* and *She tapped on the table*: in both, an actor moves an effector in relation to some spatial target. Consequently, as discussed in the following section, examples such as (11a) and (11 b) can be analyzed as instantiating an A-S construction that identifies its meaning with an EffectorMotionAlongAPath schema (the same schema that is used to represent the meaning of the IntransitiveEMAAP A-S constructions discussed in the previous chapter).

One obvious difference between (11a and b) and similar 'conative' examples concerns the explicit mention of the entity that serves as effector in the action. In addition, there is a wider range of prepositions used in the description of the effector's path than in the 'conative' examples. For instance, in addition to *at* and *on*, we also find *over*, *across*, *against*, and *through*, as in (12a) and (12b).

(12) a. She slapped her hand over / across her mouth.
     b. He kicked his foot through the door /at the ground

One possible reason for this increased range is that explicit mention of the effector may focus greater attention on the specific spatial relation the effector has to the target entity in each situation, leading to finer-grained specifications of this relation. There are some semantic constraints on the prepositional phrases used in these 'effector motion' examples, however. Generally speaking, the path of effector motion described by the prepositional phrase needs to be consistent with that specified by the verb. For verbs like *slap* etc., this specified path involves the motion of an effector towards a target, with the effector typically contacting the target at the end of its path of motion.

Accordingly, the prepositional phrases that occur in these examples typically indicate both motion towards a target, as well as contact at the end of the path. In some cases, as in (11a and b), the spatial relation specified by preposition (*on*, *against*) definitely involves contact. In other cases, as in (12a and b), even though the preposition itself is not always used to describe a contact relation, we are nonetheless very likely to infer that contact occurred. Occasionally, examples of this type are used to describe situations in which the effector does <u>not</u> contact the target, e.g.:

(13) He lightly kicked his foot towards the lying Niou, not quite hitting him but still making his intention clear.[5]

Nonetheless, this example does still indicate that the effector moved toward the target. Note that similar to the case with 'conative' examples, even when we infer that contact occurred, there is not necessarily an expectation that the target entity was necessarily affected by this contact.

In sum, while the prepositional phrase does not have to explicitly specify contact, it does need to be able to indicate that the direction of motion is toward the target. Consequently, when the prepositional phrase describes some other direction of motion relative to the target, as in *She slapped her palms off / away from the desk* only the 'caused motion' seems plausible, not the 'effector motion' reading.

8.3.1 Effector motion A-S constructions

For their 'effector motion' reading, sentences such as *She slapped her hand on his leg* are analyzed as instantiating a TransitiveEMAAP2 A-S construction. This A-S construction is similar to the IntransitiveEMAAP constructions discussed in the previous chapter with respect to the following:

[5] [www.fanfiction.net/s/5598737/1/Twisted_Rivalries. Accessed 7/9/10]

- It describes the same kind of event (represented by the EffectorMotionAlongAPath schema).
- It specifies that this event should be simulated from the perspective of the event's actor participant (i.e. the actor is the profiledParticipant)
- It has a pp constituent which elaborates the path of the effector's motion, via specification of spatial relations to the target/landmark entity. And, to indicate the semantic relation between the pp and the A-S construction, the meaning of the pp constituent is bound to the SPG part of A-S cxn's meaning.

The key difference between these two types of A-S constructions is that the transitive constructions include a 'direct object' NP which explicitly expresses the filler of the effector role. To represent this, the transitive A-S constructions include an np constituent whose meaning is bound to the event's effector role.

Similar to the IntransitiveEMAAP A-S constructions, I define TransitiveEMAAP2 as an extension to a central case A-S construction. In this central case TransitiveEMAAP1 construction (Figure 8.4), the verb constituent identifies its meaning with the same schema as the A-S construction. This central case construction is used in the analysis of sentences such as *She reached her hand into her purse*.

In examples such as *She slapped her hand on his leg*, the meaning of the verb differs from that of the instantiated A-S construction. To support the analysis of such examples, I define aTransitiveEMAAP2 A-S construction (Figure 8.4), an extension to the central case. In this extension the meaning of its verb constituent is identified with a ForcefulMotionAction schema (the schema with which constructions for verbs such as *slap*, *tap*, and *kick* identify their meaning). The ForcefulMotionAction schema includes EffectorMotionAlongAPath schematic structure.[6] Therefore, a <u>portion</u> of the verb constituent schematic structure is the same as that of the A-S construction as a whole. This relation is formally represented as a binding constraint within TransitiveEMAAP2 (self.m <--> v.m.process2).

[6] Specifically, the second subprocess (process2) of ForcefulMotionAction is constrained to be of type EffectorMotionAlongAPath.

```
construction TransitiveEMAAP1
  subcase of  ArgStructure
  constructional
    constituents
      v : Verb
      np: NP
      pp: Path-PP
  form
    constraints
      v.f before np.f
      np.f before pp.f
  meaning: EffectorMotionAlongAPath
    evokes EventDescriptor as ed
    constraints
     self.m<--> ed.eventType
     v.m<--> ed.profiledPorcess
     self.m<--> v.m
     self.m.effector <--> np.m
     self.m.protagonist<-->ed.profiledParticipt
     self.m.process2.spg <--> pp.m.spg
```

```
construction TransitiveEMAAP2
  subcase of  TransitiveEMAAP1
  constructional
    constituents
      v : Verb
      np: NP
      pp: Path-PP
  form
    constraints
      v.f before np.f
      np.f before pp.f
  meaning: EffectorMotionAlongAPath
    evokes EventDescriptor as ed
    evokes ForcefulMotionAction as fma
    constraints
     ignore self.m <--> v.m
     v.m <--> fma
     self.m <--> v.m.process2
     self.m<--> ed.eventType
     v.m<--> ed.profiledPorcess
     self.m.effector <--> np.m
     self.m.protagonist<-->ed.profiledParticipnt
     self.m.process2.spg <--> pp.m.spg
```

Figure 8.4 The TransitiveEMAAP1 and TranstiveEMAAP2 constructions.

8.3.2 Sentence Analysis: *She slapped her hand on his leg*.

The sentence *She slapped her hand on his leg* (with an 'effector motion' reading) can be analyzed as instantiating the following constructions:

- Lexical constructions for each of the words, including a SlapPast construction for 'slapped'
- NP constructions for 'She', 'her hand' and 'his leg'
- Path-PP construction (for 'on his leg')
- TransitiveEMAAP2 A-S construction
- Declarative clause construction (Figure 4.1)

Unification of these instantiated constructions produces a SemSpec which includes several different schemas with various bindings between them. This SemSpec includes an EventDescriptor schema, whose eventType role is bound to an EffectorMotionAlongAPath schema. Thus, the type of event to be simulated includes structure related to an actor moving and effector toward (and contacting) a target. But, it does not include causal structure that would support active simulation of an effect to this target. Accordingly, the entities described by different sentence NPs are presumably conceptualized primarily in terms of the role they play within this 'effector motion' event (i.e. subject NP is actor, direct object NP is effector, and prepositional object NP is target). This means bindings to force-related elements of the verb-designated action will be attentionally backgrounded. The prepositional phrase indicates the goal location of the effector (SPG.trajector) in relation to the target (SPG.landmark).

Each event participant role is bound to several other schema roles, as indicated below (attentionally backgrounded roles are shown below in square brackets).

The referent described by the 'subject' NP (*She*) is bound to the following roles:

- profiledParticipant of EventDescriptor
- actor and protagonist of EffectorMotionAlongAPath
- [actor and protagonist of ForceApplication]
- [supplier of ForceTransfer]
- [actor and protagonist of ForcefulMotionAction]

The referent described by the 'direct object' NP (*her hand*) is bound to:

- effector of EffectorMotionAlongAPath
- mover of MotionAlongAPath
- trajector of SPG
- [effector of ForceApplication and ForcefulMotionAction]

And, the referent described by the NP in the prepositional phrase (*his leg*) is bound to:

- target of EffectorMotionAlongAPath
- landmark of SPG
- [actedUpon of ForceApplication]
- [actedUpon/Target of ForcefulMotionAction]

8.3.3 Comparison with 'conative' examples

This sentence analysis of *She slapped her hand on his leg* and the SemSpec it produces captures both similarities and differences of meaning to the similar 'conative' example *She slapped at his leg.* And, more generally, they support semantic comparisons between 'effector motion' and 'conative' uses of verbs such as *slap.*

For both of these examples, the type of event is similar: an actor controls the location or orientation of an effector in relation to a spatial target. This is reflected in the SemSpecs for both of these examples, both of which have a binding between an EffectorMotionAlongAPath schema and the eventType role of an EventDescriptor schema. Furthermore, in both cases the verb meaning and its relation to the A-S construction meaning is also similar. Accordingly, in both SemSpecs, part of the schematic structure associated with the verb construction is bound to the schema associated with the A-S construction. The main difference concerns the 'effector motion' example's explicit expression of the effector role. As mentioned earlier, this explicit mention may serve to foreground the motion of the effector and its spatial relation to the target.

8.3.4 Comparison with 'cause motion' examples

The analysis and SemSpec above also captures similarities and differences to 'cause motion' examples. For instance, compare the following:

(14) a. She slapped her hand on his leg
b. She slapped his hand off her leg.

In both examples, the prepositional phrase describes the path of a mover. But, this moving entity (*her hand / his hand*) plays different roles in relation to the event's actor participant. In the 'effector motion' reading of example (14a), the moving entity is the effector that the actor is using to perform the action (i.e. a body part or other instrument). However, in the 'cause motion' example (14b), the mover is some other object to which the actor is applying force to (via the effector). Thus, there are both similarities and differences in the roles played by the 'direct object' NP in each of these examples.

These similarities and differences are captured in the SemSpecs for these examples by different bindings to the referent that is described by the 'direct object' NP. In both cases this referent is bound to the mover role in a MotionAlongAPath schema, and the trajector in a SPG schema. But, bindings to the ForcefulMotionAction schema (the verb schematic meaning) differ. For the 'effector motion' example, mover is bound to the effector role, while for the 'cause motion' example it is bound to the actedUpon role.

The relation between the path of motion described by the prepositional phrase and the action described by the verb differs as well. In the 'effector motion' reading, this path of motion is an integral part of the slap action. So, in this case, the prepositional phrase elaborates an internal component of the slapping action. In the cause motion events, however, the path of motion described by the prepositional phrase is <u>not</u> part of the verb's core meaning. The prepositional phrase therefore instead serves to elaborate a portion of event meaning that is not shared by the verb.

One additional important difference concerns the 'acted upon' participant of the slapping action. In 'cause motion' and also in simple transitive examples, this participant is expressed by the direct object NP. In 'effector motion' examples, however, this participant is expressed by the NP constituent of the prepositional phrase

It may be a little easier to understand this difference if I explain it by comparing an 'effector motion' example with a simple transitive example, e.g.:

(15) a. She slapped his leg (with her hand).
b. She slapped her hand on his leg.

As observed by Fillmore (1970), these two patterns of expression also occur for other 'hit' verbs (e.g. *hit, strike*, *bump*), each of which have three basic participant roles (e.g.

Agent, Instrument, and Place; or in the ECG grammar used here, actor, effector and actedUpon/target). In both of these examples (15 a and b), *She* is the actor, *his leg* is the thing the actor forcefully contacts, and *her hand* is the body part the actor uses to performs this action. Thus, both types of examples can be viewed as expressing the same set of verb-related semantic roles, but doing so in different ways.

How are these different ways of expressing this 'acted upon' role handled by the current grammar? The relatively short answer is that each pattern is associated with a different A-S construction. These different types of A-S constructions describe different types of events and therefore have different types of event participant roles. In each case, one of these event participant roles has some semantic similarities to the actedUpon role associated with the SlapPast construction (see Figure 8.5 for specific points of similarity). In the case of the 'cause effect' events (example 15a), slap's actedUpon role is similar to the affected event participant role, which is bound to the meaning of the 'direct object' np constituent. In the case of 'effector motion' events (example 15b), however, slap's actedUpon role is semantically similar to the target event participant role, which is bound to meaning of the prepositional phrase's np constituent. Thus, in each case, there is a semantic similarity which motivates composition with an event participant role. But the nature of the similarity with the event participant role differs, as does the constituent to which this event role is bound.

Construction:	**Slap**	**TransitiveCEA**	**TransEMAAP**
Construction Meaning:	FMA	CEA	EMAAP
Schemas	***Roles***	***Roles***	***Roles***
ForcefulMotionAction (FMA)	**actedUpon**		
CauseEffectAction (CEA)		**affected**	
ForceApplication	actedUpon	actedUpon	
ForceTransfer	recipient	recipient	
EffMotionAlongAPath (EMAAP)	target		**target**
SPG	landmark		landmark

Figure 8.5 Roles and binding diagram for Slap's actedUpon role.

So, as discussed in the sections above, the actions described by 'forceful motion action' verbs such as *slap* have semantic similarities to more than one kind of event. This semantic similarity provides semantic motivation for these verbs to compose with several different A-S constructions. In each case, this composition produces a set of complex semantic roles. And, because of the way these complex roles are analyzed and represented using the current grammar, it is possible to recognize both similarities and differences between them.

8.4 'Part Possesor': *She slapped him on the leg*

Having examined two of the three types of slap examples discussed at the beginning of this chapter, we can now turn to the third type. In this section, I sketch out an analysis for examples such as the following:

(16) a. She slapped him across the face
b. He kicked him in the shins
c. He poked him in the eye
d. He tapped him on the shoulder

Examples such as these are often viewed as 'possessor raising' alternations. For instance, *She slapped Jack across the face* is seen as an alternation to *She slapped Jack's face*, with the 'possessor' (Jack) being 'raised' from its position within the prepositional phrase into the direct object position.

It is beyond the scope of this dissertation to survey the extensive body of literature on the analysis of 'possessor raising' in various languages. Instead, I provide a brief overview of some basic observations that various analysts have made. Then, in the following sections, I address the main objective of this chapter section, which is to show how some of these insights can be viewed and integrated into the current framework. First, I compare these 'part possessor' examples with other types of examples that have already been examined in this and previous chapters. Then, I propose schemas and A-S constructions to support a compositional constructional analysis of this additional type of example.

8.4.1 Background

In addition to noting that *slap* and other 'hit' verbs are used in 'effector motion' examples (e.g. *He hit the stick against the fence*), Fillmore (1970) also observed that these verbs occur in 'part-possessor' examples (e.g. *He hit him on the leg*). Since these verbs describe actions which involve contact, this is consistent with Levin's more general observation that: "It appears that a verb shows the body-part possessor ascension alternation only if its meaning involves the notion of contact." (1993: p. 8). Levin also suggests that this alternation – unlike the conative – does not require the verb to include a motion component. Thus, *slap* is one of a larger – but semantically restricted – group of verbs that can appear in 'part-possessor' examples.

There are also constraints on the types of referents described by the 'direct object' and prepositional phrase object NPs that occur in 'part-possessor' examples. Consider the following:

(17) a. She slapped him / the table
b. She slapped his leg / the top of the table/ the table top / his leg.
c. She slapped him on the leg

d. *?She slapped the table on the top.
e. *She slapped him on the table (with the meaning that she slapped his table)

As the first two examples illustrate, simple transitive sentences can include direct objects that describe a wider variety of entities, such as 'whole' animate or inanimate entities (17 a), and parts of such entities (17 b). In contrast, the 'part-possessor' construction generally requires that the direct object describe an animate, sentient being, as indicated by (17c) and (17d). In addition, as indicated by the unacceptability of (17e), the 'part' expressed by the prepositional phrase must be a body part or other inalienable possession[7] of the person expressed by the 'direct object' NP (Baker 1988).

Based on cross-linguistic analysis, O'Connor (1996) suggests that a key part of the meaning of 'possessor raising' constructions is related to a body part possession scene. Important features of this scene include the various experiential relations that a possessor has to parts of his body, and the fact that actions on a particular body part will have various consequences for the possessor of that part. O'Connor further argues that "The construction as a whole imposes a perspective, or frame, in which the experience of the body-part possessor is foregrounded…" (O'Connor 1996: p. 141).

8.4.2 Comparison to previously examined types of examples

In terms of general form, the part-possessor examples are similar to the ones examined in the preceding sections of this chapter. And, in some respects their roles and meanings are also similar, though the specific points of similarity differ. However, they also differ in some significant ways. To illustrate these similarities and differences, let us compare the following examples:

(18) a. She slapped Jack across the face
b. She slapped Jack across the room
c. She slapped her hand across Jack's face

The 'part-possessor' example (18a) is similar to the 'cause motion' example (18b) with respect to the role played by Jack (i.e. the referent described by the direct object NP). In both cases, Jack is affected by the actor's causal action. Unlike the 'cause motion' example, though, the effect is not necessarily one of motion, and Jack is therefore not necessarily also a mover. [8] And the 'part-possessor' example is similar to the 'effector motion' example (18c) in that in both cases the prepositional phrase indicates the particular location where contact was made, though it is referred to in somewhat different ways (*the face / Jack's face*). The prepositional phrase in the 'part-possessor' example

[7] See Chappell and McGregor (1995) for a cross-linguistic examination of the notion of inalienability within grammar.
[8] So, Jack's role in the part-possessor example is more similar to the one played by Jack in the basic transitive example *She slapped Jack*.

thus serves a different purpose than it does in the 'cause motion' example (18b), where it describes the path and landmark for the motion of the affected entity.

In a sense, it seems that the 'part-possessor' examples refer twice to the same being, but at two different spatial granularities (i.e. at the relatively wide spatial scope involving the whole person, and at the narrower scope that focuses on a specific region of that person's body). We can compare such examples to simple transitive examples, in which the 'affected' entity can typically be specified at <u>either</u> of these granularities. For instance:

(19) a. She slapped him across the face
b. She slapped him / his face
(20) a. He kicked him in the shins
b. He kicked him / his shins

What differences are there between these different examples? Why would we choose one or the other? As discussed in Chapter 6, simple transitive examples such as those above (19 b and 20 b) support simulation of some sort of effect that occurs to the entity described by the direct object NP. In the case of animate beings, use of different 'granularities' of reference may indicate differences in the scope of affectedness. When the 'direct object' NP denotes a (whole) person, we are likely to infer a larger scope of affectedness than when it denotes only a part of a person's body. We might further speculate that when the body part appears as direct object, this indicates that primary effects (sensations such as touch, pressure, pain) should be simulated. And when the whole person is the direct object, it indicates that secondary effects (e.g. affective states such as pleasure or displeasure) should be simulated.

In situations where the scope of affectedness is conceptualized as involving the whole person, what motivation is there for also specifying which particular part of that person's body is 'acted upon'? That is, why would we say *She slapped him on the leg* instead of *She slapped him*? One reason is that the body part provides a more precise specification of the spatial target (i.e. the particular location that is being contacted). Another very important reason is that the contact location may actually indicate something about the larger effect of the action. Compare, for example, the different effects we are likely to infer for:

She slapped him on the wrist / on the back / across the face

As the location of contact differs, so too does the experience of the person being contacted. Moreover, these different effects are typically related to the actor's reasons for performing the action in the first place (e.g. to cause pain, get attention, reprimand, congratulations, etc.). So, even when the (whole) person appears as direct object, indicating that the person as a whole ***is*** affected, it may still be relevant to know which particular body region was actually contacted.

Given this basic characterization of 'part possessor' examples, we can now turn to an examination of how they can be analyzed using ECG schemas and constructions.

In the sections that follow, I present a schema and A-S construction that support the analysis of examples such as (19a and 20a). As I show, these ECG representations, and the sentence analyses they support, integrate and formally represent many of the insights described above.

8.4.3 Analysis within the current framework

The events described by 'part possessor' examples can generally be characterized as ones in which an actor contacts and applies force to a particular part of someone's body with the goal of affecting that person in some way. To define a schema to represent this type of event, I follow O'Connor's suggestion described above, and first define a 'body part possession' schema. Then, I integrate the structure of this schema with that of the CauseEffectAction schema to define a CauseEffectToPossessor schema. This CauseEffectToPossessor schema is then used to represent the meaning of the PartPossessor1 A-S construction.

8.4.3.1 Schemas

To represent the relation between a possessor and his body part, we can define a very simple PossessBodyPart schema (not shown). This schema has two key roles: a possessor (which is constrained to be an animate entity) and a bodyPart.

The CauseEffectToPossessor schema (Figure 8.6) represents the schematic structure of actions in which an actor acts upon some part of another sentient being's body, with the goal of affecting that being in some way. This schema is defined as a subcase of the more general CauseEffectAction schema (Figure 5.5). In addition to its inherited causer and affected roles, this subcase introduces an additional role, the contactedPart. This contactedPart role is bound to the bodyPart role of an evoked PossessBodyPart schema.

As described above, in 'part possessor' event descriptions, the affected entity (the whole person) is distinguished from the part of that person's body that the actor acts upon. This means that the affected role should <u>not</u> be bound to the actedUpon role associated with the causal action. Therefore, the CauseEffectToPossessor schema includes a constraint that the inherited binding between these roles should be ignored (**ignore** affected ↔ process1.actedUpon). Instead, the affected role is bound to possessor role of the evoked PossessBodyPart schema. And the actedUpon role is bound to the contactedPart role (and is therefore also bound to the bodyPart role of PossessBodyPart). In this way, the CauseEffectToPossessor schema indicates that the causer acts upon the possessed body part, thereby causing some effect to that part's possessor.

```
schema CauseEffectToPossessor
  subcase of CauseEffectAction
  evokes PossessBodyPart as pbp
    roles
      process1: ForceApplication
      process2: Process
      causer
      affected
      x-net: @causeeffectpossessor
      contactedPart
    constraints
      protagonist ↔ causer
      protagonist2 ↔  affected
      ignore affected ↔ process1.actedUpon
      affected ↔ pbp.possessor
      contactedPart ↔ pbp.bodyPart
      contactedPart ↔ process1.actedUpon
```

Figure 8.6 The CauseEffectToPossessor schema.

8.4.3.2 A-S construction: PartPossesor1

To support analysis of examples such as *She slapped him on the leg*, I define a PartPossessor1 A-S construction whose meaning is identified with the CauseEffectToPossessor schema described above. In this A-S construction, the meaning of the verb constituent is bound to an evoked ForcefulMotionAction schema. This means that in addition to *slap*, other verbs which identify their meanings with ForcefulMotionAction will meet the semantic constraints on this verb constituent.

Both of the schemas with which the A-S construction and its verb constituent identify their meaning include schematic structure represented by the ForceApplication schema. This schematic semantic commonality (which provides the motivation for the composition of these constructional meanings) is represented by a binding between the relevant parts of the meanings of these two constructions (self.m.process1<--> v.m.process1).

In addition, the participant roles associated with CauseEffectToPossessor (the schema with which this A-S construction identifies its meaning) have the following bindings:

- causer is bound to profiledParticipant
- affected is bound to the meaning of the np constituent
- contactedPart is bound to the meaning of the pp constituent's np constituent (self.m.contactedPart <--> pp.np.m)

Because affected is bound to the possessor role of PossessBodyPart, the referent described by the np constituent is thereby constrained to be an animate entity. Similarly, constraints on the bodyPart role of PossessBodyPart will serve as semantic constraints on the constituent bound to the contactedPart role.

```
construction PartPossessor1
 subcase of  ArgStructure
 constructional
     constituents
         v : Verb
         np: NP
         pp: Path-PP
 form
 meaning: CauseEffectToPossessor
     evokes EventDescriptor as ed
     evokes ForcefulMotionAction as fma
     constraints
         self.m<--> ed.eventType
         v.m<--> ed.profiledPorcess
         v.m <--> fma
         self.m.process1<--> v.m.process1
         self.m.affected <--> np.m
         self.m.causer <--> ed.profiledParticipant
         self.m.contactedPart <--> pp.np.m
         self.m.process1.process2.spg <--> pp.m.spg
```

Figure 8.7 The PartPossessor1 A-S construction (instantiated in examples such as *She slapped him on the leg*).

Even though the pp constituent's np constituent describes a body part / possession, a possessive pronoun is not commonly used. For instance *She slapped him on the leg* is typical, not *She slapped him on his leg* or *She slapped him on a leg*. Therefore, we could add the further (default) constraint that this np constituent is a type of determiner-noun construction, in which the determiner is constrained to have the orthographic form of 'the'.

8.4.3.3 Sentence Analysis: *She slapped him on the leg.*

The example *She slapped him on the leg* can be analyzed as instantiating this PartPossessor1 A-S construction, with the resultant SemSpec indicating that the EventDescriptor's eventType role is bound to a CauseEffectToPossessor schema. Thus, the type of event to be simulated includes structure related to an actor affecting a person by acting on some part of that person's body. This causal structure should support active simulation of an effect to this person, with the particular type of effect that is inferred depending both on what type of action is involved and on what part of the body is acted upon.

The entities described by different sentence NPs can be assumed to be conceptualized primarily in terms of the role they play within this 'part possessor' event (i.e. subject NP is causer, direct object NP is affected (possessor) and prepositional object NP is contactedPart (the body part that is acted upon).

The referent described by the 'subject' NP (*She*) is bound to the following roles:

- profiledParticipant of EventDescriptor
- causer of CauseEffectToPossessor
- actor of ForceApplication
- supplier of ForceTransfer
- [actor of ForcefulMotionAction]
- [actor of EffectorMotionAlongAPath]
- protagonist of CauseEffectToPossessor, ForceApplication, [ForcefulMotionAction, EffectorMotionAlongAPath]

The referent described by the 'direct object' NP (*him*) is bound to:

- affected of CauseEffectToPossessor
- protagonist2 of CauseEffectToPossessor
- possessor of PossessBodyPart

And, the referent described by the NP in the prepositional phrase (*the leg*) is bound to:

- contactedPart of CauseEffectToPossessor
- bodyPart of PossessBodyPart
- actedUpon of ForceApplication
- recipient of ForceTransfer
- [ActedUpon < -- > Target of ForcefulMotionAction]
- [Target of EffectorMotionAlongAPath]
- landmark of SPG

The causal structure specified by this SemSpec should support active simulation of an effect to this person, with the particular type of effect that is inferred depending both on the type of action involved and on the part of the body is acted upon. For this reason, the effect inferred for the current example (*She slapped him on the leg*) will differ from examples which refer to other parts of the body, as in example (21a). And the inferred effect will also differ for examples which instantiate other 'forceful motion action' verbs as in (21b).

(21) a. She slapped him across the face / in the mouth / on the back
 b. She tapped / patted /whacked him on the leg.

In each case, the SemSpecs produced by analysis of these examples provides the basic 'stage directions' for simulation of the described event. And, through simulation, we can gain a richer, more fully fleshed out understanding of these different sentences.

8.5 Summary

In this chapter I examined three types of *slap* sentences, each of which expresses three different event participant roles. These different types are illustrated by examples such as the following (examples (4)-(6), repeated as (22) – (24)):

(22) She slapped his hand off her leg.
(23) She slapped her hand on his leg.
(24) She slapped him on the leg.

As with many other ‘verb alternation’ sentences, I showed how these examples can be analyzed as instantiating the same verb construction but different A-S constructions. Composition of this verb construction with these different A-S constructions and the other constructions instantiated in a given example produces SemSpecs which capture both the similarities and differences as to the types of events these different examples describe, and as to the way in which the verb designated process is conceptualized in each case. In addition, these SemSpecs indicate that for each example the expressed participant roles are semantically complex, consisting of bindings between several different more ‘primitive’ roles. By analyzing and representing these roles in this manner, it is possible to recognize commonalities and differences in the roles associated with different examples.

To understand why these verbs can be used in these different types of event descriptions, and to understand why and how the semantic roles associated with the verb are integrated with those of the A-S constructions instantiated in these different examples, it is crucial to look beyond the constructions themselves, and to more deeply consider the nature of the actions and events these constructions are used to describe. Particularly important, we need to consider the nature of the actions described by *slap* (and other similar verbs, such as *tap*, *kick*, *hit*, *rap*, etc.). As I discussed in Chapter 7, these are internally complex actions, involving motor-control, the translational motion of an effector (body part or other instrument), and the transfer of force to another entity. Significantly, these actions can potentially be part of many different kinds of experiences. Thus, independent of language, the processes described by these verbs can potentially be parts of different event conceptualizations. Each A-S construction represents a pairing between a particular kind of basic event conceptualization and an argument realization pattern by which this conceptualization is expressed. In addition, A-S constructions in the current grammar each indicate how a particular type of verb-designated process is related to the event as a whole. In each case, this relation is based on commonality of the schematic semantic structures associated with these constructions. But, the particular relations, and the specific type of schematic structure the constructions have in common differ.

Reflecting the fact that the three types of examples discussed in this chapter describe different kinds of events, each of the A-S constructions instantiated in these examples identify their meaning with a different schema. Specifically:

- *She slapped his hand off her leg* instantiates CauseMotion4, which identifies its meaning with CauseMotionAction.
- *She slapped her hand on his leg* instantiates TransitiveEMAAP2, which identifies its meaning with EffectorMotionAlongAPath.
- *She slapped him on the leg* instantiates PartPossessor1, which identifies its meaning with CauseEffectToPossessor.

The verb construction instantiated in all three of these examples identifies its meaning with a ForcefulMotionAction schema. Because of the way each of these schemas is defined, it is possible in each case to recognize and represent schematic structure that the verb and A-S construction meanings have in common, though the commonalities differ. For example, for cause motion examples such as (22), there is a commonality of ForceApplication structure, whereas for effector motion examples (23), the commonality is one of EffectorMotionAlongAPath structure. These examples consequently differ as to which facet of verb meaning they foreground.

Each of these schemas include various semantically complex roles. For each type of example, the SemSpec produced by unification of the instantiated constructions indicates that some of these roles are bound together, producing even more complex roles. In addition, these SemSpecs show that in each case the verb-designated process is part of a different type of event.

These schemas and constructions thus support analyses of these different types of slap examples that capture important similarities and differences in meaning. In addition, the constituents of these A-S constructions are defined generally enough that they support the analysis of a wide range of sentences that contain 'forceful motion action' verbs (i.e. verb constructions that identify their meaning with ForcefulMotionAction). Moreover, the A-S constructions are defined such that they will unify with a variety of different clause constructions including, but not limited to, the Declarative construction instantiated in the examples examined in this and other chapters. Thus, the relatively small number of schemas and constructions in the current grammar support the compositional constructional analysis of a very large number of different sentences. Importantly, these analyses capture sentence meaning at a deep, embodied level. In this way, these analyses explicitly indicate the sometimes subtle similarities and differences in the meaning of various verb 'alternations'.

Chapter 9

Conclusion

9.1 General Summary

At the beginning of this dissertation I raised what at first glance appears to be a fairly simple question: How is it that the same words be used in different combinations to convey so many different meanings? In order to address this general question, I have focused, for the most part, on a more specific question: How can the same verbs (e.g. *slide, slap*) be used in different argument realization patterns to describe several different kinds of situations?

The compositional constructional account of sentence meaning that I have presented in this dissertation shows that ultimately, the key to answering these questions lies in recognizing the multi-faceted, interconnected nature of the meanings conveyed by various constructions. Given this, we can analyze how different patterns of constructional composition can be used to convey different patterns of conceptual composition.

The account presented here incorporates and builds upon insightful work performed by many different people working in various disciplines, including linguistics, computer science, psychology, cognitive science and neuroscience. A large part of my own contribution is to demonstrate how many of insights can be formalized and integrated into a larger story about constructional and conceptual composition.

Although the grammar discussed in this dissertation is relatively small, the schemas, constructions, and inter-relations between them are rather detailed and complex in many ways. This level of detail and complexity is an essential component of the compositional account of meaning that I have presented. Furthermore, it is important to keep in mind that this complexity has not simply been created for analytical purposes. Rather, I have endeavored to identify and represent the structured complexity that is inherent in language and thought, given the nature of its neural substrate, and to determine how this structure is utilized by language.

As with other complex systems in other domains, computational implementations to deal with such complexity are an invaluable tool. As mentioned previously, one benefit of using the ECG formalism is that it serves as a computer specification for several implemented computational applications. Especially relevant for the current work, this includes the ECG workbench (Bryant and Gilardi, to appear), a tool that enables us to interactively create and view these grammars, as well as providing access to the

Constructional Analyzer (Bryant 2008), a construction-based system of language interpretation. Using these applications, it is possible to define internally consistent grammars and use them to determine a 'best-fit' interpretation of a given sentence which takes into account semantic, syntactic, and contextually supplied information.

Other unification and constraint based grammars, such as HPSG (Pollard and Sag 1994) and LFG (Dalrymple 2001) have also been used to develop computational implementations of wide-coverage grammars. However, ECG differs in several crucial respects from these other grammars, most notably in its commitment to a deep level of embodied semantics. As I have shown, the grammar described in this dissertation integrates and expresses several different cognitive linguistic and NTL insights. This includes: (1) the recognition of recurrent schematic conceptual structures (schemas, including those that capture motion-related and causal event structure); (2) different combinations of primitive conceptual elements that form more complex composite conceptual gestalts; (3) basic types of cognitive organization (e.g. prototypes radial categories of A-S constructions); and; (4) different attention-related conceptualization patterns (e.g. different simulation perspectives and foregrounding of certain facets of meaning). Crucially, the compositional account of sentence meaning that I have presented here relies on both of these elements, requiring both an internally consistent wide-coverage grammar, and a grammar that enables us to capture the different event conceptualizations described by the sentences examined here.

A compositional account of sentence meaning is possible in large part due to the recognition that in addition to lexical constructions, sentences also instantiate various non-lexical constructions. Goldberg's (1995) groundbreaking work on A-S constructions is particularly relevant, showing that the various argument realization patterns present in examples such as those studied in this dissertation can be analyzed as meaningful constructions.

As described in Chapter 4, an important step taken in the current account has been the recognition that many sentence patterns can be analyzed as an interaction of these argument realization patterns with separate clause-level patterns. Accordingly, A-S constructions in the current grammar are defined as phrasal constructions that will potentially compose with different clause-level constructions. By analyzing examples as instantiating lexical, A-S and other phrasal constructions, as well as clause-level constructions, it is possible to use a relatively small set of constructions to compositionally analyze a broad range of examples.

Ultimately, the main function of constructional composition is one of conceptual composition. That is, we use different constructions in different combinations in order to convey different coherent meanings. Consequently, in addition to determining which types of constructions different sentence examples instantiate, it is also necessary to identify and represent the meanings of these constructions. Moreover, it is crucial to do so in such a way that when these instantiated constructions unify with one another, their composed meanings accurately indicate the meaning of the sentence as a whole.

Part of the reason a limited number of words (and other constructions), in different combinations, can be used to describe a wide range of situations has to do with the fact that language-specified meaning is relatively sparse and schematic. As Slobin (2003) nicely puts it:

> "Utterances are not verbal filmclips of events. An event cannot be fully represented in language: linguistic expression requires schematization of some sort. Every utterance represents a selection of characteristics, leaving it to the receiver to fill in details on the basis of ongoing context and background knowledge." (p. 159).

Given the schematicity of utterances, it is apparent that the meanings of the individual constructions instantiated in these utterances will also be schematic.

The NTL framework and, more specifically, the simulation-based model of language understanding, provide a principled account of how relatively schematic specifications of constructional meaning can produce much fuller, richer understandings of the sentences in which these constructions are instantiated. As outlined in Chapter 2, the general idea is that we understand language by (subconsciously) imagining or simulating the situations that language describes. This simulation process involves activation of some of the same or closely similar structures as are active for other (non-linguistic) experiences of such situations.

Utilizing this model, a given utterance is analyzed as instantiating several different constructions, whose unification produces a SemSpec (semantic specification) that supplies relatively schematic parameters for the simulation of the described event. The context in which the utterance occurs supplies supplementary information, and enactment of the event specified by the SemSpec further fleshes out the details of this event, utilizing additional conceptual structure related to the understander's general world knowledge, specific experiences, state of mind, relation to speaker, etc.. In this way, relatively schematic constructionally-specified meanings give rise to a much richer, fuller understanding of the utterances in which these constructions are instantiated.

But what sorts of sparse schematic meanings do these constructions specify? And how can these constructions and their meanings be defined such that they support a compositional analysis of a range of different utterances? As I have shown, these questions can be addressed by employing a methodology that includes the following elements. (1) Look beyond individual words and other constructions to the underlying processes and relations that various form patterns are being used to describe. (2) Identify recurrent schematic structures associated with these processes and relations. (3) Define schemas that capture the internal complexity and oftentimes composite nature of these processes, and which identify relevant schema roles and relations. (4) Use these schemas in the representation of constructional meaning (i.e. define constructions that link constructional 'forms' to these schemas). (5) Define constructions instantiated in examples being examined such that they unify with one another to produce SemSpecs that provide appropriate parameters for simulation of a given utterance. And (6) define these constructions such that they can combine in different ways, supporting a compositional analysis of a range of different sentence examples. Because these different elements are crucial to the analysis I have presented, I briefly expand upon them below.

Meaning and Schemas

As I have demonstrated, one crucial step in the development of a compositional constructional account of sentence meaning is to look more deeply at the rich conceptual structure used in the simulation and understanding of these sentences (i.e. the actions and experiences described by these sentences), and, more specifically, to determine the grammatically relevant elements of these structures that are directly specified by language. My specific focus has been on the schematic elements of this conceptual structure that are relevant to the composition of constructional meanings, in particular, the schematic commonalities that verb-designated processes have to the types of basic experiences described by A-S constructions. Accordingly, I examined multiple forms of evidence which provide insight into the conceptual structures (and, ultimately, neural circuitry) associated with various basic types of experiences, such as moving our body parts and bodies in relation to the surrounding environment, physically interacting with other entities in this environment, and causing various effects to other entities.

Following the methodology outlined above, I defined a lattice of interconnected primitive and composite schemas to represent the schematic grammatically-relevant elements of these experiences. The schemas in this lattice have several important properties:

- Each schema is a 'gestalt' structure which includes various roles. Thus, roles are defined as parts of larger structures, rather than as isolated, 'stand-alone' conceptual elements.
- Some schemas are gestalt 'primitives', while others are composite gestalts (gestalts which integrate the structure of other gestalts). 'Primitives' in this lattice include Motion, MotorControl, ForceTransfer, and some basic image schemas. More complex, composite schemas include Locomotion (animate translational motion), EffectorMotionAlongAPath (actor's control of the translational motion of an effector in relation to a spatial target), ForceApplication (actor's application of force to another entity), and CauseEffectAction (actor's force application brings about some effect to another entity).
- Many schemas are part of more than one other schema. That is, the same schema structure may be integrated into more than one other schema. For instance, Motion is part of both Locomotion and EffectorMotionAlongAPath, and MotorControl is part of all of the composite schemas named above.
- The roles within the composite schemas commonly have bindings to the roles of other schemas, and can therefore be characterized as complex composite roles. For

instance, Locomotion's mover role is bound to a motor-control actor role. And ForceApplication's actor role is bound to the supplier role of a ForceTransfer schema.

Thus, rather than being defined as isolated, stand-alone conceptual elements, both the schemas and their roles are defined as parts of a larger conceptual system, with various connections to other schemas and roles. In this way, this lattice of schemas indicates the complex compositional nature of some basic parts of our conceptual system, reflecting the structured interconnectivitiy of its neural substrate.

Constructional meaning

The schemas from this lattice are used to represent the meanings of various constructions in the current grammar. In essence, each construction links a specified form pattern with some substructure portion of this schema lattice. As a result:

- Constructional meanings are related to one another via relations between the schemas used to represent their meanings.
- Many constructional meanings have composite internal structure (indicated by the use of composite schemas to represent their meanings).
- Constructional meanings include various semantic roles associated with the schema(s) used to represent their meaning. Many of these construction-related roles are actually role 'bundles': roles from different schemas that are bound together, forming a more complex composite role. For instance, constructions that identify their meaning with Locomotion have a semantic role that is both a motor-control actor and a translational motion mover.

For verbs, I defined constructions in which a verb's core meaning is identified with a 'process' schema within this lattice. Commonly, more than one verb construction identifies it meaning with the same schema; this is one means of indicating schematic commonalities of verb meaning that can be used to define various semantic 'classes' of verbs. Individual constructions typically have further meaning specifications, which can include evocation of additional schemas, and binding and/or value constraints on schema roles. These additional specifications indicate differences in the meanings of verbs from within the same class. Moreover, comparisons of verb-specified meaning, along different dimensions and at different granularities of comparison, are supported by relations in the schemas and roles used to represent their meanings. Together, these different aspects of constructional meaning representation capture both similarities and differences in the meanings of different verbs.

Consistent with Goldberg's (1995) analysis of A-S construction meaning, each of the A-S constructions in the current grammar describes some type of basic human scene or event (Slobin 1985). This event type structure is also represented using 'process' schemas. Consistent with a simulation-based, embodied view of language meaning, rather than just being objective descriptions of events, A-S constructions in the current grammar describe particular kinds of experiences of events. Accordingly, in addition to indicating the type of event, these A-S constructions also specify the perspective taken on this event (specified by a binding between the profiledParticipant role and an event participant role), and indicate which elements of the process designated by its verb constituent are attentionally foregrounded. In this way, these A-S constructions specify different event conceptualizations that are associated with various argument realization patterns.

<u>Putting the parts together</u>

Each of the sentences examined in this dissertation instantiate several different constructions. In addition to identifying their individual meanings, we also need an account of how these constructions combine with one another to produce the meaning of the sentence as a whole.

One fundamental assumption that has guided the definitions of the constructions presented here is that constructional composition of meaning is typically motivated by some degree of shared schematic meaning of the composing constructions.[1] Defining verb and A-S constructions that identify their meanings with schemas from the same 'process' schema lattice enables us to recognize and specify the relevant commonalities that motivate the composition of these two types of constructions. In the prototypical case, the composing constructions share much of the same schematic structure. But, as has been shown in this and other analyses of argument structure constructions (e.g. Goldberg 1995, Michaelis 2003, Goldberg & Jackendoff 2004), other semantic relations are also possible. One important strength of the meaning representations in the current grammar is that they enable us to recognize and precisely represent semantic relations between constructions based on relations between the schemas with which these constructions identify their meanings. In this way, we are able to tap into the semantic relations inherent in the underlying conceptual structure.

A-S constructions play a central part in the account of constructional and conceptual composition presented in this dissertation. Each A-S construction is a phrasal pattern associated with the description of (a conceptualization of) some kind of event. These phrasal patterns have one or more identifiable constructional 'parts'. The general ArgStructure construction captures some broad generalization about A-S constructions, including the fact that they all include a verb constituent part. Specific A-S constructions differ as to the number and type of additional constituents they have: many of the ones discussed in this dissertation include NP and/or prepositional phrase constructional constituents.

Each A-S construction specifies how the meanings of its constructional constituents are integrated into the meaning of the larger whole. As noted above, the composition of verb and A-S constructions is assumed to be motivated by commonality of schematic meaning. The prepositional phrases in the examples examined here serve to elaborate a

[1] This assumption is consistent with Lakoff's 'cog' theory, described in Gallese and Lakoff (2005).

path of motion that is part of the described event. Thus, in these uses, these phrases provide what can be characterized as SPG (Source-Path-Goal) meaning. The semantic relation between the A-S constructions instantiated in these examples and their prepositional phrase constituent is specified by binding the meaning of this constituent to the SPG structure within the A-S construction's event type schema. Additional meaning constraints indicate role-filler relations by binding the A-S construction's event participant roles to the meanings of its NP constituents which express these roles. Via these bindings, semantic specifications associated with these roles provide semantic constraints on the fillers of these roles (e.g. animacy constraints).

Significant for the compositional story told here, the constraints on roles and constructional types within these A-S constructions are general enough to support unification with a range of more specific constructions that meet these constraints. Moreover, A-S constructions are defined such that they will also unify with various clause-level constructions, including but not limited to the Declarative construction.
As described elsewhere (Bryant 2008; Feldman, Dodge and Bryant 2001) this includes constructions for control and questions. Thus, the constructions in the current grammar are designed to support a compositional constructional analysis of a wide range of examples which differ as to which specific lexical, phrasal, and clause-level constructions they instantiate.

Different compositional possibilities

Having established the essential groundwork in earlier chapters, I turned in Chapters 7 and 8 to an examination of some of the *slap* examples that originally piqued my interest in compositionality. These include examples such as *She slapped at his hand*, *She slapped her hand on his leg*, and *She slapped his hand off her leg*. Two key questions raised by such examples are: Why does *slap* occur with these different patterns of argument realization? And what meanings are these different patterns used to express?

To answer these questions, one important step involves taking a close look at the actions described by *slap* and other similar verbs (such as *kick, tap, rap, hit*, etc.). Doing so, it is apparent that these are complex motor-control actions which involve both a motion-related spatial component and a force transfer component. As I showed, the composite nature of these actions can be represented using a ForcefulMotionAction schema that integrates the structure of other schemas from the process schema lattice. These actions can potentially be used to accomplish various different kinds of objectives. Moreover, the relevance of these components differs depending on what kind of objective these actions are used to accomplish. Consequently, the nature of these actions is such that they have the potential to be part of various different event conceptualizations.

Another important step is to consider the different A-S constructions instantiated in these different types of *slap* examples, focusing in particular on the different types of events they are used to describe. The aim here is to define each A-S construction meaning such that it indicates the schematic conceptual structure it has in common with *slap* (and other semantically similar verbs). In this way, we can identify the semantic motivation for the composition of *slap* (and other 'forceful motion action' verbs) with each of these different A-S constructions, and can explicitly specify how the meanings of the verb and A-S constructions are integrated with one another in each case.

Crucially, by representing the meaning of these verbs using 'composite' schemas that include force and motion-related structure, it is possible to identify various different points of commonality with different types of events. For instance, because these verb meanings include 'force application' structure, it is possible to identify their commonality with various causal event structures (as in *She slapped the cup off the table*). And because they include 'effector motion' structure, it is possible to identify commonalities with various event structures that involve motion and/or change in location (as in *She slapped her hand on the table*).

The specified semantic relation between the A-S construction and its verb constituent serves another purpose as well: it indicates that the schematic structure the verb shares with the A-S construction is foregrounded in the particular event conceptualization described by that A-S construction. For example, in A-S constructions that describe causal events, the 'forceful motion action' verb constituent shares force-application structure, indicating that the force transfer elements of the verb-designated action are foregrounded. Thus, these specifications indicate the elements of a verb-designated action which are most relevant for a particular type of event conceptualization.

Many of the verbs examined in this dissertation describe processes and actions which can be conceptualized in more than one way. The particularly intriguing thing about *slap* (and other 'forceful motion action' verbs) is that the multi-faceted nature of the actions they describe is such that several different types of conceptualizations are possible.

The analysis of these *slap* examples serves to further illustrate the larger, more general story told throughout this dissertation. As I have shown, rather than positing separate verb constructions for different verb senses, verb 'alternation' examples for a number of different types of verbs can be analyzed compositionally, as the same verb construction in composition with different A-S constructions. In each case, composition of verb and A-S construction meaning is motivated by commonality of (schematic) meanings. Additionally, each A-S construction serves to focus attention on whatever portion of schematic structure that the verb has in common with the A-S construction. Thus, when a given verb construction composes with different A-S constructions, we get different construals of the verb-designated process.

Complex semantic roles

As we have seen, the meanings of many constructions are often compositions of more conceptual primitive elements. Thus, even absent any composition with other constructions, constructionally-specified meanings often reflect some amount of conceptual composition. When the meanings of the constructions instantiated in a given utterance are composed, further conceptual composition occurs. The end result is a complex, interconnected network of meaning, represented in the SemSpecs produced by different sentence analyses as a set of schemas, roles, bindings and value constraints.

As indicated in these SemSpecs, each of the referents described by the NPs in these examples is bound to at least one, and commonly more, schema roles. As a result, rather than being associated with a unitary atomic semantic role, each NP referent is typically associated with what can be described as a semantic role 'bundle'. Thus, this compositional account of sentence meaning also provides a compositional account of semantic roles.

This method of analyzing and representing these semantic roles has some significant advantages over other linguistic analyses of semantic roles. Thematic-type roles such as Agent, Patient and Theme are commonly based on generalizations about recurring semantic elements. The semantic role bundles associated with the different examples examined here capture the elements on which such generalizations are based. For instance, we can recognize that many different role bundles include an actor role: we could therefore characterize all of these bundles as representing an 'actor' thematic role (essentially ignoring other roles in the bundle). But thematic-type roles run into problems when their definition is based on classical category assumptions, e.g. that each thematic-type role has a set of properties that are common to all instances of the role, and which also serve to distinguish this role from other roles. For example, if we define an Agent role as an actor who causes some effect, how do we handle actors who don't cause effects, and effects that are not brought about by actors? Due to difficulties such as these, there is no consensus on what thematic roles should be posited, nor on how such roles should be defined. In large part this problem arises because, as the semantic role bundles associated with different sentence examples show, it is actually possible to make several different, cross-cutting generalizations about these semantic roles.

Rather than attempting to define classic categories of semantic roles, the method used here reflects a more-cognitively plausible, natural and pervasive form of cognitive organization, with rich central prototypes, and various extensions which share some, but not all of the structure of the central case (Rosch 1975, 1978; Lakoff 1987). Significantly, many of the semantic role bundles capture sets of 'properties' associated with various semantic role archetypes. For example, in prototypical transitive examples, the role bundle that includes the causer role of the CauseEffectAction schema captures many of the properties Langacker ascribes to archetypical agents, which he describe as "a person who volitionally carries out physical activity which results in contact with some external object and the transmission of energy to that object" (Langacker 1991: 210). One contribution of the current approach is that SemSpecs for such examples formally and explicitly represent these different properties using schemas and role bindings. Another valuable contribution is that this method also enables us to recognize extensions to these central case prototypes, in which a given role bundle includes some, but not all of the roles included in the archetypical role bundle.

Perhaps best of all, while these role bundles enable us to recognize similarities and relations to other semantic roles, none of these roles are solely defined by their membership in any one specific category. While we can recognize resemblances to various other ‘family members’, near and distant, each role bundling is unique to some extent, a product of the composition of many different interacting variables.

9.2 Future Work

As mentioned in Chapter 2, there are clearly many other important linguistic phenomena that are not covered by the grammar presented in this dissertation. To the extent that such phenomena are orthogonal to those examined here, it should be possible to integrate the current grammar with other schemas and constructions to form wider-coverage grammars. But, while the current grammar was designed with this larger scale compositionality in mind, these extensions will inevitably require some degree of change to the schemas and constructions described here. For instance, we are likely to discover additional semantic elements that are relevant to some of the current constructions' interaction with other constructions in the grammar, and/or which are relevant to best-fit analysis. Some of the additions and modifications that might be needed for extending the current grammar are included in the discussion which follows.

Below, I discuss some additional types of sentence examples that suggest areas for future investigation. In addition, I explore some ways that we might analyze these examples by building upon the constructions and schemas presented in this dissertation. I focus here on sentences that exhibit some additional, different uses of *slap*, but the issues these examples raise, and the possible ways they may be handled have more general implications as well.

Tense and Aspect

As noted in Chapter 2, the current grammar employs a simplified approach to handling tense and aspect. This approach is based on the idea that the process-related meaning of the verbs examined here is to a significant extent orthogonal to the particular time that this process occurs and/or to a particular conceptualization of the aspectual structure of this process. Consistent with this idea, the full meaning of a given verb form is analyzed as a composition of verb-specific ‘process’ meaning and non-verb-specific tense and aspect meaning. Because the focus of this work has been on the process-related facet of these verbs, I have only examined sentences that contain past tense verb forms, and which therefore do not differ as to tense and aspect-related meaning. The verb constructions instantiated in these examples are defined as subcases of a general PastTense construction that specifies facts about the tense and aspect of past tense verbs. In addition, each of these constructions identifies its meaning with a specific Process schema. While this simple method suffices for the analysis of this particular set of examples, clearly the grammar needs to be extended in order to analyze sentences containing verbs with other types of tense and aspect marking, such as *She has slapped the table*, *She is slapping the table*, and *She will slap the table*. This might be accomplished by defining a set of verb 'root' lexemes, each of which would specify the process-related meaning of the verb, along with a separate set of general tense/aspect constructions. Then, specific verb constructions could be defined as subcases of both a root verb construction and a tense/aspect construction, with the 'child' construction also specifying form and meaning constraints that are relevant for that individual construction. Some work has been done on how the meanings of these general constructions can be analyzed within an NTL framework (e.g. see Chang et al. 1998). Much further work needs to be done, however, to determine the feasibility of the compositional approach sketched here.

<u>Non-actor subjects</u>

In this dissertation I have largely focused on sentences which describe events involving various kinds of motor-control actions, with a prime motivation for this focus being that such motor-control actions are an important, conceptually rich part of many of our most basic types of experiences. Typically, such actions are conceptualized and described from the perspective of the actor, but other perspectives are also possible. For instance, in Chapter 6, I discussed how a passive example such as *He was slapped by her* is analyzed as describing a 'cause-effect action' event from the perspective of the affected entity (the person or thing that the actor acts upon). Thus, this example contrasts with the active sentence *She slapped him*, which describes the same type of 'cause-effect action' event, but from the perspective of the causer (the person who is performing the causal action). As I showed, in the current grammar these different perspectives are specified by binding different event participant roles to the profiledParticipant role of the linguistic EventDescriptor schema.[2]

One further benefit of this approach is that it can be extended to handle an 'instrument subject' interpretation of examples such as *Her hand slapped him*. In this interpretation, this sentence describes the same type of agentive event as *She slapped him*, but does so from the perspective of the instrument (effector) rather than the causer (actor). DeLancey (1991) argues that in examples such as these, we only consider such entities to be filling an 'instrument' role because of our knowledge about that action. For instance, for this particular example, one of the main reasons we are likely to view 'a hand' as an instrument is because we know that actors typically perform slapping actions using their hands. In my analysis, though, I consider this grammatically-relevant information, and

[2] Recall from Chapter 4 that Declarative binds the profiledParticipant role to the meaning of its subject NP. Therefore, unification of a given A-S construction with the Declarative construction will indicate that the 'subject' NP is bound to whatever event participant role that the A-S constructions specifies is bound to profiledParticipant.

include it in the specification of the meaning of the construction for *slap*. Furthermore, given the design of the current grammar, it is a fairly straightforward matter to define A-S constructions that will support an 'instrument subject' interpretation of examples such as these. These A-S constructions can be defined as extensions of 'actor subject' constructions, with the same form and constituent specifications, and most of the same meaning specifications. The key difference is that the profiledParticipant role is bound to the effector role rather than the actor role (see Feldman, Dodge and Bryant 2010 for further description).

As discussed in Chapter 6, some *slap* examples with 'non-actor' subjects can be analyzed as descriptions of non-agentive cause-effect events (e.g. *A branch slapped him*). Thus, examples of very similar form (*She / Her hand / A branch slapped him*) can be analyzed as describing different kinds of events, from different perspectives. Determination of the best-fitting interpretation in a given context relies heavily on semantic constraints associated with the different roles. In the current grammar, the construction for *slap* specifies that the motor-control actor role is constrained to be an animate entity of some kind, and that the default effector is an open hand. This grammar could be enhanced by adding further semantic constraints, such as specifically indicating that this hand is part of the actor's body, and that the effector can also be an object that shares the basic image schematic properties of the default effector (i.e. an object that is a flat thing, like an open hand). These additional specifications are relevant for the determination of an 'effector motion' interpretation of examples such as *She slapped her hand / the newspaper on the table*. Undoubtedly it would be beneficial to make similar enhancements for other kinds of actions. In addition, a means for indicating which image schematic properties a given referent has (or can be readily construed as having) is also needed.

Nominal uses of slap and other verbs

Another topic that warrants further investigation involves the nominalized uses of *slap* and other verbs, as evidenced in examples such as *She gave him a slap / whack / push*. Goldberg (2005) analyzes examples such as these as descriptions of a metaphorical understanding of these actions, in which the directional nature of the action is metaphorically conceptualized in terms of object transfer. Additionally, we can recognize that in this metaphorical use, the action designated by the verb is conceptualized as a bounded entity (a bounded instance of an action), and is expressed using a nominal construction that is a constituent in a ditransitive A-S construction. Given the analysis of these actions presented in this dissertation, we can make the further observation that it is the force transfer component of these actions that is being metaphorically conceptualized in terms of object transfer, and that in the events described by these examples, the force supplier is the giver, and the force recipient is a recipient of this object. Moreover, we can observe similarities in verbal and nominal uses with respect to event perspective. As discussed above, in verbal uses of *slap*, active and passive argument realization patterns signal differences in event perspectives. In nominalized uses, these perspective differences are instead signaled by the use of verbs which indicate different perspectives on ‘transfer’ events. For instance, an actor/supplier perspective is indicated by the use of verbs such as *give* and *deal* (e.g. *She gave him a slap*, *She dealt him a rap over the head*). And an affected/recipient perspective is indicated by the use of verbs such as *get* and *receive* (e.g. *He got a slap from her*; *He received a tap on the shoulder*). Thus, recognition of force transfer and event perspective are both relevant for a deepened analysis of such examples.

The current grammar could readily be extended to support analyses of examples such as these. To capture similarities of both form and meaning in the verbal and nominal uses of words such as *slap*, we might define a ‘root’ lexeme that links the bare stem form (*slap*) with the core verb meaning (a particular kind of forceful motion action).[3] To handle nominal uses, we could define a ‘nominalizing construction’ with two constituents: a determiner, and a ‘root’ (verb lexeme) constituent. The meaning of this construction would be a bounded instance of the action described by the root constituent. In addition, the grammar would need to include additional A-S constructions. Examples such as *She gave him a slap* can be analyzed as instantiating a variant of a basic ditransitive A-S construction.[4] The grammar would also need to include a schema for object transfer (used for the representation of the meanings of verbs such as *give* and *get*, and also for the ditransitive A-S construction). Intriguingly, examples such as *She dealt him a rap over the head* suggest that in some cases the basic ditransitive pattern may interact with the argument realization patterns associated with the verbal uses of these words (as in *She rapped him over the head*). Thus, examination of these nominal uses may also provide further insights into the nature and relations of various A-S constructions.

<u>The relevance of sound</u>

Slap is also sometimes used as a noun to describe a particular sound of impact, as in *His feet hit the ground with a slap*. There are several other ‘noisy impact’ words that are also used in these two different ways, as nouns which describe the sound made on impact (e.g. *The car hit the post with a thunk / crash / bang / thud*) and as verbs which are used to describe the process of impact (e.g. *The car thunked / crashed / banged /thudded into the post*). As with the nominal uses above, these uses indicate that the grammar needs to include some kind of ‘nominalizing construction’. In addition, these uses indicate that the meaning representations of these words should include a sound component.

Sound is an integral part of our experiences of many motor-control actions: significantly, neuroscientific research indicates that motor-control regions include auditory neurons that fire when an animal performs an action and also when it hears a sound related to that action (Kohler 2002). Furthermore, it is likely that the phonetics of some of these word forms may be related to their meaning, either through an iconic relation to the sound of

[3] As mentioned above, this construction could also be used in the analysis and representation of tense and aspect.
[4] See Bergen & Chang (2005) and Bryant (2008) for possible ways to represent this construction in ECG.

the impact itself, and/or through the formation of a sound-meaning pairing for some phonetic segment of these forms (e.g. an "-ap" phonaestheme in *slap*, *rap*, *tap*) (Bergen 2004).

Sound is also a salient cue in our perception of motion and changes in location. Given the embodied basis of verb meaning, it is not surprising that many verbs which describe motion events indicate some sort of sound that accompanies this motion. In some cases, these verbs specifically describe motion-related sounds (e.g. *whiz*, *zoom*). But in many cases, while the verb itself describes a sound, it is only within certain contexts that this sound is associated with a mover's motion. In many cases this sound is directly caused by the motion (e.g. *The arrows hissed past his ear*). But there are also other types of relations, including indirect causation (*He crunched across the gravel driveway*) and sound that is associated with the energy source for the motion (*The car roared / purred down the road; The fly buzzed around the room*). By adding a sound component to motion schemas, it would then be possible to define A-S constructions to handle these different uses of 'sound' verbs to describe motion events, without having to define additional 'noisy motion' senses of these verbs. In sum, the analysis and representation of the sound-related elements of various processes is clearly another valuable conceptual component that can further investigated and integrated into the current work.

Metaphor

The current grammar will also needed to be extended in order analyze metaphorical verb uses such as *The judge slapped a fine on him* and *The judge slapped him with a fine*. Interestingly, as with other meaning extensions, these metaphorical uses retain some of the properties of the core agentive meaning of *slap*. For instance, in these particular examples, the relevant properties include the rapidity of the action and its relatively moderate effects (which, in the physical case, is due to the moderate amount of force involved). In addition, the argument realization patterns in the metaphorical uses are also similar to the non-metaphorical uses (e.g. compare the metaphorical sentences above to *The judge slapped the newspaper on the table* and *The judge slapped him with a newspaper*). Therefore, metaphorical uses such as these can likely be analyzed using constructions and schemas that are similar in many respects to those used to analyze non-metaphorical examples. This suggests that the current work will provide a valuable base for analyzing metaphorical uses of many of the verbs examined here.

Note, though, that not all of the verbs within this same semantic class exhibit similar metaphorical uses. For instance, while we may say *The judge hit /smacked him with a fine* we are not likely to hear *The judge tapped / patted / kicked him with a fine*. As with other usage variations within sets of semantically similar verbs, these different usage patterns are a topic which merits further investigation.

Cross linguistic work

One of my central objectives has been to develop schemas that represent the schematic conceptual structure associated with a variety of very basic, presumably universal experiences. These schemas are therefore likely to be universally available for language use. At the same time, as indicated by the work of Talmy (1972, 1983, 2000b) and others, it is clear that languages differ as to which conceptual elements they consistently specify, and as to how they 'package' (compose) the elements they do make use of. Therefore, another area of future work is to look at how actions like slapping and hitting are described in other languages. To what extent can these descriptions be analyzed using various compositions of the schemas in the current lattice? What modifications and additions do they suggest? This work will help us better determine which elements of conceptual structure may be universally available, as well as helping us identify specific similarities and differences in how actions and events are conceptualized and described in different languages.

9.3 Concluding remarks

In this dissertation, I have presented a compositional construction-based analysis of a set of different verb 'alternation' sentences that captures the sometimes subtle similarities and differences in the meanings these sentences are used to convey.

The success of this endeavor depends on several different factors. For one thing, it is necessary to identify the different constructional form patterns at work, as well as recognizing various relations between the different types of constructions in the grammar as a whole. In addition, to get a compositional account of sentence meaning, we need to determine the meaning associated with the constructions instantiated in a given sentence, as well as determining how the meanings of these constructions fit together into a coherent whole. But above all, a compositional account of sentence meaning depends on getting the meaning right, delving deeply not only into the meanings of the individual constructions, but also into the nature of language meaning itself.

Details matter. If we want to capture subtle similarities and differences in sentence meaning, it is essential that we recognize subtle similarities and differences in the meanings of different constructions. At the same time, compositionality is possible in large part due to our ability to make various kinds of generalizations. Therefore, it is also essential to recognize relations between constructional meanings and generalizations we can make with respect to these meanings, and also to do the same thing with respect to the constructions themselves.

As I have shown, by choosing the appropriate theoretical framework, utilizing a suitable formalism, and by making a serious commitment to examining and representing the schematic structure and interconnectivity of the conceptual systems utilized by constructions, it is possible to formally represent constructional meanings such that both the motivation for and results of the conceptual composition that accompanies constructional composition are clear.

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