Aspectual Morphology of Russian Verbs in Fluid Construction Grammar

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Abstract

Aspect is undoubtedly the most capricious grammatical category of the Russian language. It has often been asserted as a mystery accessible only to native speakers, leaving all the others lost in its apparently infinite clutter. Recent work in cognitive linguistics has tried to bring order to the seeming chaos of the Russian aspectual system. But these approaches have not been operationalized so far. This paper demonstrates how the aspectual derivation of Russian verbs can be handled successfully with Fluid Constructional Grammar, a computational formalism recently developed for the representation and processing of constructions. **Keywords:** Fluid Construction Grammar; Russian aspect.

Introduction

Russian aspect is notorious for its complexity. Traditional analysis organizes Russian verbs according to a paired imperfective vs. perfective distinction, but this only offers partial explanations and requires a large list of "exceptions" to account for the characteristics of the verb system. These problems have cast doubt on whether there is a system underlying the conceptualization of Russian aspect. And consequently, Russian and other Slavic languages are typologically often classified as an idiosyncratic group in terms of their aspectual behavior.

However, a promising approach to this issue has emerged within cognitive linguistics, particularly in the work of Laura Janda (2004). She motivates Russian aspect with metaphors grounded in embodied experience and has argued that Russian has in fact a "highly constrained and well-motivated" structure of aspectual verb clusters that goes well beyond the distinction between perfective and imperfective (Janda, 2007, p. 608). She therefore proposes a novel way of classifying Russian verbs using a more intricate interaction between semantic distinctions than assumed so far.

However, no operationalization exists yet of this hypothesis, indeed most proposals from cognitive linguistics remain stuck in verbal description without formalisation. Nevertheless, we believe that operationalization is a crucial step in the empirical research process because it is the only way to demonstrate the validity, completeness, and coherence of a proposed linguistic system. The main contribution of this paper is to offer an operationalization of Russian aspect based on the analysis developed by Janda (2004, 2008) and to show that Fluid Construction Grammar (FCG), a computational grammar formalism recently developed to allow the bidirectional processing of grammatical constructions (Steels, 2004; Steels and De Beule, 2006), is adequate to capture this analysis. As part of this effort, we found that an additional dimension had to be added to Janda's analysis based on the well known notion of Aktionsart.

The next section briefly describes the proposal of Janda and the extension with Aktionsart. Then we briefly report on the formalisation and implementation effort. Since the linguistic structures of the provided examples are quite elaborate, we can only sketch here the outline of the solution and give some examples. The interested reader is invited to look at the complete demonstration of the examples at `www.fcg-net.org/aspect/`. In the conclusion, we discuss the next steps to be undertaken.

Linguistic Background

Russian verbs can be roughly divided into 'simple' verbs, consisting of a stem, suffix and ending, e.g. чит-а-ть^i ('read'), щип-а-ть^i ('pinch'), and 'complex' verbs, which are derived from the latter by the addition of aspectual markers, e.g. by prefixation пере-читать^p ('re-read'), вы-щипать^p ('pinch out'). Simple verbs typically describe activities and are imperfective (indicated by an index ^{i}), e.g. резать^i ('cut'). In this paper, we focus on how the addition of a prefix changes the aspect of simple verbs into Perfective (indicated by an index ^{p}), e.g. на-резать^p ('cut'), пере-резать^p ('cut off'), по-резать^p ('cut for a while') etc. Russian has nineteen verbal prefixes that productively form Perfective (Krongauz, 1998). There is also a perfectivising suffix -ну- leading to such forms as реза-ну-ть^p ('cut once').

This study draws upon a theory developed by Janda (2004, 2008), postulating that the lexical meaning of verbs dictates their aspectual behaviors because different types of events and their relationship to time are conceptualized in different ways. This necessitates a distinction among (at least) four different types of Perfective: Natural, Specialized, Complex and Single Act Perfectives (Figure 1) – each with different semantic and morphological behavior. For instance, the verb щипать^i ('pinch') describes an activity that can be completed, which is why it can derive a Natural Perfective об-щипать^p ('pinch') (upper right corner in Figure 1). Other verbs lacking this component in their meaning cannot form Natural Perfective, e.g. пахнуть^i ('smell').

If after a modification by a prefix the verb describes an activity with a potential completion, Specialized Perfectives can be formed, e.g. вы-щипать^p ('pinch out'), от-щипать^p

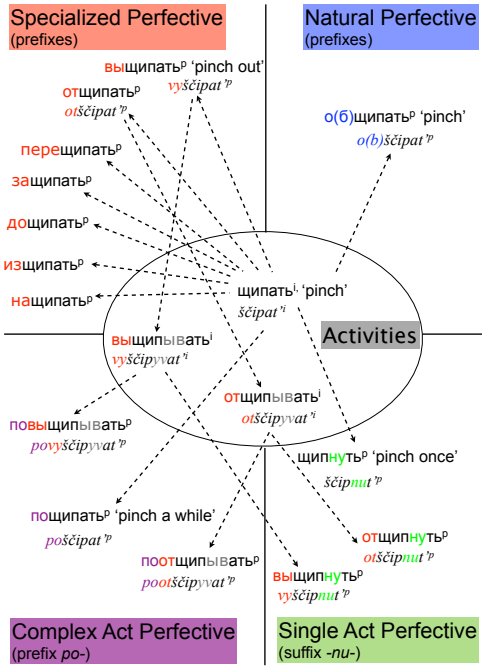

Figure 1: Diagram of aspectual derivation of the verb щипать^{i} ('pinch'), which can form all four Perfective types: Natural, Specialized, Complex and Single Act Perfectives. Adapted from Janda (2007).

('separate pinching'), пере-щипать^{p} ('pinch to exhaustion') etc. Next, if the verb describes an activity that one can engage in without making progress toward a goal, it is possible to get Complex Act Perfective, e.g by setting a temporal limit to the corresponding activity - по-щипать^{p} ('pinch a while'). The last Perfective type - Single Act Perfective - can be formed if it is possible to extract a single cycle from a repeated activity, e.g. щип-ну-ть^{p} ('pinch once').

Our efforts to operationalize these aspectual behaviors showed that Janda's analysis needs to be expanded with an explicit implementation of Aktionsart (Forsyth, 1970) in order to separate between the different temporal semantics within a single Perfective type. For instance, the Complex Act Perfective combines an activity with temporal limits, so it can highlight either the beginning of an activity leading to an ingressive Aktionsart, e.g. за-работать^{p} ('start working'), its ending phase – terminative Aktionsart, e.g. от-работать^{p} ('stop working'), or just a notion of a limited time span – delimitative Aktionsart, e.g. по-работать^{p} ('work for a while'). Aktionsarten bridge the gap with prefixes, which encode exactly what feature of an activity is emphasized. It is, however, not always the case that there is one single prefix for each Aktionsart.

Operationalizing Aspect in FCG

We operationalized Russian aspect in Fluid Construction Grammar (FCG) (Steels, 2004; Steels and De Beule, 2006). FCG is currently the only computational implementation of construction grammar which can handle both production and parsing. FCG is a unification-based grammar formalism that uses feature structures for representing linguistic knowledge. A feature structure contains a set of units, a set of features or slots for each unit, and values for these features. The units might correspond to lexical items, morphemes, words, or phrases. Features are both related to syntactic aspects, for example the form constraints associated with a unit or its syntactic categories, and to semantic aspects, for example, the associated meaning, the referent identified by the unit, the semantic categories, etc.

General Architecture

In line with cognitive linguistics, FCG represents all linguistic knowledge in a uniform way, namely as constructions that map some aspects of meaning into some aspects of form and back (Goldberg, 1995; Croft, 2005). The proposed constructions can nevertheless be organized into four sets according to their functionality: There are *lexical constructions* which map lexical stems to their meanings, *semantic constructions* which recategorise meaning in terms of semantic categories (within certain syntactic contexts), *mapping constructions* which map abstract semantic structures to abstract syntactic structures, and *syntactic constructions* which work out and refine syntactic categories (within certain semantic contexts). The latter include morphological constructions. The following subsections provide examples of these various constructions using the verb щипать^{i} ('pinch') as example (see Figure 1). It falls out of the scope of the present paper to explain all technical details of FCG and the reader is therefore not expected to understand the FCG examples given here in full detail. Nevertheless these examples are useful as illustrations and as proof that the whole system has successfully been implemented.

Lexical Constructions Lexical constructions couple for a particular word its meaning with a string acting as the lexical stem. In production, the construction triggers when a particular meaning is detected as target meaning and then creates a new unit (using the J-operator; De Beule and Steels, 2005), which has particular semantic categories, for example a base-type and a potential for perfectivisation, a particular string as lexical stem, and additional syntactic categories like the part of speech. In parsing, the same rule triggers when a certain lexical stem is detected in the utterance and then creates a new unit for this word with the same syntactic and semantic information and the relevant meaning.

The lexical entry for щипать ('*ščipat'*', 'pinch') (technically for its stem щип- because the rest depends on conjugation) is as follows:

```
(define-lex-entry pinch
   ((?top-unit
     (tag ?meaning
      (meaning (== (pinch ?event)))))
    ((J ?new-unit ?top-unit)
     ?meaning
     (referent ?event)
     (sem-cat
       (==1 (base-type ?event event)
            (potential ?event
             (completable-culminating
              completable-specializing
              non-completable
              singularizable))))))
   <-->
   ((?top-unit
     (tag ?form
      (form (== (string ?new-unit "scip")))))
    ((J ?new-unit ?top-unit)
     ?form
     (syn-cat (==1 (pos verb))))))
```

The semantic pole of this rule contains features for *meaning*, *referent* and *sem-cat* (stands for semantic category), and the syntactic pole has *form* and *syn-cat* (syntactic category) features. The lexical entry states that the *meaning* of щипать is 'pinch', the *referent* is the event itself, *sem-cat* declares it as an event with a certain potential. The potential plays an important role because it implements the constraints encoded in the lexical semantics of the verb, i.e., which aspectual forms it can derive. We saw in the derivational diagram (Figure 1) that щипать can form all four Perfective types. So, it includes the potential to become completable-culminating by forming Natural Perfective, completable-specializing for Specialized Perfective, non-completable for Complex Act Perfective and singularizable for Single Act Perfective. The syntactic side defines a string "scip" as a *form* of the stem and its *syn-cat* states that it is a verb as a part of speech (pos).

Semantic Constructions Semantic constructions translate parts of the meaning which are not directly expressed by lexical items into semantic categories that then will be mapped onto syntactic features of the utterance, such as morphological markers and word order. We argue that Russian aspect involves two semantic categories. The first one, according to Janda (2004), is based on the metaphor that "Perfective is a discrete solid object" and "Imperfective is a fluid substance." Without this opposition it is not possible to distinguish between, e.g., the two forms щипать^i ('pinch') and общипать^p ('pinch') or between перещипать^p ('pinch to exhaustion') and перещипывать^i ('pinch to exhaustion'), which differ only in how the event is "viewed" as a fluid substance or a solid object. The second shade of meaning encodes the semantic category of Aktionsart, which, simply stated, refers to the phase in which the action finds itself. For instance, the perfective derivatives of жить^i ('live'), such as зажить^p ('begin to live'), пожить^p ('live some time'), отжить^p ('stop living'), прожить^p ('live for a certain amount of time'), all belong to the Complex Act Perfective type, but differ in Aktionsart, which is ingressive, delimitative, terminative, and totalizing, respectively.

Here is an example of a semantic rule that maps an event viewed as solid-object into a perfective semantic aspect. The Aktionsart remains undetermined so far because the solid-object-view is compatible with many event-types, and is therefore filled in with a logic variable (`?event-type`).

```
(define-sem-rule solid-object-sem
  ((?top-unit
    (tag-only ?meaning
     (meaning
      (== (event-view ?event solid-object)
          (event-type ?event ?event-type))))
    (sem-subunits (== ?event-unit)))
   (?event-unit
    (referent ?event)
    (sem-cat (==1 (base-type ?event event))))
   ((J ?event-unit ?top-unit)
    ?meaning
    (sem-cat
     (==1
      (sem-aspect ?event perfective)
      (sem-actionsart ?event ?event-type)))))
  <-->
  ((?top-unit
    (syn-subunits (== ?event-unit)))
   (?event-unit
    (syn-cat (==1 (pos verb))))))
```

An analogous semantic construction has to be created associating a "fluid substance" view with the semantic category of imperfective.

Mapping Constructions The mapping constructions map abstract semantic categories onto abstract syntactic categories. Roughly speaking, semantic aspect (Perfective/Imperfective) and semantic Aktionsart are translated into their corresponding syntactic counterparts depending on the semantic and syntactic context, particularly the potential of the verb. For instance, the delimitative Aktionsart can be expressed only within the Complex Act Perfective, so that the relevant mapping construction has to verify that the corresponding semantic aspect is Perfective, the syntactic aspect is Complex Act Perfective, and the verb is actually able to derive this form, meaning that its potential includes non-completable. Here is an example of a mapping rule that implements this constraint:

```
(define-con-rule delimitative-con
 ((?event-unit
  (referent ?event)
  (sem-cat
   (==1 (potential ?event (== non-completable))
        (sem-actionsart ?event delimitative)
        (sem-aspect ?event perfective)))))
 <-->
 ((?event-unit
  (syn-cat (==1 (pos verb))))
 ((J ?event-unit nil)
  (syn-cat
   (==1
    (syn-aspect complex-act-perfective)
    (syn-actionsart delimitative))))))
```

Analogous rules for other Aktionsarten are needed, e.g. ingressive Aktionsart requires a Complex Act Perfective, semelfactive Aktionsart requires the Single Act Perfective, and includes both non-completable and singularizable potentials because only non-completable events are singularisable, etc. for the other Aktionsarten.

Syntactic Constructions Syntactic constructions complete the meaning/form relation by specifying the surface forms (here in particular morphological markers) of abstract syntactic categories (like Perfective or delimitative Aktionsart). Here is an example of the rule for the prefix по- ('po-'):

```
(define-morph-rule po-prefix-morph
 ((?verb-unit
   (syn-cat
    (==1 (syn-aspect complex-act-perfective)
         (syn-actionsart delimitative)))))
 <-->
 ((?top-unit
   (syn-subunits (== ?verb-unit))
   (tag-parts
    ?prefix-form
    (form (== (string ?prefix-unit "po-")
              (meets ?prefix-unit ?verb-unit)))
    ?suffix-form
    (form (== (string ?suffix-unit  "-a-")
              (meets ?verb-unit ?suffix-unit)))
    ?ending-form
    (form (== (string ?ending-unit "t'")
              (meets ?suffix-unit ?ending-unit)))))
  (?verb-unit
   (syn-cat (==1 (pos verb))))
  ((J ?prefix-unit ?verb-unit)
   ?prefix-form)
  ((J ?suffix-unit ?verb-unit)
   ?suffix-form)
  ((J ?ending-unit ?verb-unit)
   ?ending-form)))
```

The rule states that the prefix 'po-' can be used by the delimitative Aktionsart within the Complex Act Perfective type, such as in попрыгать^p ('jump for a while'), погулять^p ('walk for a while'), подержать^p ('hold for a while') etc. Other prefixes and a perfectivizing suffix -ну- have similar morphological rules, bringing together syntactic aspect, Aktionsart, and the form of the marker. Additionally, the morph rule attaches other infixes such as suffix -а- and infinitive ending ть (we are neglecting conjugation) and establishes the ordering prefix-stem-suffix-ending of the verb pattern.

Producing

Let us go through an application of these rules to see how everything works. We will focus on the utterance пощипать^p ('pinch a while') whose meaning is 'pinch-event viewed as a solid object and having a limited time span'. Figure 2 presents the initial feature structure in production: on the semantic side the top unit consists of the meaning, the syntactic pole is empty so far.

The first phase in production is the unification of the semantic pole of the construction with that of the linguistic structure that the speaker has to build. Lexical constructions are applied first, so we are searching whether parts of the meaning to be expressed can be captured by lexical items. This is the case for the verb 'pinch', which has as *meaning*: (pinch ?event). Because in production the unification operates on the semantic side, the top unit of the lexical rule for 'pinch' unifies with the top unit of the initial feature structure and subsequent application of the J-operator creates the new unit for the found word, moves a tagged *meaning* to it and makes it a child unit of the top unit declaring some of its

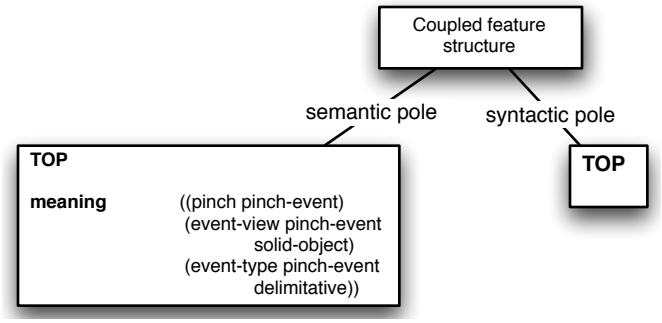

Figure 2: The initial linguistic structure for production.

semantic features such as *referent* and *sem-cat*. In the merging phase, everything in the syntactic pole of the rule new to the current coupled feature structure is added to its syntactic pole. The resulting linguistic structure is shown in Figure 3.

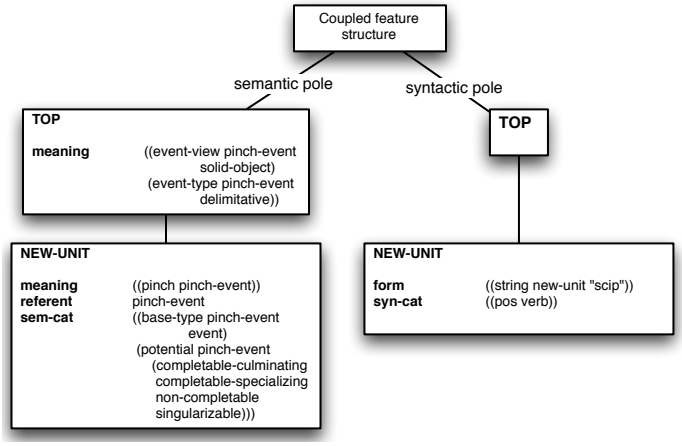

Figure 3: The lexical entry of the verb 'pinch' has created a new unit in the semantic and syntactic poles of the linguistic structure, which encapsulates all the relevant features of the verb.

The next step in production is the application of the semantic constructions. Here, the "solid-object-sem-rule" incorporates the notion that the event of a kind of event-type is (metaphorically) viewed as a solid object. Exactly those meanings were still left in the top unit of the linguistic structure, so the unification of the semantic poles can occur by binding `?event-type` to delimitative and given the coherence of other semantic features (i.e. there is a subunit of the top describing an event, its *sem-cat* includes an event as base-type and the particular event as a *referent*). After the unification, the J-operator removes the tagged meaning from the top unit, inserts it to the *meaning* of the event unit and adds the corresponding *sem-cat* of semantic aspect and Aktionsart. The

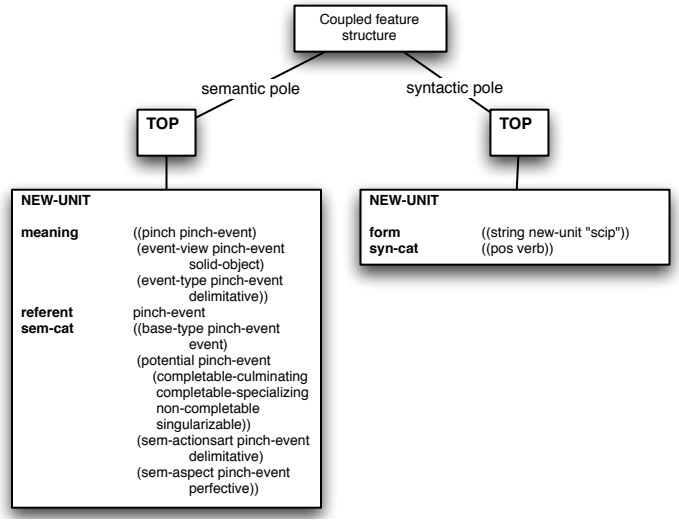

Figure 4: The semantic construction has removed the grammatically relevant meanings that were left in the top-unit and added them to the meaning-feature of the new-unit, and added more information in the sem-cat feature.

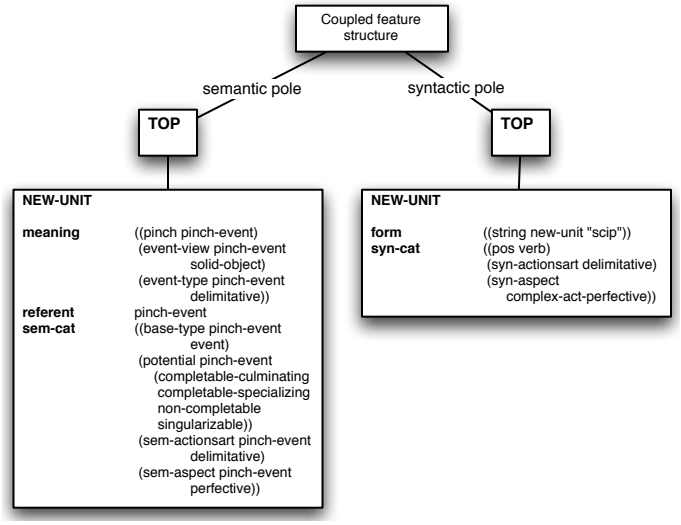

Figure 5: The mapping construction was triggered on the semantic categories added by the semantic constructions, and subsequently added grammatical aspectual features to the syn-cat of the new-unit.

merging process does not add any information to the syntactic pole because it was already integrated there by the lexical construction. In the resulting linguistic structure, the semantic side of the top is empty, so all the meaning was absorbed either by the lexicon or by the semantic categorization (see Figure 4).

Now it is the turn of the mapping constructions to take action and enhance the syntactic pole of the feature structure with syntactic categories of the language, which later become visible though morphology. The aim of the construction "delimitative-con" is to translate the semantic Perfective aspect and delimitative Aktionsart into the syntactic categories of Complex Act Perfective and delimitative Aktionsart given the proper potential of the verb, in this case to be non-completable. This rule successfully unifies with our current feature structure, which has the corresponding *sem-cat* and *referent* in its event unit. Again the J-unit inserts the needed syntactic categories to the syntactic pole of the current feature structure in the merging phase (see Figure 5).

The last rule type applied in production is the morphological rules, which express syntactic categories as morphological markers attached to the word. The rule for the prefix "po-" requires the presence of the *syn-cat* Complex Act Perfective and delimitative Aktionsart to unify. The current feature structure has those, so the rule can apply and create three additional units for the prefix, suffix and ending through the J-operator, each with strings and meets-constraints. Figure 6 shows the resulting feature structure.

The final step in production is to gather all the strings from the *form* of all units taking care of the meets-constrains. The resulting utterance is "po-scip-a-t'" - пощипать^{p}.

Parsing

One major advantage of using FCG is that it can apply the same constructions and processing mechanisms for parsing the utterance "po-scip-a-t'" - пощипать^{p} - into the meaning 'pinch-event within the limited time span viewed as a solid object' (as opposed to declarative formalisms that need to compile their constructions into separate generation and parsing procedures). Parsing is achieved in FCG by simply reversing the order of construction application: this time, unification will take place in the syntactic pole followed by the merging of the semantic pole.

The only major difference is that the various types of constructions are applied in a different order: lexical constructions still come first, but are immediately followed by the morphological rules. This is necessary because these two rule types provide the syntactic information that is required to map constructions for determining a verb's semantic Aktionsart and aspect. Finally, after the mapping construction has been applied, the semantic constructions can integrate the grammatical aspect with the inherent Aktionsart of the verb.

Discussion

This paper focused on the notoriously difficult domain of Russian aspect, examining how the necessary lexical and grammatical rules could be operationalized using a construction grammar approach. The analysis was primarily based on

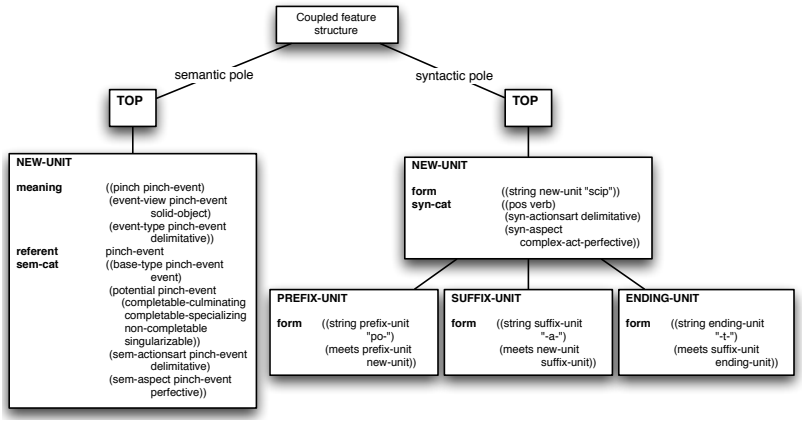

Figure 6: In the final resulting linguistic structure, the morphological rules have added a prefix and two suffixes based on the specific syntactic context of this example. These morphemes are represented as subunits of the new-unit.

the work of Janda (2004, 2007, 2008), who has argued that the potential for participating in aspect is part of the lexical definition of the verb. Experiments in operationalizing this analysis showed however that the notion of Aktionsart had to be incorporated as well in order to properly handle prefixes. In this paper, only a small example was shown due to space limitations, but the whole system has been operationalized and `www.fcg-net.org/aspect/` shows more examples for: щипать^{i} - выщипать^{p} - выщипывать^{i} - повыщипывать^{p} (diagram in Figure 1).

From the viewpoint of construction grammar, one of the most important points of the present paper is that the set of constructions needs to be subdivided into different subsets (lexical, semantic, mapping, and syntactic constructions) and the example of Russian aspect has shown how it is to be done and that it effectively works in a bi-directional system (parsing and production) without changing the definition of the constructions themselves. The division into different types of rules is also helpful to organise the learning process that is the target of our current research. Lexical constructions can be learned independently of the complex aspect system, aspect markers can be learned first in an ad hoc way, and then the more abstract and more difficult to learn categories can be acquired.

Acknowledgments

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