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Judging a *book* by its cover and its contents: The representation of polysemous and homophonous meanings in four-year-old children

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ABSTRACT

Unlike *homophonous* meanings, which are semantically unrelated (e.g., the use of *bat* to refer to a baseball bat and a flying rodent), *polysemous* meanings are systematically related to one another (e.g., the use of *book*, *CD*, and *video* to refer to physical objects, as in 'the leather book', or to the intellectual content they contain, as in 'the profound book'). But do perceived relations among polysemous meanings reflect the presence of generative lexical or conceptual structures that permit the meanings of these words to shift? If so, these structures may also support children's early representations of polysemous meanings. In four studies, we demonstrate (1) that four-year-old children can understand both the concrete and abstract meanings of words like *book*, (2) that when taught a novel label for one of these meanings, children can readily understand an extension of that label to the other meaning, and (3) that extension does not occur between two homophonous meanings, which share a common phonological form but are otherwise unrelated. We conclude that the polysemous meanings of words like *book* rely on a common representational base early in development, and suggest that this may be the result of foundational, generative properties of the lexicon or conceptual system.

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1. Introduction

A quintessential feature of the use of words is that a single phonological form can be associated with multiple meanings. This aspect of word use is the basis for many jokes. Consider the following example: "There was once a cross-eyed teacher who couldn't control his *pupils*." Or another: "The Alpine Skiing competition started poorly and went *downhill* from there." The interpretation of each of these sentences depends greatly on which of the different possible meanings of *pupils* (students in a class; parts of the eye) and *downhill* (physically sloping downward; an abstract worsening of condition) are selected, and the sentences are humorous because they make these different interpretations simultaneously available to the reader or listener.

Although both *pupils* and *downhill* can be exploited to humorous effect, these two cases of ambiguity appear different from one another upon further reflection. In particular, while there is no discernible semantic relationship between the two meanings of *pupils*, the metaphorical relationship between the concrete and abstract meanings of *downhill* is intuitive, and similar relationships can be identified between the concrete and abstract meanings of many other words such as *collapse* (The building *collapsed*/The economy *collapsed*), *rise* (The bird is *rising* above the clouds/Our spirits are *rising*), and so on (Lakoff & Johnson, 1980). Such intuitions regarding the relatedness of a word's meanings have motivated a distinction between words like *pupil* and *downhill*. While words like *pupil* are categorized as *homophones*—words that have multiple meanings that are semantically unrelated—words like *downhill* are categorized as *polysemous*—words with multiple meanings that are semantically related. This distinction is implicit in the organization of dictionaries: while the different meanings of a homophonous word such as *pupil* are typically listed as separate lexical entries, the different meanings of a polysemous word such as *downhill* are typically grouped together within a single lexical entry. But is a distinction between homophones and polysemous words also expressed psychologically, in how the meanings of these words are represented within the mental lexicon?

Research within psycholinguistics has converged in suggesting that pairs of homophonous meanings are represented as separate words, sharing a common phonological word form but otherwise diverging from one another both lexically and semantically (see e.g., Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982). However, the representation of polysemous words has remained the subject of debate (see, e.g., Beretta, Fiorentino, & Poeppel, 2005; Frazier & Rayner, 1990; Klein & Murphy, 2001, 2002; Rodd, Gaskell, & Marslen-Wilson, 2002; Williams, 1992; Pylkkanen, Llinas, & Murphy, 2006; Klepousniotou & Baum, 2007; Klepousniotou, Titone, & Romero, 2008). A first possibility is that the presence of systematic relations among polysemous meanings (see Table 1, for a list of some of these relations) reflects that these meanings share not only a common phonological word form, but also a common lexical or conceptual representational base. This is a view held by what we refer to as Generative Models of the lexicon, which claim that polysemy reflects the presence of *generative* structures: lexical or conceptual structures that permit the meanings of known words to shift along polysemous relations and that further allow these relations to generalize to novel words (e.g., Caramazza & Grober, 1976; Copestake & Briscoe, 1995; Lakoff, 1987; Langacker, 1987; Pustejovsky, 1995; Rice, 1992; Tyler & Evans, 2001). However, a second possibility is that the relations we perceive

Table 1
A list of some of the relations among polysemous meanings in English.

Relation and participating words	Examples
Animal/Meat (*chicken*, *fish*, *lamb*, etc.)	The *chicken* drank some water/The *chicken* was well-salted
Material/Product (*glass*, *tin*, *linen*, etc.)	The windows are made with strong *glass*/He poured water into a *glass*
Object/Content (*book*, *video*, *DVD*, etc.)	The *book* would not fit in her backpack/It is a very persuasive *book*
Container/Contents (*pot*, *bottle*, *glass*, etc.)	The *pot* is chipped around the edges/Make sure to stir the *pot*.
Space/Time (*long*, *on*, *around*, etc.)	They sat around the *long* table/The film is about three hours *long*
Body Part/Object Part (*leg*, *arm*, *back*, *head*, etc.)	Her *leg* is feeling weak /The chair has a broken *leg*!
Person/Product (*Dickens*, *Picasso*, *Mozart*, etc.)	*Dickens* grew up in London/He put *Dickens* on the shelf
Place/Institution (*White House*, *Wall Street*, etc.)	The *White House* is being restored/The *White House* made a decicion
Place/Event (*Vietnam*, *Woodstock*, etc.)	*Vietnam* is next to Laos/He protested during *Vietnam*

between polysemous meanings only attest to our ability for meta-linguistic reflection, and do not also describe the mental representation of polysemous words. On this view, which we refer to as the List Model of the lexicon, the different meanings of polysemous words are actually listed independently and separately, just like the homophonous meanings of *pupils* (see, e.g., Murphy, 2007).

As can be observed from the discussion above, the representation of polysemy bears directly on the notion of what a word is and on the locus of productivity in language. On traditional views of the mental lexicon, words are static, bound units of linguistic information (i.e., containing morphological, syntactic, and semantic information), and all productivity associated with language arises from other parts of language, such as syntax (e.g., Fodor & Lepore, 1998). On the other hand, generative models of the lexicon embrace polysemy and consider its representation to be central to the more general question of how a word's meaning can be continually modulated within different contexts (see, e.g., Pustejovsky, 1998). On these models, the mental lexicon—like other components of language—contains productive structures that give rise to and help constrain the flexibility of word meaning.

The present studies begin to characterize the representations that underlie the use of polysemous words by examining whether perceived relations between polysemous meanings reflect something beyond meta-linguistic assessments. They do this by testing whether even four-year-old children—who have limited meta-linguistic abilities (see, e.g., Gombert, 1992)—distinguish between homophones and polysemous words in their representation of a word's meanings. If polysemous relations reflect the presence of generative structures, as the Generative Models of the adult lexicon suggest, a distinction between homophones and polysemous words may not await the development of meta-linguistic processes, but may instead follow from the structure of the mental lexicon or conceptual system. In particular, generative lexical or conceptual structures could support young children's acquisition and representation of polysemous meanings, ensuring that polysemous meanings, but not homophonous meanings, have a common representational base. On the other hand, if a distinction between homophones and polysemous words is purely meta-linguistic, as the List Model of the adult lexicon suggests, young children should treat polysemous meanings like homophonous meanings, and store them independently without regard to their relation. And finally, if generative structures do underlie the use of polysemous words in adults, but are only constructed with meta-linguistic reflection upon these words, young children should also fail to distinguish between polysemous and homophonous meanings, due to their limited meta-linguistic ability.

In the present studies, we focus on a specific case of polysemy—that of words for representational objects, such as *book*, *CD*, or *video*. When we describe something as a 'leather book', we are describing the physical properties of a book, but when we describe it as a 'profound book', we are describing the abstract content that the book contains. While these meanings are clearly related to one another, they are also distinct—it's not the physical object that is profound, and it's not the intellectual content that is made of leather. Our studies investigate whether the polysemous meanings of words like *book* rely on a common representational base early in development, or whether they are stored as separate words. Before presenting our studies, we first consider the theoretical merits and drawbacks of the List Model and Generative Models, and then present empirical evidence that could bear upon them.

1.1. Models of polysemy and their merits and drawbacks

Before describing the List Model and Generative Models in greater detail, we must briefly consider a third proposal regarding the representation of polysemous words. This proposal denies that polysemous words have multiple meanings that are distinct from one another, suggesting instead that they have single core meanings that are vague with respect to more specific construals (see Ruhl, 1989). For instance, the uses of *tin* to refer to a material and to a product made of that material (i.e., a box made of tin), could correspond to a single core meaning that encodes only those features that are common across the word's uses (e.g., 'containing tin'). This core meaning could then be augmented by information from the surrounding context and our more general world knowledge (e.g., what products we use that are made of tin) to circumscribe the way the word is used. While intuitively plausible, this approach proves inadequate when confronted with the distinct ways in which many polysemous words are used. In particular, because polysemous meanings are often drawn from distinct ontological categories (e.g., the meanings of *book*, which cut across an abstract/concrete distinction), they often

have very few properties in common. Thus, core definitions that collapse across polysemous meanings are often too vague to constrain how polysemous words are actually used (e.g., a core definition of *book* would be likely to incorrectly apply to things that are not books, such as brochures or newspapers; see Murphy, 2007; Taylor, 2003).

For this reason, most work on polysemy has focused on contrasting the List Model with the Generative Models, both of which grant that polysemous meanings are distinct from one another, but which represent these meanings in different ways. On the List Model, the different meanings of words like *book* are learned and stored independently of one another, just as homophones such as *pupil* are represented (see, e.g., Klein & Murphy, 2001). However, on Generative Models, the relations between the meanings of polysemous words like *book* are encoded in generative structures that permit words to shift along these relations (see Fig. 1). One class of generative models claims that different meanings are derived on-line, from structured, underspecified representations (e.g., Pustejovsky, 1995), while another class claims that the primary meaning of a polysemous word is explicitly represented, with the other meanings generated by rules (see Fig. 1; Copestake & Briscoe, 1995; Lakoff, 1987; Langacker, 1987; Nunberg, 1979; Rice, 1992; Tyler & Evans, 2001). Generative models differ in many important ways—whether they postulate rules, whether meanings are generated on-line or stored and linked to one another, and so on. What these models have in common is that the different meanings of a polysemous word are given a common representational base either at the lexical or conceptual level. The studies reported here will search for evidence of this common representational base, but will not address the differences between generative models. Instead, we will be collapsing these models together, and focusing only on how they differ from the List Model.

A first drawback of the List Model is that it does not reflect our intuitions of relatedness. Homophonous meanings, which are perceived as unrelated, are thought to be represented in the same way as polysemous meanings, which are perceived as related. Obviously, it is not logically necessary that meta-linguistic intuitions be directly rooted in the lexicon. But if they were, they would make sense of the creative processes that have allowed sets of related meanings to share the same labels, instead

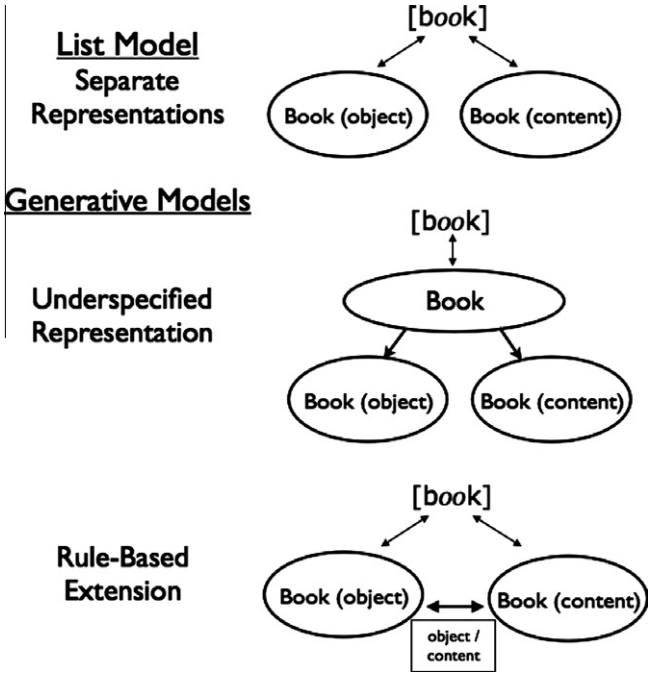

Fig. 1. A graphical depiction of the List Model and of two classes of Generative Models, as they might represent the meanings of *book*.

of treating these processes as accidental. Such creative processes would help explain how it is that new words are able to alternate along existing polysemous relations—such that, for example, we are able to use a novel word for a representational object (e.g., *blicket*) as we would use the word *book*: to refer to a physical object itself (*The shiny blicket*), as well as to the content it contains (*The interesting blicket*).

A second drawback of the List model is that it requires separate representations for each of the different meanings of polysemous words, resulting in a potentially intractable number of meanings to represent. Consider the uses of *fast* in a *fast road*, a *fast movie*, and a *fast eater*. Because *fast* modifies the noun in a different way in each expression, the List Model would have to posit separate meanings for each case. Generative Models offer a more parsimonious solution, suggesting, for example, that the nouns in these expressions have internal structure (e.g., that specifies the function of their referents) that *fast* can interpret and modify (see, e.g., Pustejovsky, 1995).

The systematic nature of many classes of polysemy provides further support for Generative Models (see Table 1, for a list of some of these classes). On the List Model, both meanings of each word that participates in a polysemous alternation must be listed in memory. In contrast, Generative Models suggest that all members of a given class of polysemy arise from a common mechanism. On the class of generative models that posits underspecified representations, the alternate meanings result from the internal structure of this underspecified representation—for instance, Pustejovsky (1995) argues that the abstract and concrete meanings of words like *book* result from the foregrounding of different aspects of its internal structure. Other Generative Models posit productive rules that extend the meanings of words from their basic to derived meanings—for example, a rule that extends words referring to physical media to refer also to the intellectual content they contain (which would apply not only to *book*, but also to words like *CD* and *video*) (Fig. 1; see Copestake & Briscoe, 1995).

However, even if some of the meanings of polysemous words could in principle be generated, these meanings could still be explicitly represented as entirely separate lexical items. Storing meanings might be more efficient for semantic processing than generating them, because their generation could require costly chains of inference (Murphy, 2007). Consider the use of words like *glass* to refer to a material (*The sheet of glass is smooth*) as well as to a product derived from that material (*The glass is full of lemonade*). While the material-to-product relation is somewhat productive (it also applies to *iron*, *tin*, *linen*, etc.) this general relation cannot explain why certain products have the same name as their material (e.g., *glasses* to refer to cups and spectacles) and not others (e.g., windows). Generative models also have trouble explaining why some words, such as *high*, are used very flexibly, while other closely related words such as *tall* have far fewer uses (Lehrer, 1990). Because such facts about how these words are used are not predicted on the basis of general conceptual or pragmatic relations, the meanings of these words might need to be learned and stored separately like those of homophones (Lehrer, 1990; Murphy, 2007).

Thus, both the List Model and the Generative Models face theoretical challenges. The following section reviews empirical evidence bearing on the psychological plausibility of the two classes of models.

1.2. Empirical evidence regarding the psychological plausibility of the models

Because Generative Models claim that the systematic relations among polysemous meanings reflect generative structures, they predict that these relations should generalize to novel cases. Some evidence for this prediction was provided by Murphy (1997), who taught adult participants novel words referring to novel meanings, and showed that participants more often accepted extensions of the novel meanings that followed existing patterns (e.g., from a plant to a product derived from that plant, as observed in the uses of words like *corn* and *tea*), compared to extensions that were equally semantically related but did not follow existing patterns (e.g., from a plant to a property of that plant). One explanation of these results is that, during the task, adult participants were able to consciously reflect upon the different ways in which polysemous words are used, and apply this knowledge toward predicting the flexibility of novel words. However, meta-linguistic reasoning is unlikely to account for the results of similar studies of on-line processing, which showed that extensions of novel

words that followed polysemous relations were also better processed on-line (Murphy, 2006; see also Frisson & Pickering, 2007).

In further support of Generative Models, a number of studies have provided evidence that adults process homophones differently than polysemous words (Azuma & Van Orden, 1997; Beretta et al., 2005; Frazier & Rayner, 1990; Klepousniotou & Baum, 2007; Klepousniotou et al., 2008; Rodd et al., 2002; Williams, 1992; Pylkkanen et al., 2006). For example, Frazier and Rayner (1990) had subjects read sentences with ambiguous words that had either homophonous meanings (e.g., *pupil*) or polysemous meanings (e.g., the concrete and abstract meanings of *book*) and varied whether disambiguating information in the sentence came before or after the critical ambiguous word. Delaying the disambiguating information until after the ambiguous word lengthened fixations on the homophonous words but not on the polysemous words, suggesting that the linguistic processor must choose between homophonous meanings, but can leave unfolding interpretations of polysemous meanings underspecified (see also Duffy, Morris, & Rayner, 1988; Frisson & Pickering, 1999).

Nevertheless, the List Model has also received empirical support. Klein and Murphy (2001) presented phrases to adult participants that picked out either one meaning of a polysemous word (e.g., 'liberal paper') or one meaning of a homophonous word (e.g., 'savings bank'). The participants then made a sensicality judgment on target phrases, some of which picked out the other meaning of the polysemous word ('wrapping paper') or homophone ('river bank'). The logic was that if polysemous meanings rely on a common representational base, they should prime one another more than do homophonous meanings. However, the results showed that primes inhibited judgments of the target phrases for both kinds of words. In another set of studies, participants were also unlikely to categorize together phrases that used the polysemous words in their different meanings (Klein & Murphy, 2002). These results suggest that despite their etymological relatedness, some polysemous meanings may be represented as separate words like homophones.

1.3. The present studies

If polysemous words do rely on generative structures, how might these structures arise over development? On one hand, these structures could follow from foundational properties of the mental lexicon or conceptual system. On this view, these structures could support even young children's representations of polysemous meanings, ensuring that polysemous meanings, but not homophonous meanings, have a common representational base. However, another possibility is that generative structures are themselves constructed over development with active reflection on words and their meanings. On this view, the different meanings of different polysemous words that participate in a given relation (e.g., *book*[object] and *book*[content]; *CD*[object] and *CD*[content]; *video*[object] and *video*[content]) may be stored separately of one another until it is recognized that they are related to one another in the same way (e.g., that each word can refer to an object or to the content it contains).

If generative structures are indeed abstracted through a conscious, reflective process, polysemous meanings should be represented as separate words prior to the development of meta-linguistic ability. A significant body of work suggests that, before the age of seven, children lack the ability to reflect upon words and the different meanings they can have (Gombert, 1992). First, the ability to recognize words as linguistic units is very poor in children under the age of five, and improves only gradually over middle childhood. For instance, a number of studies have found that prior to age seven, children are unable to enumerate the number of words in a sentence: children instead tend to report the number of actors, objects, or actions in the sentence (Hall, 1976; Bialystok, 1986). Second, in their explicit reasoning, young children often fail to distinguish between word forms and their meanings—a distinction that is critical to an explicit understanding of ambiguity (i.e., to recognize that different meanings have the 'same label'), as well as to an understanding of a difference between homophonous and polysemous meanings (i.e., to recognize that one pair of meanings is more related than another pair of meanings). Children's difficulties have been documented in the "Sun/Moon" task (dating back to Piaget, 1929), in which children fail to understand that object names can in principle be interchanged (e.g., that 'moon' could refer to the sun, and that 'sun' could refer to the moon). Young children also appear to conflate word form and meaning in judging a word like *train* to be longer than a word like

caterpillar (Bialystok (1986)). Improvement in these abilities appears to begin around the age of seven when children are starting school, and thus may be linked to literacy (Bialystok, 1986; Gombert, 1992).

In the present studies, we reasoned that if generative structures are constructed with meta-linguistic reflection, four-year-old children should represent polysemous meanings as separate words, like homophones. However, if generative structures follow from foundational properties of the mental lexicon or conceptual system, polysemous meanings may be differentiated from homophones before this age. To our knowledge, these competing predictions have not been tested. Some prior studies have focused on individual polysemous words and the order in which their meanings are acquired (e.g., *get*, Nerlich, Todd, & Clarke, 2003; *from*, Clark & Carpenter, 1989; Johnson, 1997; *with*, McKercher, 2001). However, merely demonstrating that a child has access to the different meanings of a polysemous word does not show that these meanings are derived from a common representational base—the child could instead represent these meanings separately and select among them according to context.

Some studies of children's lexical innovations have suggested that children are capable of abstracting the relations among polysemous meanings. For example, Clark (1982) has argued that children creatively analyze the uses of words like *bicycle*, which can be used either as nouns (*I bought a red bicycle*) or verbs (*She bicycled to work*), and in doing so extract rules they can use to create innovative verbs or nouns (e.g., the novel use of *shirt* as a verb in *Mommy, will you shirt me*?) (see also, Bowerman, 1983). However, children's innovations in these cases may not reflect the use of generative structures that support polysemy, but instead an ability to stretch words for the purpose of filling communicative gaps (e.g., a child might use 'shirt' to describe dressing someone with a shirt, not because they think that 'shirt' is the appropriate label for that action, but instead because 'shirt' is the most relevant word they have at their disposal). Indeed, some work has suggested that children's overextension of a word in production (e.g., calling a horse a 'dog') is not diagnostic of their representation of that word's meaning (as measured by their comprehension of that word; see, e.g., Naigles & Gelman, 1995). Thus, it remains an open question as to whether generative structures support children's stable representations of known polysemous words.

The experiments reported here explore whether four-year-old children's representations of the polysemous meanings of words like *book* rely on a common representational base or whether they are stored as separate words. Our approach was to teach children a novel label (e.g., "blicket") that corresponded to one known meaning of a polysemous word—for example, to the physical object meaning of *book*. We then observed whether the children could flexibly comprehend an extension of that novel label to another known meaning of the polysemous word (e.g., to the abstract content meaning of *book*) in a context in which that meaning had been emphasized. We reasoned that if this extension is licensed by the children's representation of the known word, then they should easily comprehend it, but not otherwise (see Fig. 2). On the one hand, if the polysemous meanings of *book* are represented as separate words, extension would not be licensed: if taught that "blicket" means *book*, in the object meaning, children should stick to this taught use only, even in a context in which the content meaning of *book* has been emphasized (see "List Model", Fig. 2). On the other hand, if the polysemous meanings of *book* rely on a common representational base, extension of the label would be expected. For example, if the polysemous meanings are derived from an underspecified representation, the novel label "blicket" would initially be mapped onto this underspecified representation, which could then be fleshed out to the content meaning of *book* if that meaning has been made more relevant within the context (see "Underspecified Representation", Fig. 2). Similarly, if polysemous meanings are generated by rule, "blicket" would initially be mapped to the physical meaning of *book,* but then could be extended to the content meaning of *book* (if it has been made more relevant within the context) by way of a rule linking objects to their contents (see "Rule-Based Extension", Fig. 2).

Our first goal, in Experiment 1, was to make sure that four-year-old children have access to both the object and content meanings of words like *book*. We used a Truth Value Judgment Task (TVJT; Crain & Thornton, 1998; Gordon, 1996). In this method, the child watches a puppet show that an experimenter conducts. Then another puppet, Elmo, who has watched the show with the child, describes what happened in the story. The child's task is to judge whether Elmo's critical statement is true or false. The TVJT is considered to be a sensitive measure of linguistic knowledge, placing minimal meta-linguistic demands on children. In Experiment 1, Elmo's critical statements were ambiguous,

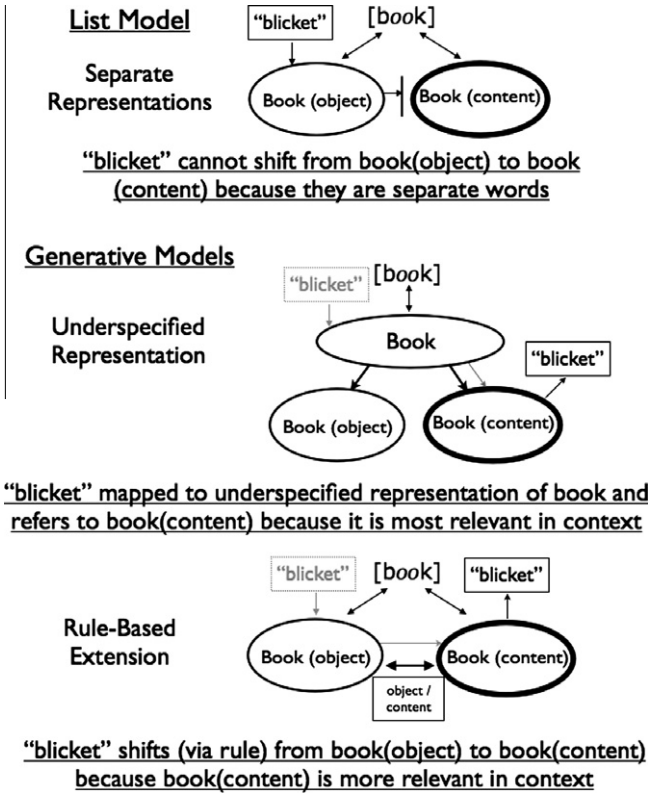

Fig. 2. A graphical depiction of predictions for how the novel label "blicket" may or may not extend between the different meanings of *book*, according to different models of polysemy. In the example, "blicket" is originally taught to refer to *book*[object], but *book*[content] has been emphasized in the context.

and each contained a critical polysemous word. For example, after watching a particular story, Elmo said, "Ernie had the long *book*", which could be either true or false depending on whether 'the long book' was taken to refer to a physically long book, or to a book containing a long story. We presented children in one group with stories that emphasized the object readings of Elmo's statements, while another group of children received stories emphasizing the content readings. To determine whether children in each group could access the emphasized meanings of the critical polysemous words, we observed how the children judged Elmo's critical statements (as well as how they justified those judgments).

Experiment 2 then explored how children represent the meanings of the polysemous words tested in Experiment 1. Prior to each story, the children were taught novel labels that referred to the object meanings of polysemous words (e.g., "blicket" = *book*[object]). Then, the children received the same stories from Experiment 1, and we examined how they interpreted Elmo's critical statements when these statements included the novel labels instead of the known polysemous words ("Ernie had the long *blicket*"). Of particular interest to us were children's judgments of Elmo's statements following the stories that emphasized the content readings of these statements, because these judgments revealed whether children would extend the novel labels from the object to the content meanings of the known words (see Fig. 2). We reasoned that if the object and content meanings are separate words, children should interpret the novel labels based on their taught object meanings alone. However, if these meanings rely on a common representational base, we reasoned that children should shift the novel labels to the content meanings, because these meanings were made more relevant within the context.

Experiment 3 followed up on the results of Experiment 2. Prior to each story, the children were taught novel labels that referred not to the object meanings of the polysemous words, but instead to their content meanings (e.g., "blicket" = *book*[content]). The stories were the same as those in Experiments 1 and 2 that emphasized the object readings of Elmo's critical statements. By observing children's judgments of Elmo's statements following these stories, we explored whether children would accept extensions of the novel labels from the content to object meanings of the critical polysemous words.

Finally, in Experiment 4, we focused on children's representations of homophonous meanings, and examined whether they diverge from children's representations of polysemous meanings. Prior studies of children's processing of homophones have not contrasted them with polysemous words. Instead, these studies have tended to assume that homophonous meanings are separate words, and have focused on children's ability to use context to disambiguate between these meanings (see, e.g., Campbell & Bowe, 1983; Peters & Zaidel, 1980). Thus, Experiment 4 directly tested whether children represent homophonous meanings as separate words. Using a similar method to that in Experiments 1 and 2, we examined whether children would accept extensions of the novel labels between homophonous meanings (e.g., from *bat*[animal] to *bat*[baseball]). We expected that if children represent homophonous meanings as separate words, children should reject extensions of the novel labels and stick to their taught uses.

2. Experiment 1

2.1. Method

2.1.1. Participants

The participants were 32 4-year-old children (22 girls), between the ages of 4;0 and 4;11 (mean age 4;7). Two additional children were excluded for missing three or more of the five filler trials (which suggested that they were not paying attention) (1), or for lack of cooperation (1). The participants were randomly assigned to the content-emphasis and object-emphasis conditions (defined below). Sixteen children (11 girls) participated in the content-emphasis condition, ranging in age from 4;0 to 4;11 (mean age 4;8), and 16 children (11 girls) participated in the object-emphasis condition, ranging in age from 4;1 to 4;11 (mean age 4;7). As in all of the experiments reported here, children were either brought into the lab or recruited from daycares or museums in the Cambridge, Massachusetts area. All children received a token gift for their participation.

2.1.2. Procedure

We tested children's interpretations of polysemous words such as *book*, which can refer to the physical properties of objects, as well as to the contents those objects contain. Comprehension of these words was measured using the TVJT (Crain & Thornton, 1998; Gordon, 1996). Before the experiment began, children were introduced to the mechanics of the task, as well as to the confederate puppet (in this case, Elmo) and the other Sesame Street characters that would be featured in the stories. They were told that Elmo was just a little baby that often made mistakes, and so they needed to help him by rewarding him when he was right (with a cookie), or reminding him when he was wrong (with a dirty rag). If children judged Elmo's statement to be wrong, they were also asked to provide a justification of their judgment.

The task consisted of four critical and five filler stories. Before receiving any critical stories, the child first saw two filler stories. After this, the four critical stories alternated with the remaining three filler stories, in a fixed order. At the end of the experiment, children were tested on the names of the Sesame Street characters in the study, to confirm that they knew them. All sessions were audiotaped so that the children's justifications could later be transcribed.

2.1.3. Materials

The critical stories were always followed with a statement by Elmo that contained a polysemous noun. The stories were designed so that both readings of the noun were reasonable, but one resulted

in a true statement while the other resulted in a false statement. For example, in one story, Cookie Monster had a book that was physically long but contained a short story, while Ernie had a physically short book that contained a long story. At the end of this story, Elmo said: "I know what happened! That was a story about Ernie and Cookie Monster. Ernie read the long book!" Thus, on the object reading of the polysemous noun, Elmo's statement was false, while on the content reading, the statement was true. However, both readings of Elmo's statement were possible given the scene. Thus, if the children could only access one of the meanings of the polysemous word, they would still have a basis on which to answer. Notice that to create this divide between the two meanings, a polysemous adjective had to be used (e.g., *long*). This was true of all critical items. Thus the entire noun phrase was ambiguous and could be interpreted as referring to either a concrete physical object or to the abstract content of that object. Neither of the critical polysemous words (e.g., *long* or *book*) were used in the story, and thus they were not modeled for the child prior to their judgment of Elmo's statement.

To determine whether children were able to access the different meanings of the polysemous words we tested, we varied our critical stories to emphasize either the physical properties of the object or its content, resulting in two conditions—the object-emphasis and content-emphasis conditions (see Fig. 3 and Appendix A). For example, in the object-emphasis condition of the story described above, Cookie Monster's book was described as being very heavy and difficult to carry, and Ernie's book as being very small and able to fit in his pocket. Thus, Elmo's statement ("Ernie read the long book!") was inconsistent with the reading that had been emphasized. In the content-emphasis condition of the same story, the properties of the books' content were emphasized—while Ernie was able to

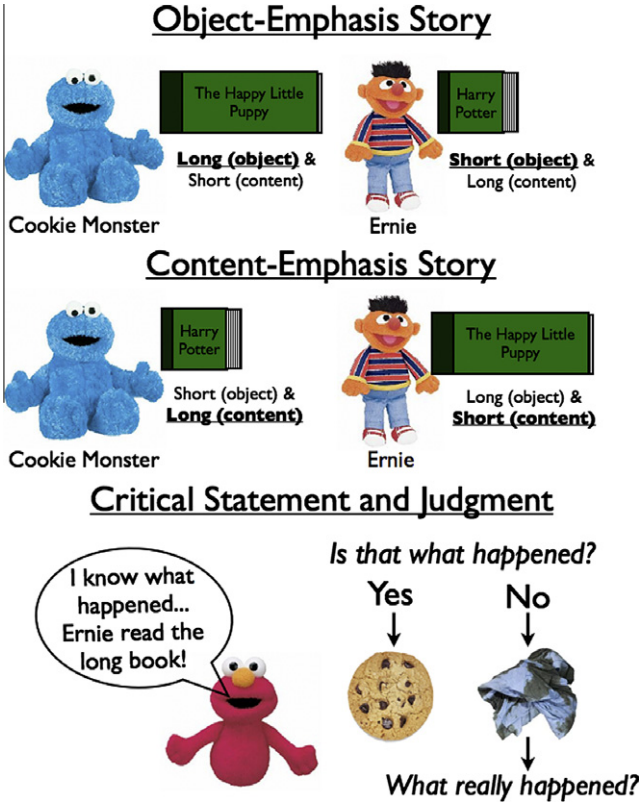

Fig. 3. An example of a critical trial in Experiment 1, depicting how the story for "book" differed between the "object-emphasis" and "content-emphasis" groups (boldface indicates emphasis), and how children were asked to judge Elmo's critical statement following this story.

read his story very quickly, Cookie Monster was reading all night and everyone fell asleep (see Appendix A for examples of the stories).

Note that in the content-emphasis story, the characters had the opposite objects that they had in the object-emphasis story (i.e., Ernie had the physically long book that contained the short story, while Cookie Monster had the physically short book that contained the long story). This was so that Elmo's statement ("Ernie read the long book!") would be inconsistent with the emphasized reading following both kinds of stories (see Fig. 3). This ensured that if children correctly rejected Elmo's statements, they could also be asked to justify their judgments. Justifications were coded as appropriate if they made it clear that the phrase was being interpreted in the correct way—if they referenced the appropriate dimension by pointing out that the mentioned character did not have that object (e.g., "No, Ernie read the *short* book!") or that the unmentioned character did have that object (e.g., "No, *Cookie Monster* read the long book!"). Thus, rejections of Elmo's statements in the critical stories and justifications of those rejections served as measures of children's ability to access the interpretation of the polysemous word that was emphasized in the story. Table 2 provides a description of the objects that the characters had in each of the critical stories, and displays Elmo's critical statements that followed each of these stories.

The five filler stories were included to ensure that children's performance on the test stories was not affected by a lack of attention, or a tendency to perseverate with "yes" or "no" answers. In these stories, the two characters each had an object of the same kind, but these objects differed on a dimension that was not labeled with a polysemous word, and so the statements were not ambiguous. For example, in one story, Ernie had a blue lego block and Big Bird a yellow block, and Elmo's critical statement was: "Ernie had a blue block!" In these stories, the experimenter controlling Elmo changed the final statement so that the correct response was always the opposite of the child's response on the previous trial. This allowed us to determine whether the child was willing to give both "Yes" and "No" judgments (Elmo's statements for each of the five filler trials are given in Table 3).

2.2. Results

Our dependent measure in the critical stories was the proportion of times children rejected Elmo's ambiguous statement, because the emphasized interpretation of the statement was always false in these stories. Children in the content-emphasis group ($M = .84$, $SE = .06$) 'correctly' rejected the puppet's statement more than children in the object group ($M = .67$, $SE = .08$), but both groups said "no" more often than chance (0.5). In the filler stories, in which the puppet's statement was unambiguous, and correct judgments could correspond to either "yes" or "no" judgments, performance in both

Table 2
A list of the test items, stories, and critical statements from Experiment 1. The bolded words indicate the manipulation of emphasis in the stories.

Item	Story	Statement
Book (object-emphasis)	Ernie = **short (object)** & long (content); Cookie Monster = **long (object)** & short (content)	"Ernie read the long book!"
Book (content-emphasis)	Ernie = long (object) & **short (content)**; Cookie Monster = short (object) & **long (content)**	
CD (object-emphasis)	Prairie Dawn = **pretty (object)** & noisy (content); Ernie = **dull (object)** & pretty (content)	"Ernie played the pretty CD!"
CD (content-emphasis)	Prairie Dawn = dull (object) & **pretty (content)**; Ernie = pretty (object) **& noisy (content)**	
Puzzle (object-emphasis)	Zoe = **hard (object)** & easy (content); Prairie Dawn = **soft (object)** & difficult (content)	"Prairie Dawn did the hard puzzle!"
Puzzle (content-emphasis)	Zoe = soft (object) & **difficult (content)**; Prairie Dawn = hard (object) **& easy (content)**	
Video (object-emphasis)	Prairie Dawn = **short (object)** & long (content); Ernie = **tall (object)** & short (content)	"Ernie played the short video!"
Video (content-emphasis)	Prairie Dawn = tall (object) & **short (content)**; Ernie = short (object) **& tall (content)**	

Table 3
A list of the filler items, stories, and critical statements from Experiment 1.

Item	Story	Statement
Ball	Cookie Monster: Big & Colorful; Zoe: Small & Gray	True: "Zoe bounced the small ball!" False: "Cookie Monster bounced the small ball!"
Box	Cookie Monster: Green & Empty; Ernie: Yellow & Full	True: "Ernie had the full box!" False: "Cookie Monster had the full box!"
Car	Cookie Monster: Purple & Slow; Ernie: Yellow & Fast	True: "Ernie had the fast car!" False: "Cookie Monster had the fast car!"
Lego	Big Bird: Big & Yellow; Ernie: Small & Blue	True: "Ernie played with the blue block!" False: "Big Bird played with the blue block!"
Crayon	Big Bird: Big & Sharp; Zoe: Skinny & Dull	True: "Zoe used the skinny crayon!" False: "Big Bird used the skinny crayon!"

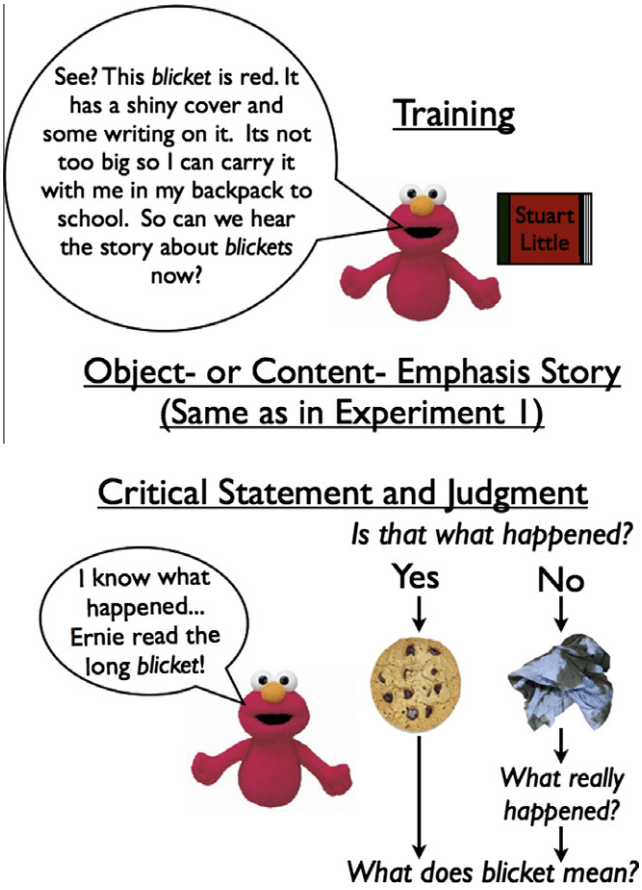

Fig. 4. An example of a critical trial in Experiment 2. Children were initially taught a novel label to refer to "book" in the object-sense. Then, they saw the same stories from Experiment 1, had to judge Elmo's statement, and translate the novel label that he used in his statement.

groups was at ceiling (M(object) = .98, M(content) = 1.0, for the object-emphasis and content-emphasis groups, respectively).

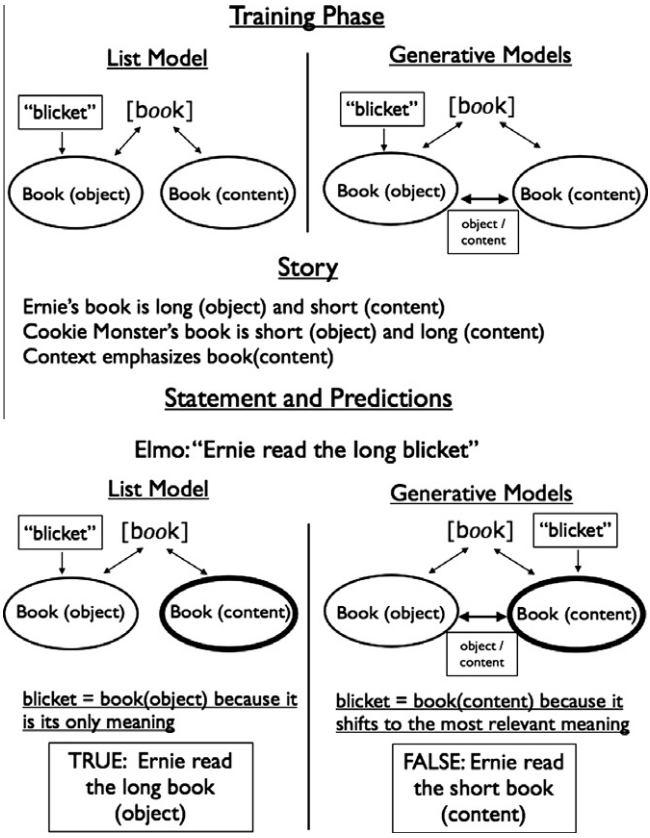

Fig. 5. Predictions of the List Model and the Generative Models for the content-emphasis condition of Experiment 2. If the meanings of words like *book* are separate words, children should stick to the taught object meaning of the novel label and accept Elmo's statement. But if the meanings of these words rely on a common representational base (the rule-based extension view is depicted), children should shift the meaning of the novel label to the content meaning because it is more relevant in the context, and thereby reject Elmo's statement.

Because of our small sample size and the ordinal nature of our data, we analyzed our data using non-parametric tests.[1] To determine whether children reliably rejected Elmo's statements in the critical stories, we entered the data into two Wilcoxon signed-rank tests, comparing each child's proportion of rejections to chance (0.5). The tests yielded a reliable effect for children in the content-emphasis condition (Wilcoxon $T = 0$, $N = 12$, $p < .001$ (two-tailed)), and approached significance for children in the object-emphasis condition (Wilcoxon $T = 18.5$, $N = 13$, $p = .06$ (two-tailed)). When the children did reject Elmo's statement, they were also able to provide appropriate justifications for their judgments (Object-emphasis group: 87% of rejections, Content-emphasis group: 89% of rejections; e.g., "Cookie Monster had the long book", "Ernie had the short book"). To determine whether children in the content–emphasis group rejected Elmo's statements on the test stories reliably more often than the children in the object-emphasis group, we used a 2-sample, Mann–Whitney test, and the effect approached significance (Mann–Whitney $U = 86$, $p = .09$).

[1] Preliminary analyses for Experiment 1 and for the other experiments reported here did not find significant effects of gender or age. We have thus excluded these factors from our analyses.

2.3. Discussion

The results from Experiment 1 demonstrate that children can access both the physical and abstract meanings of words like *book*. By emphasizing one or the other of these meanings, our stories were able to make that meaning more relevant to children when they were interpreting Elmo's ambiguous phrases. The stories that emphasized the physical meanings may have been less successful in this regard (.67 compared to .84), because collocations such as "long book" and "short video" tend to refer to the abstract properties of representational objects and not their physical properties. To confirm this, we conducted Google searches with the search strings of "long book", "hard puzzle", and "short video". We examined the first 20 instances that appeared and coded whether they had a physical or abstract meaning. All of the first 20 hits for "long book", "short video", and "hard puzzle" had abstract meanings, suggesting that the physical meanings of these collocations are indeed rare. In light of this, it is remarkable that the stories used in Experiment 1 were able to encourage children to access the concrete meanings of the ambiguous phrases. These stories therefore provided sufficient contextual support to allow us to ask our primary question: do the physical and abstract meanings of words like *book* rely on a common representational base, or are they represented separately?

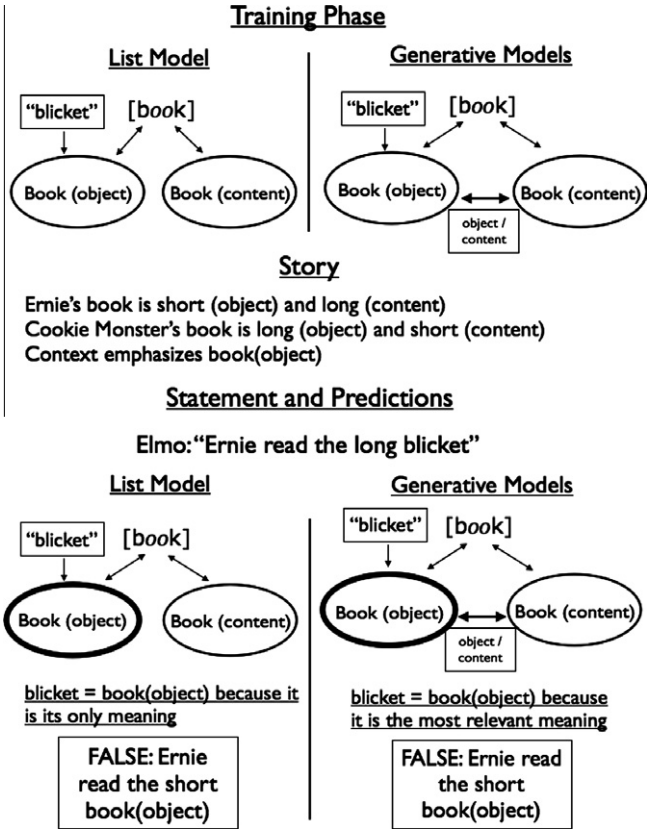

Fig. 6. Predictions of the List Model and the Generative Models for the object-emphasis condition of Experiment 2. Both the List Model and Generative Models (the rule-based extension view is depicted) predict that children should stick to the taught object meaning of the novel label and reject Elmo's statement. Under the List Model, the object meaning is the only meaning the novel label *could* have, while under the Generative Models, the object meaning is the most relevant meaning for the novel label within the context.

To address this question, we taught children a novel label that referred to only the object meaning of a polysemous word, and observed whether they would accept an extension of this novel label to the content meaning. Before each story began, children were taught a novel label (e.g., "blicket") from "muppet language". In teaching the label, we referred only to the object's physical properties (see Fig. 4). The story would then proceed exactly as before, but Elmo would use the novel label—instead of the regular word—in his critical statement at the end of the story (e.g., "Ernie had the long *blicket*").

Of particular interest were children's judgments following the stories that emphasized the abstract properties, because these judgments revealed whether children would extend the novel labels from the object to the content meanings of the known words (see Fig. 5). We reasoned that if the object and content meanings of a polysemous word like *book* are indeed separate lexical items, children should stick to the taught, object meaning of the novel label and accept Elmo's statement (see "List Model", Fig. 5), but that if these two have a common representational base, children should extend the meaning of the novel label to its abstract counterpart and reject Elmo's statement (see "Generative Models", Fig. 5). Whether or not the meanings of words like *book* are separate words, we expected that children would reject Elmo's statements following the object-emphasis stories, because these stories would not require children to extend the meanings of the novel labels (see Fig. 6).

3. Experiment 2

3.1. Method

3.1.1. Participants

The participants were 33 4-year-old children (17 girls), between the ages of 4;1 and 4;11 (mean age 4;5). Four additional children were excluded because they missed two or more of the first three filler trials (2), failed to remember the Sesame Street characters' names in a post-test (1), or would not cooperate (1). Participants were randomly assigned to the content-emphasis and object-emphasis conditions. 16 children (6 girls) participated in the content-emphasis condition, ranging in age from 4;2 to 4;8 (mean age 4;5), and 17 children (11 girls) participated in the object-emphasis condition, ranging in age from 4;1 to 4;11 (mean age 4;6).

3.1.2. Procedure

As in Experiment 1, children's comprehension was measured using the TVJT. During the introduction to the task, children were told that Elmo sometimes uses words from muppet language, and that they should try their best to understand what those words mean. Before each story, the first experimenter would ask Elmo what story he wanted to hear next, and Elmo would respond with a request using a novel label (e.g., "I want to hear the story about *blickets*!") The first experimenter would then ask if the child knew what the novel label meant, and, having established that it was a new label, would suggest that Elmo must be speaking muppet language and would ask Elmo to explain the label's meaning. Elmo would then explain the label's meaning, using a prop as an example referent of the label. After the story, Elmo would use the novel label in the critical statement, in place of the nouns that were used in Experiment 1 (e.g., "Ernie read the long *blicket*"). After being asked to judge Elmo's statement (and provide a justification if they rejected it), children were also asked to guess what Elmo's label meant (see Fig. 4). Justifications were coded as in Experiment 1.

Before receiving any critical stories, the child first saw three filler stories. The first filler story introduced children to the task, and the second and third filler stories introduced them to the use of the novel labels. After this, the four critical stories alternated with the remaining three filler stories. Novel labels were taught and used in Elmo's statements for each of the four critical stories, as well as in the fifth filler story. All other aspects of the procedure were the same as in Experiment 1.

3.1.3. Materials

In explaining the meanings of the novel labels for the critical stories, Elmo only used descriptions of the objects' physical properties. For example, in the test story about books, Elmo held a book prop and described it as a "blicket" with a certain color, shape, and size. Thus, "blicket" was paired only with the object meaning of book (see Fig. 4). As in Experiment 1, children were randomly assigned to either the object-emphasis or content-emphasis group, which meant that they either heard critical stories that focused more on the physical properties of the objects, or stories that focused on the content those objects contain, respectively (these stories were the same as those in Experiment 1). However, children in both of these groups were introduced to the novel labels only in the object sense. Thus, the performance of children in the content-emphasis condition was of particular interest: would these children stick to a physical meaning of the novel label when listening to Elmo's statement (and consequently accept it), or would they extend the novel label's meaning to include the content of the object (and thereby reject the statement) (see Fig. 5)? All other aspects of the materials were the same as in Experiment 1.

3.2. Results

As in Experiment 1, our dependent measure in the critical stories was the proportion of times children rejected Elmo's ambiguous statement with the novel label. Children in the content-emphasis group rejected the puppet's statement more often than chance ($M = .73$, $SE = .06$; $T = 4$, $N = 12$, $p < .005$), as did children in the object-emphasis group ($M = .66$, $SE = .07$; $T = 12$, $N = 12$, $p < .05$). In fact, the children in the content-emphasis group, who had to extend the meaning of the novel label, rejected Elmo's statement more than did the children in the object-emphasis group, although this difference was not reliable, $U = 116$, $p = .45$. In the filler stories, in which Elmo's statement was unambiguous, performance in both groups was high ($M = .90$, $M = .94$, for the object-emphasis and content-emphasis groups, respectively). When the children in both groups did reject Elmo's statement, they were also able to provide appropriate justifications, demonstrating their understanding of the stories and critical utterances (Object-emphasis group: 93% of rejections, Content-emphasis group: 95% of rejections; e.g., "Cookie Monster had the long blicket", "Ernie had the short blicket"). Children in Experiment 2 performed remarkably similarly to children in Experiment 1 (who received the same stories but did not have to interpret Elmo's novel label): there was no detectable difference between the content-emphasis groups of Experiments 1 and 2 ($p = .16$), or the object-emphasis groups of Experiments 1 and 2 ($p = .82$).

Finally, children in the object-emphasis group were able to provide appropriate translations of the novel labels in the test trials (e.g., "book", "story book", etc.) reliably more often than children in the content-emphasis group (Object-emphasis group: $M = .79$, $SE = .05$; Content-emphasis group: $M = .48$, $SE = .05$; $U = 74.5$, $p < .05$), but this effect did not extend to the translations of the novel labels on the filler trials (e.g., "ball", "lego", etc.; Object-emphasis group: $M = .78$, $SE = .09$; Content-emphasis group: $M = .69$, $SE = .06$; $U = 109.5$, $p = .45$).

3.3. Discussion

Children in Experiment 2 were readily able to understand extensions of the novel labels to their untrained uses. Indeed, in rejecting Elmo's statements, children did the opposite of what they would have done had they been guided by the taught meaning of the novel label. Insofar as children's extension of the novel labels depended on their representations of the actual polysemous words, these results suggest that early representations of the polysemous meanings of words like *book* are not separate and unrelated, but instead rely on a common representational base.

One unexpected result of Experiment 2 was that although children in the content-emphasis group were able to understand extensions of the novel labels, they had trouble providing appropriate translations for these labels (e.g., many said they did not know what Elmo's label meant). This was despite the fact that some of these children had even shouted out appropriate translations of the novel labels when they were first introduced, or while the stories were being told (e.g., "That's

not a blicket! That's a book!"). We will return to this issue when discussing the results of Experiment 3 below.

One concern with the results of Experiment 2 is that although the novel label training did not mention abstract properties of the representational objects, the presence of the objects may have been sufficient to activate the abstract meanings. On this account, even though *book*[object] and *book*[content] may be represented as separate words, they both refer to books, and so the presence of a book during the training may have activated both meanings, allowing the novel label to apply to either of them. To address this, in Experiment 3, a novel label was trained on only the abstract meaning of a polysemous word—Elmo did not use a prop and indicated the novel label's meaning only with the linguistic context (e.g., "I like to read interesting blickets") (see Fig. 7). We then observed whether children would accept an extension of the novel label to the untrained physical meaning of the polysemous word (see Figs. 7 and 8). Teaching the novel label to refer to the abstract meaning (e.g., *book*[content] or *video*[content]) provides a strong test of children's ability to extend between these meanings, given that there are a number of closely related words—such as *story* and *movie*—which typically do not refer to physical objects.

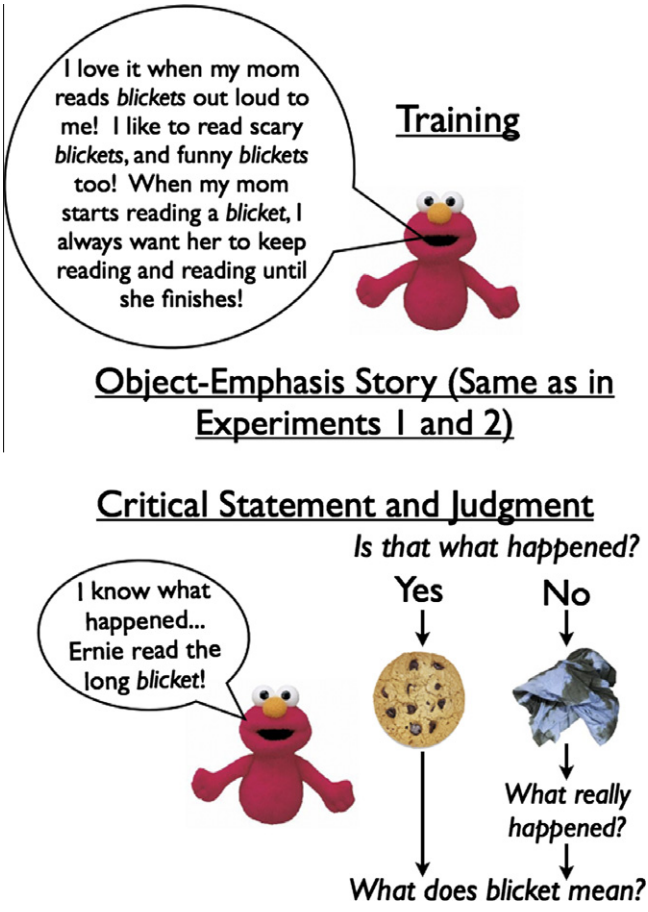

Fig. 7. An example of a critical trial in Experiment 3. Children were initially taught a novel label to refer to the abstract meaning of *book*. After this, they saw the object-emphasis story for *book*, and then had to judge Elmo's statement and translate the novel label that he used in his statement.

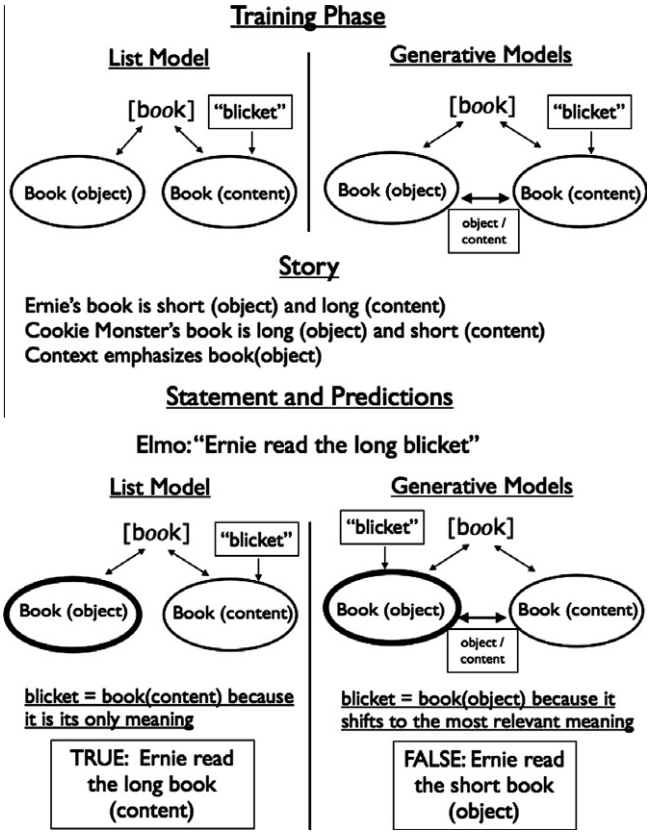

Fig. 8. Predictions of the List Model and the Generative Models for Experiment 3. If the meanings of words like *book* are separate words, children should stick to the taught content meaning of the novel label and accept Elmo's statement. But if the meanings of these words rely on a common representational base (the rule-based extension view is depicted), children should shift the meaning of the novel label to the object meaning because it is more relevant in the context, and thereby reject Elmo's statement.

4. Experiment 3

4.1. Method

4.1.1. Participants

The participants were 16 4-year-old children (9 girls), between the ages of 3;11 and 4;10 (mean age 4;5). Five children were excluded because they missed two or more of the first three filler trials (3), or would not cooperate (2).

4.1.2. Procedure

The procedure was the same as that of Experiment 2: children were taught the meaning of the novel label prior to the story, and Elmo used this novel label in his critical statement at the end of the story. What differed from Experiment 2 was the actual teaching of the novel label, which is described below.

4.1.3. Materials

In explaining the meanings of the novel labels for the critical stories, Elmo did not use a physical prop and described only the abstract properties of the representational object. For example, in the test story about books, Elmo explained what a "blicket" was by saying that he liked to "read interesting

blickets, and funny blickets too" (see Fig. 7). Thus, "blicket" was taught only on the content meaning of book. Children then heard the critical stories (identical to those from Experiments 1 and 2) that focused on the physical properties of the objects. Of interest was whether children would stick to the abstract meaning of the novel label when listening to Elmo's critical statement (and consequently accept it), or would extend the novel label's meaning to include the physical properties of the object which had been made more relevant in the context (and thereby reject the statement) (Fig. 8). Finally, one of the critical stories from Experiment 2 ('hard puzzle') was excluded, because we thought it would be difficult to teach the abstract meaning of this word without a physical prop. All other aspects of the materials were the same as in Experiment 2.

4.2. Results

Our dependent measure was the proportion of times children rejected Elmo's ambiguous statement in the critical stories. Children tended to reject Elmo's statements more often than chance ($M = .65$, $SE = .08$, $T = 38$, $N = 16$, $p = .06$), and no differences were detected when this rate of rejection was compared to children who received the same stories in Experiment 1 ($p = .77$) and Experiment 2 ($p = .94$), for whom no extension was required. Children's judgments may not have been as robust as children's judgments in the content-emphasis group of Experiment 2 (who extended the novel labels from the object to content meanings) because of less statistical power (i.e., Experiment 3 included one less item than did Experiment 2). However, when children did reject Elmo's statements, they were readily able to provide appropriate justifications for their judgments (94% of rejections; e.g., "Ernie read the short blicket" or "Cookie Monster had the long blicket"), demonstrating that they had not been randomly responding (and thus militating against statistically comparing their performance against chance). Children's performance was also high in the filler stories ($M = .95$, $SE = .02$). Finally, children were able to provide appropriate translations of the novel labels in the critical trials (e.g., "book", "story", etc.; $M = .88$, $SE = .07$) and in the filler trials (e.g., "ball", "lego", etc.; $M = .98$, $SE = .02$).

4.3. Discussion

Children in Experiment 3, like the children in the content-emphasis condition of Experiment 2, were able to understand extensions of the novel labels from their trained meanings to their untrained meanings (in this case, the physical meaning of the polysemous word). This was despite the fact that, during the training, the physical meanings were not depicted with a prop or referred to linguistically. Indeed, children conceivably could have initially mapped the novel labels onto words such as *movie* or *story*, which do not typically refer to the physical properties of representational objects. Thus, children's extension of these novel labels to the untrained physical meanings provides evidence that, early in development, the different meanings of polysemous words like *book* rely on a common representational base.

These results also clarify why the children in Experiment 2, who successfully understood extensions of novel labels from physical objects to abstract contents, had difficulty providing translations of these labels. One possible explanation might have been that these children created a new semantic representation for the novel label during the training based on the actual conventional word (e.g., *blicket* = *book*[object]), and that after extending it to understand Elmo's critical statement, they could no longer access the base form of the conventional word (i.e., *book*) and provide it as a translation. But this explanation predicts, wrongly, that children in Experiment 3—who also had to extend the taught meanings of novel labels—would experience similar difficulties. Children's success in providing translations when they extended the novel labels to physical referents, suggests that the difficulty experienced by children in Experiment 2 was not related to extension of the novel label, but instead to the production of words referring to abstract content.

While the results of Experiments 2 and 3 suggest that the polysemous meanings of words like *book* rely on a common representational base, there are two alternative accounts of the data. A first alternative is that the use of the novel labels in the two experiments had no effect on the children—by merely listening to the story, ignoring the novel label, and attending to the linguistic context in Elmo's statements, children may have correctly inferred Elmo's communicative intentions (see, e.g., Tomasello, 2001). A second alternative is that the polysemous meanings of words like *book* are indeed

represented as separate words, but having the same phonological form ([book]) promotes extension in the task. The latter account is plausible in light of evidence that children are capable of identifying pairs of objects with homophonous names (Backscheider & Gelman, 1995).

In Experiment 4, we addressed these alternative accounts of the data, by asking whether children would extend a novel label from one meaning of a homophone (e.g., baseball bat) to another (animal bat), given a supportive linguistic context. Previous studies of children's processing of homophones have tended to assume that homophones are separate words, focusing on whether children can make use of context to disambiguate between homophonous meanings (see, e.g., Campbell & Bowe, 1983; Peters & Zaidel, 1980). Experiment 4 sought to directly test the assumption that children represent homophonous meanings as separate words. We expected that if children do represent these meanings separately, and if extension of the novel label within our task requires more than a common phonological form and a supportive linguistic context, children should stick to the taught meanings of the novel labels. To examine whether children would extend the novel label between homophonous meanings, we compared performance in a novel label condition to performance in a baseline condition in which the real homophonous words were used in Elmo's statement and no novel labels were introduced.

5. Experiment 4

5.1. Method

5.1.1. Participants

The participants were 33 4-year-old children (17 girls), between the ages of 4;0 and 4;11 (mean age 4;5). Six additional children were excluded because they missed two or more of the first three filler trials (5), or because of parental interference (1). The participants were randomly assigned to the novel label and baseline conditions. 17 children (7 girls) participated in the novel label condition, ranging in age from 3;11 to 4;11 (mean age 4;5), and 16 children (8 girls) participated in the baseline condition, ranging in age from 4;0 to 4;11 (mean age 4;6).

5.1.2. Procedure

Children only received a critical story if they knew both meanings of the pair of homophones that were featured in that story. To assess knowledge of each of these meanings, all children were first pre-tested on a set of 24 words in an elicited production task, which included eight pairs of homophones (*bat*(animal)/*bat*(baseball), *night*/*knight*, *sun*/*son*, *star*(celestial body)/*star*(celebrity), *chest*(body part)/*chest*(container), *calf*(animal)/*calf*(body part), *pen*(writing instrument)/*pen*(enclosure), *pitcher*(baseball player)/*pitcher*(container)), with eight filler words interspersed. The critical trials were arranged such that members of a particular pair of homophonous words did not appear within six trials of each other. For each trial, the experimenter began a sentence that stopped just short of producing the target word (e.g., "Wow, this animal flies around in caves, I think that's a _____"), while showing the child a picture that depicted that word. If children did not immediately produce the target word, or if they produced a different word, they were encouraged to keep trying until they had no further guesses. Responses were only judged correct if children produced the word in its exact form (responses such as 'night time' and 'treasure chest' were not accepted).

Immediately after the pre-test, children took a 5–10 min break in which they could draw a picture or play with some toys. This was to minimize interference between the pre-test and the primary task. As in the prior experiments, children's comprehension was measured using the TVJT. Before receiving any critical stories, the children first saw three filler stories, and children who responded incorrectly on two or more of these stories were not tested further. After this, the children were shown up to four critical stories, but only received a particular story if they had been able to identify the pair of homophonous meanings relevant to that story in the pre-test. The critical stories alternated with filler stories, and were presented to children in a fixed order (e.g., the *night*/*knight* story was always presented before the *bat* story, which was always presented before the *sun*/*son* story, and so on). On average, children in the baseline condition received 2.0 critical stories (9 children were tested on *night*/*knight*, 15 on *bat*(baseball)/*bat*(animal), and 8 on *son*/*sun*), and children in the novel label condition

received 1.73 critical stories (8 children were tested on *night/knight*, 13 on *bat*(baseball)/*bat*(animal), 3 on *son/sun*, and 1 on *star*(celestial)/*star*(movie)).

In the novel label condition, children were trained on novel labels prior to the stories, and Elmo used these labels in his critical statements (as in Experiments 2 and 3), but in the baseline condition, children were not trained on novel labels, and Elmo used actual homophonous words in his statements (as in Experiment 1). After being asked to judge Elmo's statement (and provide a justification if they rejected it), children in the novel label condition were also asked to guess what Elmo's label meant. All other aspects of the procedure were the same as in the prior experiments.

5.1.3. Materials

In the critical stories, there were two main characters, each of whom had an object that corresponded to one word of a homophonous pair. For example, in one story (see Fig. 9 and Appendix B), Big Bird had a gray baseball bat, and Zoe had a black animal bat. In the baseline condition, at the end of this story, Elmo said: "I know what happened! That was a story about Big Bird and Zoe. Zoe had the black bat!" As seen in this example, in the baseline condition, the context supported a "Yes" judgment of the critical phrase, and so we expected the children to accept Elmo's statements. Table 4 lists the objects that the characters had in each of the possible critical stories, and also displays Elmo's critical statements following these trials.

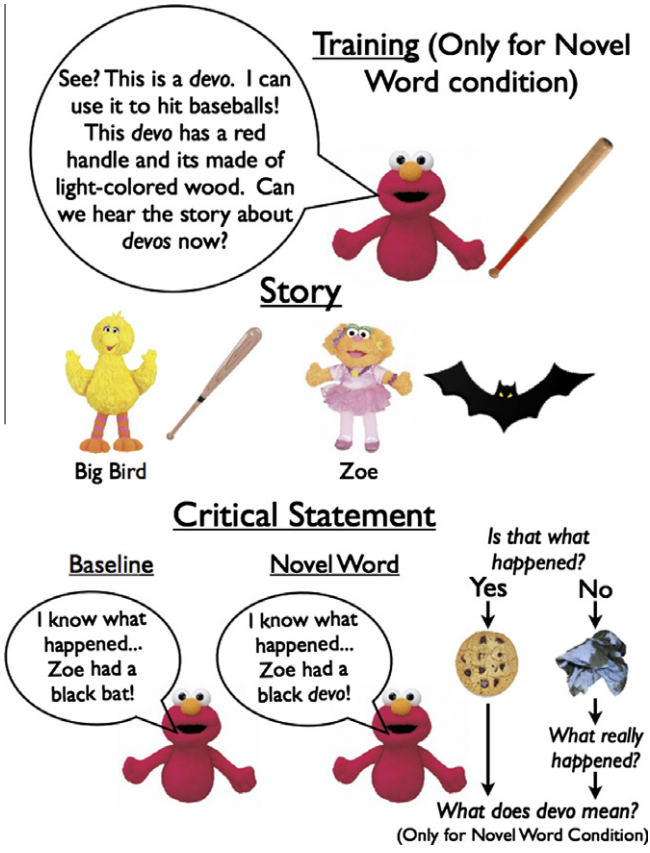

Fig. 9. An example of a critical trial in Experiment 4. In the "novel label" condition, children were initially taught a novel label to refer to a baseball bat. They then saw the critical story, and then had to judge Elmo's statement, which used the novel label to refer to the homophonous meaning (animal bat). In the baseline condition, children were not taught a novel label, and Elmo did not use a novel label in his statement.

Table 4
A list of possible test items, stories, and critical statements for the "novel label" and "baseline" groups from Experiment 4. The novel labels and their trained meanings for each item are indicated in parenthesis.

Item	Story	Statement
Knight/Night (*Blicket* = Knight)	Ernie's story was about a tall knight; Zoe's story was about a short night	"Zoe told the story about a short night (*blicket*)!"
Bat (*Devo* = Bat (baseball))	Big Bird had a light-colored bat(baseball); Zoe had a black bat (animal)	"Zoe had a black bat (*devo*)!"
Son/Sun (*Tima* = Son)	Zoe had a big son; Big Bird had a little sun (in the park)	"Big Bird had a little sun (*tima*)!"
Star (*Widget* = Star (movie))	Cookie Monster saw a big star(movie); Ernie saw a little star (sky)	"Ernie saw a little star (*widget*)!"

In the novel label condition, children learned a new label for one member of the homophonous pair. This novel label was always paired with the meaning that would ultimately support a "No" judgment of Elmo's critical statement. For example, before hearing the *bat* story, children were taught that "blicket" meant baseball bat (see Fig. 9 and Appendix B). Elmo then used the novel label in his critical phrase ("Zoe had the black blicket!"). If children ignored the use of the novel label and paid attention only to the context ("Zoe had the black ____"), or extended the meaning of the novel label to the homophonous meaning based on phonological overlap, they should accept Elmo's statement (as in the baseline condition) (see "Phonological Mapping", Fig. 10). If, on the other hand, extension requires

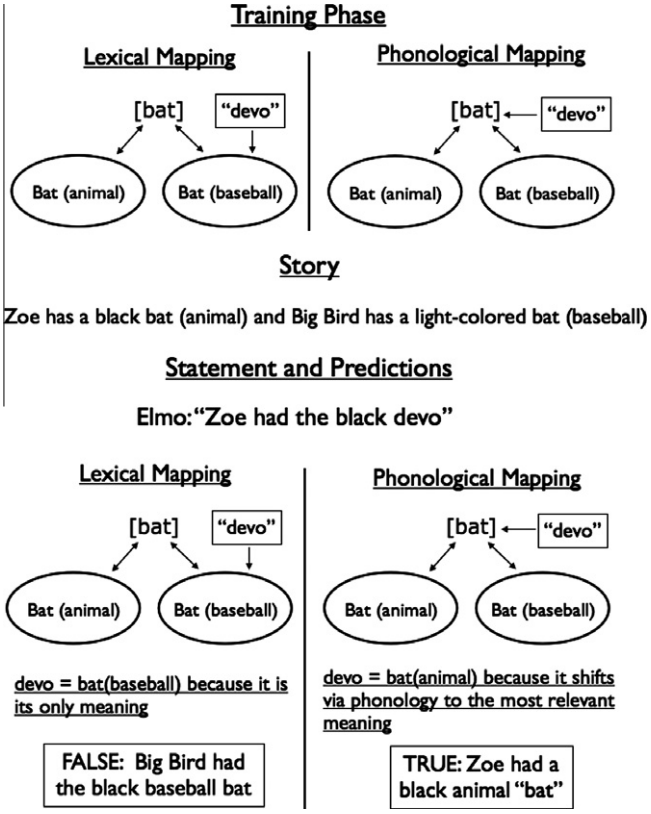

Fig. 10. Predictions for the "novel label" condition of Experiment 4. If phonological overlap between meanings is sufficient to promote extension of the label, children should accept Elmo's statement. If a common lexical representation is necessary to promote extension, children should stick to the taught meaning of the novel label and reject Elmo's statement.

that both meanings have a common lexical representational, then children in the novel label condition should not extend the novel label to the unrelated, homophonous meaning, and should reject Elmo's statement (see "Lexical Mapping", Fig. 10).

Note that, unlike Experiments 2 and 3, extension of the novel labels in Experiment 4 led to acceptance of Elmo's statements. Because we expected that children would fail to extend the novel labels in this experiment (i.e., under the hypothesis that children represent homophonous meanings separately), we designed the stories so that this would lead to a rejection of Elmo's statements (a standard practice in Truth-Value Judgment studies; see Crain & Thornton, 1998). This is because rejections allow us to ask children to justify their judgments, and are thus more informative than acceptances. An example of how the novel labels were taught and how the stories were told is given in Appendix B.

5.2. Results

Our dependent measure in the critical stories was the proportion of times children *accepted* Elmo's statement, because the critical statements that used the real, homophonous words were always true in these stories. Children in the novel label group rarely accepted Elmo's statement ($M = .25$, $SE = .11$, $T = 20$; $N = 17$, $p < .005$), and did so significantly less than did children in the baseline group ($M = .69$, $SE = .09$, $U = 64$, $p < .01$), who had a strong tendency to accept it ($T = 16$; $N = 12$, $p = .06$). Critically, children in the novel label group accepted extensions of the novel labels for homophones ($M = .25$) less often than did the children in the content-emphasis group of Experiment 2 ($M = .73$, $U = 54$, $p < .005$) and the children in Experiment 3 ($M = .65$; $U = 59$, $p < .005$), both of whom had extended novel labels between polysemous meanings. When children in the novel label condition did reject Elmo's statement, they were also able to provide appropriate justifications, which indicated that they interpreted the novel label as having its trained meaning (84% of rejections; e.g., "Zoe didn't have a devo", "Big Bird had the devo"). In the filler stories, performance in both groups was high ($M = .88$, $M = .84$, for the baseline and novel label conditions, respectively). Finally, children in the novel label group were able to provide appropriate translations of the novel labels in the test trials (e.g., "baseball bat", "knight", etc.; $M = .73$, $SE = .09$) and in the filler trials (e.g., "ball", "lego", etc.; $M = .90$, $SE = .05$).

6. General discussion

The present studies examined 4-year-old children's representations of the polysemous meanings of words like *book*, which can refer to either the physical or abstract properties of representational objects. After being taught a novel label that corresponded to one meaning of an actual polysemous word, children flexibly understood an extension of the novel label to the other meaning of the polysemous word (Experiments 2 and 3), but did not do so for extensions between homophonous meanings (Experiment 4) (see Table 5). These results suggest that early in development, the different

Table 5
Predictions of the different models for the critical experiments reported here, and the results that were ultimately found.

	List model	Generative models	Phonological mapping	Results
Experiment 2 (object-emphasis) *Blicket* initially refers to book(object) Interpret *blicket* as book(object)?	YES	YES	YES	YES
Experiment 2 (content-emphasis) *Blicket* initially refers to book(object) Interpret *blicket* as book(content)?	NO	YES	YES	YES
Experiment 3 *Blicket* initially refers to book(content) Interpret *blicket* as book (object)?	NO	YES	YES	YES
Experiment 4 (novel label condition) *Devo* initially refers to bat (baseball) Interpret *devo* as bat(animal)?	NO	NO	YES	NO

meanings of polysemous words like *book* rely on a common lexical or conceptual representational base, while the different meanings of homophones are represented independently, overlapping only at the phonological level. Given the limited meta-linguistic abilities of young children (Gombert, 1992), we conclude that children do not need to actively reflect upon the polysemous meanings of words like *book* to abstract the relations between them. Instead, these relations may reflect the presence of generative structures that allow the meanings of these words to shift.

This conclusion converges with recent evidence that children over-generalize this form of polysemy. Rabagliati, Marcus, and Pylkkanen (2010) tested the development of interpretations of words like *movie* and *story*, which in adult usage tend to refer only to abstract content and not physical objects. Early in development children readily adopted unattested physical interpretations of these words and only later pruned back on them. For example, young children, but not older children, would say that movies can be round. As described before, a number of other studies, examining children's lexical innovations, have also suggested that children over-generalize polysemous meanings (e.g., in using *shirt* as a verb to refer to putting on a shirt; see, e.g., Berman, 1999; Bowerman, 1983; Clark, 1982; Clark & Hecht, 1982). But while these studies have shown that children generate innovative polysemous meanings, they have only indirectly suggested that generative structures also underlie the stable representations of known polysemous meanings. The present studies therefore extend this previous work, offering direct evidence that the polysemous meanings of words like *book* rely on a common representational base early in development.

Our results are compatible with a number of generative models but do not favor one of these models over the others (e.g., Caramazza & Grober, 1976; Copestake & Briscoe, 1995; Lakoff, 1987; Langacker, 1987; Nunberg, 1979; Pustejovsky, 1995; Rice, 1992; Ruhl, 1989; Tyler & Evans, 2001). For example, polysemous meanings could logically result from the internal structure of underspecified representations. For instance, Pustejovsky (1995) argues that the relations among a word's uses are encoded directly into the representation of the word. The representation of *book*, for example, specifies that it is a physical artifact that contains information (as do also the representations of other words such as *CD* and *video*), accounting for the related interpretations of *book* in "He read a good book about polysemy" and "He used the large book as a doorstop". On the other hand, polysemous meanings could also be derived from one another, with one explicitly represented and the other generated by lexical rule (e.g., Copestake & Briscoe, 1995; Frisson & Frazier, 2005). For example, a rule extending a word from referring to a physical object to the information contained within that object could apply not only to *book*, but also to other words such as *CD*, *newspaper,* and *video*.

Our data are also compatible with a model in which the meanings of polysemous words are specified by generative conceptual structures, but do not rely on a common *lexical* representation. On this account, even though the children in Experiments 2 and 3 may have mapped the novel labels onto actual words (as is documented by their ability to provide appropriate translations), their lexical representations of those words' meanings were not the critical driving factors in extension—the conceptual relations among those meanings were. Of course, not just any conceptual relation between a pair of meanings would be expected to license extension on our task—for instance, while cows are conceptually related to milk, it is unlikely that children would extend a novel label between those meanings. It is a possibility, however, that it is just those conceptual relations (e.g., object/content, animal/meat, etc.) that motivate forms of polysemy that license extension in our task (and perhaps during language acquisition). Because this model would credit children with conceptual structures specifying the relations between polysemous meanings, it is in opposition to the List Model and appears to make the same predictions as the Generative Models do.

Taken together, the present studies have suggested that generative structures are available to four-year-old children, allowing children to extend a polysemous word between its different meanings. However, because our studies have focused on children's representations of *known* polysemous words, they do not bear on whether the structures underlying these representations are productive, and thus support the interpretation of novel words with novel meanings. Do children, for example, understand that *any* word for a representational object can be used to refer both to the physical object itself, as well as to the content it contains? Future studies could examine the abstractness of children's knowledge of polysemous relations by evaluating the flexibility of their interpretations of novel words that have novel meanings.

The present studies also leave open how generative structures may arise over development. A first possibility is that these structures could be present before children begin to learn language and could themselves give rise to polysemy, constraining children's first expectations about how a word's meaning may shift (see, e.g., Srinivasan & Carey, 2010, for a similar proposal regarding the use of spatial language to describe time). However, a second possibility is that children have few initial expectations about how the meanings of words can shift, but are able to abstract the relevant patterns after having encountered a sufficient number of polysemous meanings (see, e.g., Bowerman & Choi, 2001, for a related proposal). As the studies reported here have suggested, this process of abstraction would not be based on meta-linguistic reflection, but would instead occur more implicitly. Similar implicit processes of abstraction are likely to be at work early in development in other domains of language as well, such as in the acquisition of the regular inflection of the past tense ('*-ed*'), which children have acquired by age three.

Our conclusion also needs to be reconciled with evidence from Klein and Murphy (2001) that adults represent polysemous meanings as separate and unrelated words. Below, we consider the possibility that this difference stems from (1) the age of our participants, (2) the nature of our task, and (3) the kinds of polysemous words that we tested. A first possibility is that there is a genuine developmental difference in the lexical representations of adults and young children. In particular, if an extended meaning of a word requires a number of extra inferences or is frequently enough used, it may become more efficient to store it in memory rather than generate it anew (Murphy, 2007). Thus, as adults we might store many meanings that we generated as children, and may only continue to generate meanings when we encounter new uses of words—as, for example, when people were first introduced to compact discs and heard phrases such as "a scratched CD" and "a good CD". This possible routinization of generative processes highlights the importance of studying polysemy early in development, prior to extensive experience.

A second possibility is that the difference in findings is a consequence of differences between the tasks used in the two studies: our task encouraged generalization, while the tasks used in Klein and Murphy (2001) did not. Indeed, we suspect that if adults had been tested in our studies, they would have performed just as the children did, extending the novel labels when they were taught with polysemous meanings but not homophonous meanings. In the case of adults, however, this pattern of extension would be difficult to interpret since adults are far more likely than young children to apply their meta-linguistic knowledge to a task.

Finally, a third possibility is that the difference in findings is a consequence of the different polysemous words tested in the two studies. The polysemous words tested by Klein and Murphy (2001) were not controlled for the ways in which those words' meanings were related to one another (see Beretta et al., 2005; Klepousniotou et al., 2008). This is especially important in light of other studies that have suggested that different forms of polysemy are processed differently from one another (see, e.g., Frazier & Rayner, 1990; Frisson & Frazier, 2005; Frisson & Pickering, 1999; Klepousniotou et al., 2008). For example, a recent study that used the same methods as Klein and Murphy (2001) distinguished between polysemous words with meanings that had a "high", "moderate", or "low" degree of semantic overlap, and found that while polysemous meanings with moderate or low overlap (which tended to be metaphorically related to one another; e.g., the meanings of *atmosphere* in 'tense atmosphere' and 'polluted atmosphere') did not prime one another, polysemous meanings with high overlap (which tended to be metonymically related to one another; e.g., the meanings of *book*) did (Klepousniotou et al., 2008). These results suggest that the two classes of models that we have described—the List Model, and the Generative Models—may both apply, but to different kinds of polysemous words. Thus, one possibility is that the form of polysemy we tested happens to be one of the forms of polysemy that does rely on generative structures. An important task for future research is to examine just what aspects of the relation between a pair of polysemous meanings help determine how those meanings are represented and processed.

7. Conclusion

Do perceived relations among polysemous meanings arise late in development, perhaps as a result of meta-linguistic reflection? Or do these relations play an implicit role in how polysemous words are

represented? The studies reported here provided evidence that early in development, the different meanings of polysemous words like *book* rely on a common representational base, while the different meanings of homophones have separate and unrelated representations. We conclude that children do not need to actively reflect upon polysemous meanings to abstract the relations between them. We suggest instead that these relations reflect the presence of generative lexical or conceptual structures that allow the meanings of polysemous words to shift.

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Appendix A

Examples of the test stories and critical statements from Experiment 1 for the "object-emphasis" and "content-emphasis" groups.

A.1. Emphasis: Object

Zoe loves to hear stories. Sometimes, her friends Cookie Monster and Ernie come over and read to her. First Cookie Monster reads her a story, and then Ernie reads one too. Look, Cookie Monster is looking for something in the bucket.

(Content mention) Cookie Monster chooses a quick story because he is tired!

(Object elaboration) Wow, Cookie Monster is carrying something that is very, very big. Can he even carry it? It must be heavy. This is the hugest thing I've ever seen. He's dragging it over so that he can read it, and finally, he's ready to read to Zoe.

But, Ernie wants to read his story now. So it's his turn. Now, *he*'s looking for something in the bucket.

(Content mention) Ernie chooses a slow story because he loves to read!

(Object elaboration) Look, Ernie is carrying something that is very, very small. It's so little he is going to have to use a magnifying glass to read it! Look, it's so small Ernie could almost put it in his pocket! Look how tiny it is! Now he's reading his story!

What happened in this story, Elmo?

Elmo: I know what happened! Ernie read the long book!

A.2. Emphasis: Content

Zoe loves to hear stories. Sometimes, her friends Cookie Monster and Ernie come over and read to her. First Cookie Monster reads her a story, and then Ernie reads one too. Look, Cookie Monster is looking for something in the bucket.

(Object mention) Wow, Cookie Monster is carrying something that is very small!

(Content elaboration) Oh, look! Cookie Monster picked out *Harry Potter*. This is going to take *forever*. Ernie starts reading, "Once upon a time..." and he keeps reading and *reading* and *reading*. He reads all night! Zoe even falls asleep! When he finishes, it is morning time! But Zoe wants to hear another story!

So, now Ernie is getting something from the bucket.

(Object mention) Oh look! Ernie is carrying something that is very big!

(Content elaboration) Ernie is going to read a story called 'The Happy Puppy.' Ernie is tired, so he chose a story that is very quick. Let's listen to the story! "The happy little puppy was very happy. The end!" Wow, Cookie Monster is all done. That story was so quick!

What happened in this story, Elmo?

Elmo: I know what happened! Ernie read the long book!

Appendix B

An example of the novel label training, test story, and critical statement from Experiment 4, for the "novel label" and "baseline" groups. No novel labels were taught or trained for children in the "baseline" group.

B.1. Novel label training (only for "Novel Label" group)

Would you like to hear another story?

Elmo: Yeah! Can we hear the story about *devos*!?

Oh Elmo, are you speaking Muppet language again? *Devos*?! What are *devos*?!

Elmo: You don't know what devos are? I'll show you! (*Brings out prop of a baseball bat*) This is a devo. This devo is made out of really thick wood: it's pretty heavy! I can use it to hit baseballs! This devo has a red handle and its made of light-colored wood. Can we hear the story of about devos now?

B.2. Story: Black bat (Devo)

So, this story is about Big Bird and Zoe.

Big Bird just got a new toy, and he can use it to hit baseballs really far!

It is such a pretty, light-colored toy. See. . .its made out of heavy wood. See? There's a handle here, and Big Bird loves to play baseball with it.

But look, Zoe is very happy because she just got a new pet!

What a dark-colored animal! Look at its wings, and its feet—its whole body is so dark! I'll bet its hard to see it when it flies around in the sky at night!

What happened in this story, Elmo?

Elmo: I know what happened! Zoe had a black bat (devo)!

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