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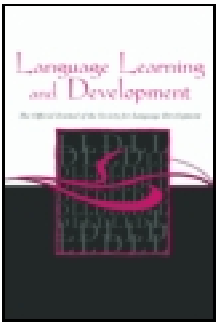

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Polysemy and the Taxonomic Constraint: Children's Representation of Words that Label Multiple Kinds

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Polysemy and the Taxonomic Constraint: Children's Representation of Words that Label Multiple Kinds

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How do children resolve the problem of indeterminacy when learning a new word? By one account, children adopt a *taxonomic assumption* and expect the word to denote only members of a particular taxonomic category. According to one version of this constraint, young children should represent polysemous words that label multiple kinds—for example, *chicken*, which labels an animal and its meat—as separate and unrelated words that each encode a single kind. Our studies provide evidence against this account: we show that four- and five-year-old children spontaneously expect that a word that has labeled one meaning of a familiar polysemous word will also label its other, taxonomically different meaning. Further, we show that children's taxonomic flexibility is importantly constrained—children do not expect a word to label thematically-related meanings (e.g., *chicken* and *egg*), or the unrelated meanings of homophones (e.g., *bat*[animal] and *bat*[baseball]). We argue that although children are initially guided by the taxonomic constraint when pairing word forms with meanings, they nonetheless relate the taxonomically-different meanings of polysemous words within lexical structure. Thus, for even young children, a single word can label multiple kinds.

Imagine that a child hears her mother use an unfamiliar word while looking at an armchair: "Look at that *chair*!" From the child's perspective, the meaning of *chair* is under-determined (Goodman, 1955; Peirce, 1957; Quine, 1957, 1960). It could refer to an unbounded number of things, including not only the chair itself but also a part of the chair, or some event in which the chair plays a role. Even if the referent can be pinned down, the meaning of the term, and how it should be extended beyond the initial referent, remains indeterminate. There is nothing to rule out the possibility, for example, that *chair* refers to chairs and anything else associated with them (e.g., to cushions, tables) or to chairs until next Friday, but to ducks thereafter. It is widely agreed, then, that children must limit the candidate meanings that they consider (Bloom, 2000; Carey, 1982; Macnamara, 1982; Markman, 1989; Pinker, 1984; Xu & Tenenbaum, 2007).

One way in which children might narrow their hypothesis space is by assuming that nouns label categories within structured taxonomies, a strategy which Markman termed the *taxonomic*

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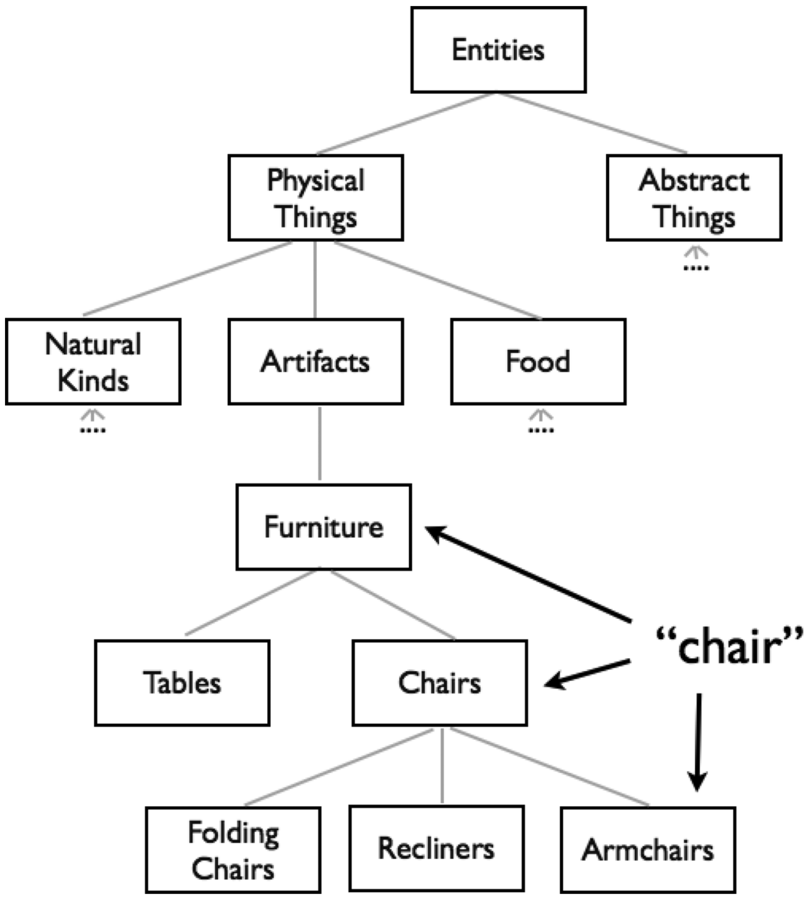

FIGURE 1 A depiction of how children might assign a meaning to an unfamiliar word "chair," given a taxonomic bias.

assumption (Markman & Hutchinson, 1984; Markman, 1989). By this account, children expect nouns to be extended to all and only members of a particular ontological kind. Thus, if the child assumes that *chair* is a basic level term, they should apply it to other kinds of chairs. Alternatively, they may assume that it is a superordinate term, and use it to label other kinds of furniture (see Figure 1). However, the child should *not* extend the word to label members of a different ontological kind, such as a carrot—unless she believes that it labels a node in the taxonomy that is a parent of both chairs and carrots.

Previous work indicates that children are indeed guided by a taxonomic assumption when learning nouns (see, e.g., Markman & Hutchinson, 1984; Waxman & Gelman, 1986; Waxman & Kosowski, 1990). For example, Markman and Hutchinson (1984) taught children that a novel label *dax* referred to a cow and then asked them to find another *dax*, presenting them with two additional items. Children preferred to extend *dax* to the taxonomically-related item (e.g., a pig) over a thematically related item (e.g., milk). This is striking because thematic relations between objects—for example, the relation between an animal and something it produces—are otherwise very salient to children. For example, when Markman and Hutchinson (1984) showed children a cow and asked them "to find another one," they reliably chose the thematically related item—the milk (see also Smiley & Brown, 1979; see Waxman & Namy, 1997, for a discussion of factors promoting thematic responding). Many studies have documented a taxonomic constraint on word learning (see, e.g., Waxman & Gelman, 1986; Waxman & Hall, 1993; Waxman & Kosowski, 1990), and this constraint is incorporated into contemporary models of word learning (e.g., Xu & Tenenbaum, 2007).

One potential problem for the taxonomic constraint is that words are often used to label multiple, taxonomically different kinds. For example, the word *chicken* can denote an animal (e.g., *The chicken drank some water*) as well as the meat derived from that animal (e.g., *The chicken was tasty*). *Chicken* is an example of a larger pattern in English in which words for natural kinds can also be used to refer to the food derived from them. This pattern includes words for animals (e.g., *chicken, turkey, fish*) as well as plants (e.g., *corn, broccoli, lettuce*).[1] For proponents of a taxonomic constraint, it is important that natural kinds and food are distinguished into two distinct taxonomic categories because these meanings are often differentiated by a fundamental ontological distinction between objects (e.g., a chicken animal is a kind of object) and substances (e.g., chicken meat is a kind of substance derived from that object). An object/substance distinction figures importantly into how a taxonomic constraint narrows children's hypotheses about word meanings (see Markman, 1989; Soja, Carey, & Spelke, 1991). For example, if children did not differentiate these concepts, they could confuse a label for a chicken animal as denoting an arbitrary portion of chicken substance (see Quine, 1957, 1960).

Beyond the relation between natural kinds and the food derived from them, English includes many other forms of polysemy in which words systematically encode multiple kinds (see Table 1).[2] Indeed, by some accounts, polysemy is the rule, rather than the exception for words (e.g., Pustejovsky, 1995). Thus, polysemy is an important explanandum for language acquisition, and potentially a challenge to extant accounts, like the taxonomic assumption.

In this article, we consider the implications of polysemy for the taxonomic constraint. Previous studies have formulated the taxonomic assumption as a constraint on how children initially pair word forms with meanings (see, e.g., Markman & Hutchinson, 1984; Waxman & Gelman, 1986; Waxman & Hall, 1993; Waxman & Kosowski, 1990). However, there has been little discussion of how these pairings might be structured in the mental lexicon and what this would predict about how children represent words that label multiple kinds, as polysemous words often do.

One possibility is that the form-meaning pairs that children construct—which are governed by the taxonomic constraint—are listed as separate and unrelated words in the lexicon. By this

[1] Although there are exceptions to this pattern—e.g., *cow* and *pig* do not refer to the meat derived from those animals in English—this form of polysemy is productive. Thus, if a novel animal called a *blicket* is discovered in the future, we would have no trouble using *blicket* to refer to the meat derived from the animal—*the blicket is well-seasoned*. Indeed, by some accounts, such uses of words are generated by a "grinding" rule that allows any word for an object to label the substance created by grinding that object up (e.g., "There is *desk* all over the floor"; see Pelletier & Schubert, 1989). The existence of exceptions to such patterns can be explained via blocking mechanisms, similar to those applying to morphological rules (e.g., *went* blocks the application of the regular past-tense rule to *go*).

[2] Not all forms of polysemy involve cases in which words cross basic ontological distinctions, such as the distinction between objects and substances. For example, *dog* can be used to describe a specific animal (e.g., "The dog is eating") as well as the species to which that animal belongs (e.g., "The dog has been domesticated for many centuries."). Whether the meanings of such words count as ontologically different more or less depends on one's particular theory of ontological structure.

TABLE 1
Forms of Polysemy in English

Relation and Participating Words	*Examples*
Natural Kind/Food (*chicken, turkey, corn*, etc.)	The *chicken* walked outside/ The *chicken* was delicious
Material/Product (*glass, tin, iron*, etc.)	Watch out for the broken *glass*/ She drank juice from the *glass*
Object/Content (*book, magazine, DVD*, etc.)	The *book* is too heavy to carry/ The *book* is very provocative
Container/Contents (*pot, bowl, box*, etc.)	She cleaned the *pot* using a sponge/ She stirred the *pot* with a spoon
Space/Time (*short, in, around*, etc.)	The couch is too *short*/ Our time together was too *short*
Body Part/Object Part (*leg, arm, back*, etc.)	He broke his *leg* while skiing/ That chair has a broken *leg*
Person/Product (*Picasso, Camus, Mozart*, etc.)	*Picasso* was born in 1881/ That museum has a *Picasso*
Place/Institution (*White House, Wall Street, City Hall*, etc.)	The *White House* is being painted/ The *White House* will make a decision
Place/Event (*Vietnam, Waterloo, Woodstock*, etc.)	*Vietnam* shares a border with China/ He championed civil rights during *Vietnam*

account, a single word for a child can only encode a single taxonomic category; words that appear to label multiple kinds in fact correspond to distinct and unrelated lexical entries. Thus, in this view, children may represent the taxonomically different meanings of polysemous words as unrelated words, much as they do unrelated homophones such as *bat* (i.e., baseball equipment vs. animal) or *bank* (i.e., financial institution vs. river's edge). This view of polysemy is consistent with a traditional view of the lexicon as an unstructured list of items that each binds together a word's linguistic information (e.g., its phonological, morphological, syntactic, and semantic properties).

An alternative possibility is that the form-meaning pairs that children acquire are not listed as unrelated items, but are instead systematically related within the lexicon. For example, the different meanings of polysemous words may not correspond to separate lexical items but may instead be embedded within common, structured representations (Pustejovsky, 1995). Even if the different meanings of polysemous words are represented separately, they may still be derived from or linked to one another by rule-like devices (see, e.g., Copestake & Briscoe, 1995). More generally, then, the lexicon may include structures that allow words to shift between taxonomically-different meanings in constrained ways. If this is the case, then early in life, children may not treat the taxonomically different meanings of polysemous words as unrelated words, but may instead *expect* words to label these different meanings. This expectation could even guide children's early hypotheses about word meaning, explaining the presence of polysemy in language.

In the present article, we provide evidence for this second account. We show that four- and five-year-olds spontaneously expect that a novel word (e.g., *blicket*) that has labeled one meaning of a familiar polysemous word—e.g., *corn*[plant]—will also label its other, taxonomically different meaning—*corn*[food]. This suggests that children do not treat the taxonomically different meanings of a familiar polysemous word as unrelated words but instead as the related uses of a single word. We demonstrate that children adopt this expectation even when they have the option of instead extending the novel word taxonomically—for example, from a corn plant to another kind of plant. Further, we document that children's taxonomic flexibility is importantly constrained: children do not expect a single word to label the thematically related meanings of familiar words (e.g., *chicken* and *egg*), or the unrelated meanings of homophones (e.g., *bat*[animal] and *bat*[baseball]).

Our results clarify the role of the taxonomic constraint in word learning. We argue that although a taxonomic constraint applies to how children initially pair forms with meanings, it does not apply to how children ultimately relate those pairings within lexical structure. In what follows, we first review previous work that is relevant to how children represent the meanings of polysemous words. Then, we describe the form of polysemy that our studies explore.

Previous Work

Previous studies of language development indicate that two- to five-year-old children produce and comprehend novel uses of words that extend words to ontologically different meanings (Bowerman, 1983; Clark, 1982; Rabagliati, Marcus, & Pylkkanen, 2010). For example, children innovatively use words for space to describe time (*Mommy, can I have some reading behind dinner*; Bowerman, 1983), words for objects to describe actions involving those objects (*Don't broom my mess*; Clark, 1982), and words for abstract content to describe objects (e.g., agreeing that a *movie* can be round; Rabagliati et al., 2010). These innovations have precedent in how familiar words are used in English; for example, the use of *broom* to label an action mirrors the use of familiar words like *shovel* and *hammer*, which also label actions involving the objects they name. This raises the possibility that children not only deploy structures that relate the taxonomically different meanings of familiar words, but also use those structures to generate novel meanings.

However, innovations do not provide strong support for this hypothesis because it is not clear that they reflect lexical representations. Indeed, on some accounts, innovations arise from pragmatic strategies that are used to communicate when lexical resources are insufficient (see, e.g., Clark, 1982; Clark & Clark, 1979). Such strategies often result in uses that diverge from stable lexical representations. For example, an adult might call a flagellum "a whip" or a child might call a horse "a doggie," not because their meaning of "whip" includes flagellums or their meaning of "doggie" includes horses but instead because they lack labels for the entities they wish to refer to (see Naigles & Gelman, 1995). If innovations are not based on lexical representations, they cannot inform how children represent words with taxonomically different meanings.

In past work, we explored whether four-year-olds represent the taxonomically different meanings of familiar polysemous words with unrelated lexical items or instead relate them within lexical structure. Our approach was to test whether children distinguish between polysemous words like *book*—which label physical objects and the abstract content they contain (see Table 1)—and homophones like *bat*, which are thought to correspond to unrelated lexical items

(Srinivasan & Snedeker, 2011). We taught children a novel label from "muppet" language (e.g., *blicket*) that corresponded to one known meaning of a polysemous word (e.g., to the content meaning of *book*) or to one known meaning of a homophonous word (e.g., to the baseball meaning of *bat*), and observed how children would interpret that novel label after hearing a confederate puppet use it to label the other meaning of the word (the object meaning of *book*, or the animal meaning of *bat*). Children shifted their interpretations of the novel labels between the taxonomically different meanings of the polysemous words—for example, accepting the puppet's use of the phrase "long *blicket*" to refer to a physically long book. However, they rejected extensions between homophonous meanings—for example, rejecting the puppet's use of "black *blicket*" to label an animal bat.

These results suggest that, while children represent homophones as unrelated words, they relate the taxonomically different meanings of polysemous words within lexical structure, consistent with previous evidence that adults also represent and process polysemous words and homophones differently (see, e.g., Azuma & Van Orden, 1997; Beretta, Fiorentino, & Poeppel, 2005; Duffy, Morris, & Rayner, 1988; Frazier & Rayner, 1990, Frisson & Pickering, 1999; Klepousniotou & Baum, 2007; Klepousniotou, Titone, & Romero, 2008; Pylkkanen, Llinas, & Murphy, 2006; Rodd, Gaskell, & Marslen-Wilson, 2002). However, due to several limitations in our studies, children could have extended the novel labels between the polysemous meanings without actually relating those meanings in lexical structure. First, unlike homophones, the meanings of the polysemous words we tested (e.g., the abstract and physical meanings of *book*) are typically encountered in the same contexts, for example, when one is read a book, a physical book is present. Thus, children's ability to shift words between these meanings could have been driven by contextual associations rather than properties of lexical structure. Second, our studies only compared children's extension between polysemous meanings to their extension between unrelated homophones. Thus, children could have shifted between the polysemous meanings simply because they are conceptually related.

Finally, even if children's extension between polysemous meanings was not driven by associations or by conceptual relatedness, it still may not reveal that children have lexical strucures that relate those meanings. Critically, if children have formed such structures, they should *expect* a word that labels one meaning of a familiar polysemous word—for example, *book*[content]—to also label its other meaning—*book*[object]. However, our previous results do not show that children expected the novel words to label multiple, taxonomically different meanings. When children were taught a novel word, they may have only linked it to a single kind, for example, *book*[content], and may only have extended it after hearing the confederate puppet use it to label the other kind—*book*[object]. Thus, children may represent the taxonomicallydifferent meanings of a polysemous word as unrelated lexical items, and only extend a word between them when given evidence that the word can be extended.

Chicken: Food or Fowl?

The present studies test children's representation of polysemous words like *chicken* and *corn*. This form of polysemy offers a means to overcome limitations of our previous studies and explore compelling questions regarding the relationship between conceptual relatedness and polysemy.

First, unlike the physical and abstract meanings of words for representational objects such as *book*, the different meanings of words for natural kinds typically do not overlap contextually. For example, while chicken animals are typically encountered on farms, chicken meat is typically encountered at the dinner table. Thus, the extension of a word between these different meanings is unlikely to be driven by contextual associations.

Second, although the relation between a natural kind and its food licenses polysemy in English, the thematic relation between a living thing and an item it produces does not—for example, no single word expresses “chicken and egg” or “cow and milk.” This contrast provides a natural test case of whether children understand that only some conceptual relations support polysemy and allow words to be extended between taxonomically different meanings. This is critical, because the majority of candidate meanings that include taxonomically different items are implausible meanings for words, for example, “backpacks and burglars” (see Markman, 1989). Previous work indicates that children between ages three and seven are still working out the limits on polysemy (Rabagliati et al., 2010). This in part motivated our choice of four- and five-year-olds for our studies.

Finally, polysemous words for natural kinds provide excellent cases for testing the relationship between children’s developing conceptual knowledge and their representations of polysemous words. Perhaps because the natural kind and food meanings of these words are typically encountered in different contexts, children are often unaware of the relations between them. For example, several anecdotes have suggested that preschool-aged children do not know that chicken meat comes from a chicken (see Foer, 2010; Gelman, 2003). Prior to understanding that a particular kind of food is derived from a particular natural kind, children may represent the two meanings as unrelated words, like homophones. It is an open question as to whether young children use newly acquired knowledge, for example, knowledge that chicken meat comes from a chicken, to relate the meanings of polysemous words within lexical structure.

The Present Studies

If children relate the taxonomically different meanings of a polysemous word within lexical structure, they should expect a word that labels one meaning of a polysemous word to also label its other, taxonomically different meaning. The present studies use a series of different methods, each more conservative than the other, to test this prediction. We contrast it with the prediction that for children a single word can only label a single, taxonomically embedded kind. Each of our experiments also tests whether children’s taxonomic flexibility is constrained by comparing extension between the meanings of polysemous words (e.g., between *chicken*[animal] and *chicken*[meat]) to extension between thematically related meanings that do not license polysemy (e.g., between *chicken* and *egg*). Finally, to test whether extension between the meanings of polysemous words is promoted by the phonological overlap of those meanings alone, Experiment 3 also tests for extension between pairs of homophones (e.g., between *bat*[baseball] and *bat*[animal]).

EXPERIMENT 1

In this experiment, using a Truth-Value Judgment task (Crain & Thornton, 1998; Gordon, 1996), we examined whether children accept extensions of words for natural kinds to refer to the food derived from them. In critical trials, children in the polysemy group were taught a novel word that labeled a single meaning of a known polysemous word. We then observed whether they would accept an extension of the novel word to the other known meaning of the polysemous word, if the context made that meaning more relevant. For example, in one critical trial, children were shown a prop of a chicken animal and were taught that a novel word labels it—for example, "In muppet language, this is called a *tima*!" They were then shown a story in which a character named Zoe placed a chicken animal in a coop and then placed chicken meat on the grill, without using the word "chicken" or *tima*. At the end of this story, the puppet Elmo, who had been watching the story along with the child said: "I know what happened! Zoe put the *tima* on the grill." We reasoned that if children stick to the taught meaning of *tima*—that is, *chicken*[animal]—they should reject Elmo's statement, because Zoe put the chicken animal on the coop and not on the grill. But if children extend *tima* to *chicken*[meat], they should accept his statement, because Zoe did put chicken meat on the grill (see Figure 2, "Truth-Value Judgment"; Appendix A).

We compared children's possible extension between polysemous meanings to their extension between thematically related meanings that do not license polysemy. Children in the thematic-relation control group, on critical trials, were taught a novel word that referred to a living thing, for example, to a chicken. We then examined whether they would accept an extension of the word to label a product created by that thing (e.g., an egg), a relation that does not license polysemy for adults (see Appendix A). We expected that children would reject extensions of the novel words if they understand that words can only be extended across taxonomically-different categories in specific and constrained ways.

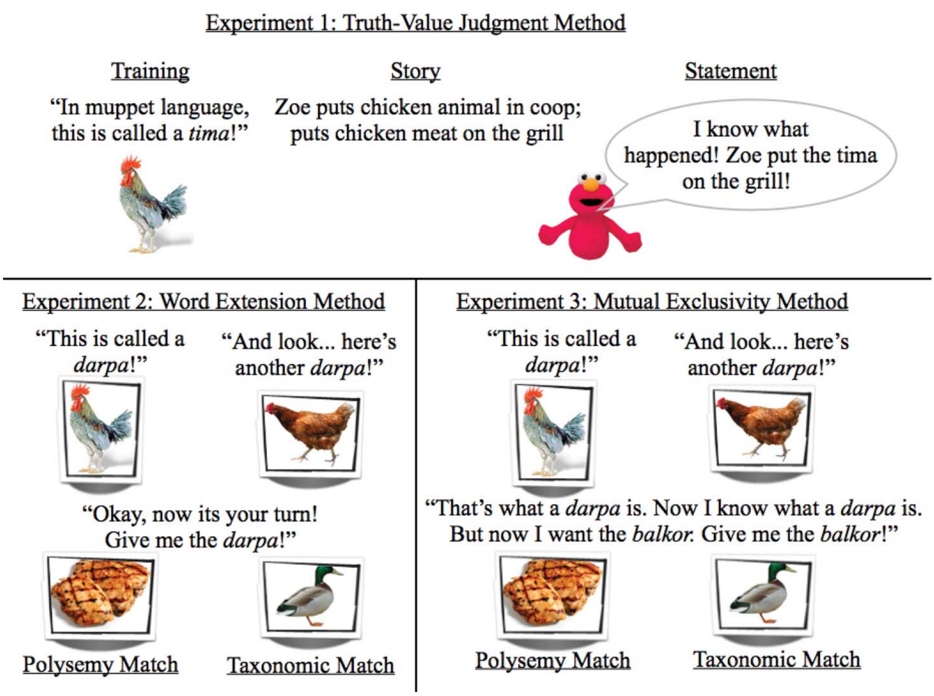

FIGURE 2 A depiction of the methods used in our three experiments. (Color figure available online.)

Method

Participants

The participants were 32 children (15 girls) between the ages of 4;3 and 5;8 (mean age 5;0). An additional nine children participated but were excluded for missing the initial training items that were used to evaluate their understanding of the task (6), for failing to identify the props that were used in the critical items (2), or for missing two or more of the posttraining filler trials (1) (which suggested that they were not paying attention). Twenty-two children (10 girls) participated in the polysemy condition, ranging in age from 4;3 to 5;8 (mean age 4;11), and 10 children (5 girls) participated in the thematic-relation group, ranging in age from 4;3 to 5;8 (mean age 5;3). Children were either brought into the lab or recruited from and tested at daycares or museums in the Cambridge, Massachusetts, area. All children received a token gift for their participation.

Procedure

Children only received a critical story in the comprehension task if they knew each of the polysemous or thematically related meanings that were featured in that story. To assess knowledge of each of these meanings, all children were pretested on a set of 20 items in an elicited production task. Children in the polysemy group were tested on six pairs of polysemous meanings (*chicken*(animal)/*chicken*(meat), *corn*(plant)/*corn*(food), *eggs*(in unbroken shells)/*eggs*(food), *turkey*(animal)/*turkey*(food), *coffee*(beans)/*coffee*(drink), *fish*(animal)/*fish*(food)) with 8 filler words interspersed (e.g., *swing, baby*), and children in the thematic-relation group were tested on five pairs of thematically related words (*chicken*(animal)/*eggs*(in shells), *cow*/*milk, bird*/*nest, bee*/*honey, spider*/*web*), with 10 filler words interspersed. The critical trials were arranged such that the polysemous or thematically related meanings words were not tested within four trials of each other. For each trial, the experimenter showed the child a picture of the target object/animal and began a sentence that stopped just short of producing the target word (e.g., "This animal lives on a farm in a coop, it's called a ______"). Responses were only judged correct if children produced the desired word, rather than a synonym or subordinate term (e.g., responses such as *rooster* and *hen* were not judged correct). The children were shown up to four critical stories in the comprehension task, but only received a particular story if they had been able to identify the pair of polysemous or thematically related meanings relevant to that story in the pretest. On average, children in the polysemy group received 3.1 critical stories, and children in the thematic-relation group received 3.5 critical stories.

Before the comprehension task began, children were told that Elmo was a little baby that often made mistakes, and so they needed to help him by rewarding him when he was right (with a cookie), and reminding him when he was wrong (with a dirty rag). Children were also told that Elmo sometimes uses words from muppet language, and that they should try their best to understand what those words mean. Before receiving any critical stories, the children received between two and four training stories, to ensure that they could correctly judge Elmo's statements when they were unambiguously true or false. If they needed it, children were given training on making each of these kinds of judgments once. Children who could not ultimately make these judgments without assistance were excluded ($n = 6$). The children were then shown up to four critical stories, which alternated with additional filler stories, and which were administered in a fixed order (e.g., in the polysemy condition, the *chicken* story was always presented before the *corn* story, which was always presented before the *eggs* story, and so on).

Once children had completed the comprehension task, they were tested on their knowledge of the relations between the polysemous meanings or thematically related meanings that had appeared in the critical stories. Children in the polysemy group were asked to name pictures depicting the food meanings of the polysemous words, and children in the thematic-relation group were asked to name pictures depicting the items produced by the animals. These were the same pictures that had been used in the pretest. After they identified the pictures, children were asked questions to determine if they knew how those things or substances are created (e.g., Where does chicken come from?). If children's answers did not demonstrate an understanding of the relevant relation (e.g., if they said that chicken comes from the store), they were asked additional questions (e.g., Where does the store get it from?) until they failed to provide additional information.

Materials

Before each story of the comprehension task, the first experimenter would ask Elmo what story he wanted to hear next, and Elmo would respond with a request using a novel word (e.g., "I want to hear the story about *gulicks*!"). The first experimenter would then suggest that Elmo must be speaking muppet language and would ask Elmo to explain the word's meaning. Elmo would then teach the child what the novel word meant, using a physical prop as an example referent. After the story, Elmo would use the novel word in describing what had happened in the story. After being asked to judge Elmo's statement and, if necessary, to justify this judgment, children were asked to guess what Elmo's novel word meant.

The first training stories children saw were included to ensure that they could extend a novel word to another object from the same basic-level category (same-category training stories) and stick to the trained meaning when a novel word was used to refer to an object of a different basic-level category (different-category training stories). For example, in the first different-category training story, Elmo taught the children that the novel word *gulick* referred to crayons, using a crayon as a physical prop: for example, "This is a *gulick*! You can draw pictures with it, and they come in all kinds of pretty colors." The children were then told a story in which Ernie put a crayon in a box and put a book on top of a table. In this story and in all of the other stories, the character's actions were described without using the muppet word (e.g., *gulick*), or its corresponding English word (e.g., *crayon*; see Appendix B). At the end of the story, Elmo said "I know what happened, Ernie put the *gulick* on the table!" If children did not reject Elmo's statement, justify why it was wrong, and explain what the novel word meant, they were given feedback and were subsequently given another different-category training story, which they had to accurately respond to without assistance in order to continue.

Children also had to accurately judge a same-category training story in order to proceed to the critical trials. For example, in the first same-category training story, children were taught that the novel word *gazzer* referred to dogs, and in the story, Big Bird gave a dog to Zoe, and also gave a dog to Cookie Monster (see Appendix B). At the end of the story, Elmo said, "I know what happened, Big Bird gave the *gazzer* to Cookie Monster." We expected children to judge Elmo's statement correct, even though he had only described part of what had happened—Big Bird *did* give a dog to Cookie Monster, but he also gave one to Zoe. If the children did not judge the first

TABLE 2
Critical Items of the Polysemy Condition of Experiment 1

Item	*Events Occurring in Story*	*Statement*
Chicken (*Tima* = Chicken (animal))	Zoe puts the chicken(animal) in the coop; puts the chicken (meat) on the grill	"Zoe put the tima on the grill!"
Corn (*Devo* = Corn (plant))	Big Bird puts the corn(plant) in the box; puts the corn(kernels) on the plate	"Big Bird put the devo on the plate!"
Eggs (*Widgets* = Eggs (in unbroken shells))	Prairie Dawn gives eggs(in unbroken shells) to Ernie; gives eggs(fried) to Zoe	"Prairie Dawn gave the widgets to Zoe!"
Turkey (*Blicket* = Turkey (animal))	Cookie Monster puts turkey(animal) on grass; puts the turkey(meat) on the table	"Cookie Monster put the blicket on the table!"
Fish (*Bambo* = Fish (animal))	Ernie gives the fish(animal) to Prairie Dawn; gives the fish(meat) to Big Bird	"Ernie gave the bambo to Big Bird!"
Coffee (*Jocko* = Coffee (beans))	Big Bird puts the coffee(beans) in the box; puts the coffee(drink) on the table	"Big Bird put the jocko on the table!"

same-category training story in this way, they were given training and then given a second same-category training story to judge. Only children that could without assistance correctly judge both a same-category training story and a different-category training story received the critical stories. Thus, the children included in the analyses had each demonstrated an understanding of the task.

Each critical story in the polysemy condition was followed with a statement by Elmo containing a novel word. This novel word had initially labeled the base meaning of the critical polysemous word (e.g., the animal or plant meaning of the word; see Table 2). For example, in one case, children were taught that *tima* referred to a chicken animal, and in the story Zoe put a chicken animal in a coop and put chicken meat on the grill (see Appendix A). Neither the critical novel word (e.g., *tima*) nor the underlying polysemous word (e.g., *chicken*), was used in the story, and thus neither was modeled for the child prior to their judgment of Elmo's statement. At the end of this story, Elmo said: "I know what happened! Zoe put the tima on the grill!" Thus, on the taught meaning of *tima* (*chicken*[animal]), Elmo's statement was false, but on the extended polysemous meaning (*chicken*[meat]), Elmo's statement was true (see Figure 2, "Truth-Value Judgment"; Appendix A). All of the critical stories were structured in this way, such that acceptance of Elmo's statement served as a measure of children's willingness to extend the meaning of the novel word. However, if children stuck to the taught meaning of the novel word, they could plausibly reject Elmo's statement (e.g., they could say that Zoe put the tima in the coop, not on the grill). The critical items in the polysemy condition are shown in Table 2.

In the critical stories of the thematic-relation condition, children were taught that the novel word referred to a living thing, and we observed whether children would accept an extension of the novel word to something that this thing creates. For example, in one case, children were taught that *tima* referred to a chicken animal, and in the story, Zoe put a chicken animal on the grass, and put an egg in the box (see Table 3; Appendix A). Elmo then said: "I know what happened! Zoe

TABLE 3
Critical Items of the Thematic-Relation Condition of Experiment 1

Item	*Events Occurring in Story*	*Statement*
Chicken/Egg (*Tima* = Chicken(animal))	Zoe puts the chicken(animal) on the grass; puts the egg in the box	"Zoe put the tima in the box!"
Cow/Milk (*Widget* = Cow)	Prairie Dawn puts the cow on the grass; puts the milk on the table	"Prairie Dawn put the widget on the table!"
Bird/Nest (*Jocko* = Bird)	Cookie Monster puts the bird in the house; puts the nest on the tree	"Cookie Monster put the jocko on the tree!"
Bee/Honey (*Bambo* = Bee)	Ernie puts the bee on the flower; puts the honey on the table	"Ernie put the bambo on the table!"
Spider/Web (*Mojo* = Spider)	Prairie Dawn puts the spider on the flower; puts the web in the box	"Prairie Dawn put the mojo in the box!"

put the tima in the box!" On the original meaning of *tima, chicken*[animal], Elmo's statement was false, but if children extended the novel word to the product of the animal, *egg*, Elmo's statement was true. The critical items of the thematic-relation condition are shown in Table 3. Across the two conditions, Elmo's statements always used the definite determiner (e.g., Zoe put *the* tima on the grill), so that the novel word remained ambiguous with respect to count/mass syntax (as it had to, to remain compatible with the different meanings of some of the items, such as *chicken*).

In each critical trial, after asking children to judge Elmo's statement and offer a translation of what his novel word meant (e.g., What does *tima* mean?), children were also asked to identify the object in the story that depicted the extended polysemous meaning (e.g., the chicken meat) or thematically related meaning (e.g., the egg) of the original meaning of the novel word (e.g., *chicken*[animal]). This was done to ensure that these props depicted their intended meanings. If children did not recognize, for example, that what Zoe put on the grill was chicken meat, they could not be expected to agree that "Zoe put the *tima* on the grill," even if they can, in principle, extend *tima* between chicken[animal] and chicken[meat]. We excluded critical trials in which the children could not identify these props (22% of items in the polysemy condition, and 3% in the thematic-relation condition). Removing these trials led to the exclusion of two children in the polysemy condition because they did not contribute usable data on any critical trials. However, independent of whether these data were excluded, the results were broadly consistent (see below).

Additional control stories alternated with the critical stories to ensure that performance on the critical stories was not affected by a tendency to perseverate with acceptance or rejection of Elmo's statements. Accordingly, if children had just accepted Elmo's statement following a critical story, they were given a different-category control (for which Elmo's statements were unambiguously false); if they had rejected Elmo's statement, they were given a same-category control (for which Elmo's statements were unambiguously true). Children were not given feedback on these control trials, and in the analyses presented below their performance on these trials is used as a comparison to their performance on the critical trials. A list of both kinds of control items is given in Appendix C.

Results and Discussion

Because our data were unlikely to be normally distributed (e.g., due to our small sample size, and the categorical nature of our data), we conducted only nonparametric analyses in this experiment and in the other experiments reported here (see Howell, 2002).[3] Our dependent measure was the proportion of times children accepted Elmo's statement, as this was an indication of whether they had extended the meaning of the novel word.

Children in the polysemy group accepted Elmo's statements following the critical stories more often than chance ($M = .75$, $SE = .07$; Wilcoxon $T = 24$, $n = 18$, $p < .01$). Eight of 13 children accepted Elmo's statement in the *chicken* item, 12 of 14 in the *corn* item, 14 of 17 in the *eggs* item, 7 of 11 in the *turkey* item, and 1 of 2 in the *fish* item. These results indicate that children were able to shift the meaning of the novel word from its original meaning to another, taxonomically-different meaning of the underlying polysemous word. Importantly, this pattern of extension is unlikely to result from the fact that polysemous meanings share phonological labels. In our previous work we found that, in a similar task, children reject extensions of novel words between homophones, which also share phonological labels but are thought to be unrelated words (see Srinivasan & Snedeker, 2011). Thus, children treat polysemous words differently from homophones, and do so even when the meanings of polysemous words pick out distinct referents that arise in different contexts.

Our results also suggest that children's extension between polysemous meanings cannot be explained merely by the fact that polysemous meanings are conceptually related. In contrast to children in the polysemy group, children in the thematic-relation group accepted Elmo's statements on the critical trials less often than chance, $M = .16$, $SE = .10$; $T = 6.5$, $n = 10$, $p < .05$, and less often than did children in the polysemy group, Mann Whitney $U = 27.5$, $n = 32$, $p < .001$.[4] Only 2 of 8 children accepted Elmo's statement in the *chicken/egg* item, 1 of 9 in the *cow/milk* item, 0 of 8 in the *bird/nest* item, 0 of 7 in the *bee/honey* item, and 0 of 2 in the *spider/web* item. Thus, children in the thematic-relation group rarely extended the novel words between thematically related meanings that are not polysemous in English. This was despite the fact that children were readily able to express the relations between these meanings during the posttest ($M = .98$, $SE = .03$), and did so even more than did the children in the polysemy group ($M = .62$, $SE = .08$; $U = 175.5$, $n = 32$, $p < .005$). That children were not willing to extend novel words among the thematically related meanings is consistent with previous work (Markman & Hutchinson, 1984; Waxman & Gelman, 1986; Waxman & Kosowski, 1990) and suggests that children place constraints on their nontaxonomic word extension.

The responses of children in the polysemy group in the post-test indicate that knowledge of the relations between polysemous meanings is still developing at this age. Consistent with previous anecdotes (Foer, 2010; Gelman, 2003), many children had difficulty expressing where meat

[3] 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.

[4] We also conducted an analysis with the full test data, including those items for which children could not identify the prop depicting the extended polysemous or thematically related meanings. As with the analysis of the reduced data, children in the polysemy group extended the novel word between the polysemous meanings reliably more than chance ($M = .71$, $SE = .07$; $T = 41.5$, $n = 21$, $p < .01$) and reliably more than did children in the thematic-relation group ($M = .18$, $SE = .10$; $U = 33$, $n = 34$, $p < .001$).

comes from: 30% (n = 11) failed to say that turkey comes from a turkey, 46% (n = 13) failed to say that chicken comes from a chicken, and 100% (n = 3) failed to say that fish comes from a fish. In contrast, only 15% (n = 14) failed to say that corn kernels comes from a plant, and 25% (n = 17) failed to say that a fried egg comes from an eggshell or a chicken. To examine whether knowledge of these relations predicted children's extension of the novel words, and thus, whether children use newly-acquired knowledge to relate polysemous meanings within lexical structure, we compared children's responses on the post-test to their responses in the comprehension task. Across items, children more often extended novel labels when they could express relations between the relevant polysemous meanings (M = .77, N = 39) compared with when they could not (M = 0.63, N = 19). However, chi-square tests did not find reliable relationships between knowledge of the relations and extension of the novel words for individual items (chicken: $\chi^2(1, N = 13) = .62$, *ns*; corn: $\chi^2(1, N = 14) = .64$, *ns*; eggs: $\chi^2(1, N = 17) = .20$, *ns*; turkey: $\chi^2(1, N = 11) = .02$, *ns*), perhaps due to lack of statistical power.[5]

Finally, children in both groups showed that they understood the task well. The children gave principled judgments of the posttraining control stories they received, accepting Elmo's statements when the novel word was extended between objects from the same basic-level category (polysemy group: M = .95, SE = .05; thematic-relation group: M = 1.0), but rejecting his statements when the novel word was extended between objects from different basic-level categories (polysemy group: M = .16, SE = .08).[6] When children in the two groups did reject Elmo's statement, they were also able to provide appropriate justifications for their judgments, for both the critical stories (polysemy group: M = .93; e.g., 'Zoe put the tima in the coop'; thematic-relation group: M = 1.0; e.g., 'Zoe put the tima on the grass') as well as for the different-category filler stories (polysemy group: M = .96). Children in both groups were also able to provide appropriate translations of Elmo's novel words, on both the critical trials (polysemy group: M = .94; thematic-relation group: M = 1.0) and the filler trials (polysemy group: M = .92; thematic-relation group: M = 1.0).

Experiment 1 shows that children accept an extension of a novel word that has labeled one meaning of a polysemous word, that is, an animal or plant, to label another, taxonomically different meaning of that word, that is, the food derived from that animal or plant. However, children may not have initially expected the novel words to label multiple taxonomic kinds, as would be predicted if children relate the different meanings of a polysemous word within lexical structure. For example, having learned that *tima* labeled a chicken, children may have linked *tima* to a single kind and expected it to be extended taxonomically—for example, to label other chickens or other birds. Critically, they may only have extended *tima* to refer to chicken meat after hearing Elmo do so. In this alternative view, children may represent the taxonomically different meanings of polysemous words as unrelated lexical items, and may only accept an extension of a word between them when given evidence that the word can be extended. Experiment 2 explored how children expect these words to be extended when such evidence is not provided.

[5] Because of the small sample size for each of these analyses, we also conducted a parallel set of Fisher's exact tests, which similarly did not reach significance. No analyses were conducted for the fish and coffee items, due to insufficient data.

[6] Very few children in the thematic-relation group received the different-category filler trials, because these trials were only used when children had given a "yes" response on the previous critical trial, which they rarely did.

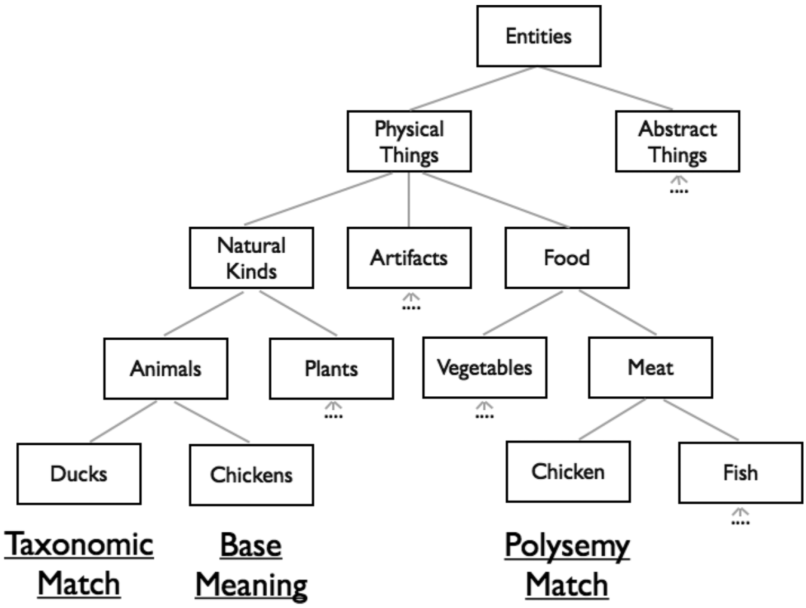

FIGURE 3 A depiction of the possible taxonomic status of the meanings depicted in the training and judgment phases of the *chicken* item (in the polysemy conditions of Experiments 2 and 3).

EXPERIMENT 2

In this experiment, we used a word extension task to explore how children prefer to extend the meanings of the words we tested in Experiment 1. For example, in a critical trial, children in the polysemy group were shown a picture of a chicken and told that in muppet language, it is called a *darpa*. Children were then shown another picture of a chicken that was also labeled a *darpa*. Then, we asked the children to give us the *darpa*, offering them a choice between a picture depicting a taxonomic match from the same super-ordinate category—a duck—and a picture depicting a polysemy match from a distinct branch of the taxonomy—chicken meat (see Figure 2, "Word Extension Method"; Figure 3). Using a similar design, Markman and Hutchinson (1984) provided evidence that children expect words to be extended taxonomically rather than thematically. In a critical trial of their study, children were first taught that a novel label *dax* referred to a cow, and were then asked to find another *dax*. Children preferred to choose a taxonomically-related item from the same super-ordinate category (e.g., a pig) relative to a thematically related item from a distinct branch of the taxonomy (e.g., milk).

Would children in the polysemy group prefer to extend the novel words taxonomically or across taxonomic categories? We reasoned that if children represent the taxonomically different meanings of polysemous words with distinct and unrelated lexical units that each encode a single kind, they may expect a word that labels one of these meanings to be extended taxonomically. Children should therefore choose the taxonomic matches rather than the polysemy matches. If, on the other hand, children relate the different meanings of a polysemous word within lexical structure, they should expect a word that labels one meaning of a polysemous word to also label its other, taxonomically different meanings. Children should therefore choose the polysemy matches, rather than the taxonomic matches.

As in Experiment 1, we compared extension between polysemous meanings to extension between thematically related meanings that are not polysemous: if children expect words to have taxonomically different meanings, do they only carry this expectation for meanings that are related in specific ways? In a critical trial, children in the thematic-relation condition were taught that *darpa* referred to a chicken animal and then had to choose whether *darpa* should extend to an egg (the thematically related match) or a duck (the taxonomic match). If children understand that only some conceptual relations license polysemy, they should not prefer the thematically related matches relative to the taxonomic matches.

Method

Participants

The participants were 30 children (14 girls) between the ages of 3;11 and 6;0 (mean age 5;1). 15 (7 boys) participated in the polysemy condition, ranging in age from 4;1 to 5;9 (mean age 5;1), and 15 (8 boys) participated in the thematic-relation condition, ranging in age from 3;11 to 6;0 (mean age 5;2). No children were excluded from the analyses below. Children were either brought into the lab or recruited from and tested at daycares or museums in the Cambridge, MA area. All children received a token gift for their participation.

Materials and procedure

Each of the trials in the task included a *training phase* as well as a *judgment phase*. In the training phase, children were shown a picture and taught that a novel word referred to the item depicted in that picture (e.g., “In muppet language, this is called a *tima*!”). This was then repeated with a second picture that depicted another item from the same basic-level category, giving children additional evidence that the novel word applied at the basic-level (“And see this? This is another *tima*!”). The experimenter then began the judgment phase of the trial by asking children to extend the novel word (“Now it’s your turn! Give me the *tima*!). The child was then shown two new pictures and had to choose between them.

In the polysemy condition, one of these pictures depicted a polysemous extension of the base meaning (the polysemy match), and the other depicted a meaning from the same super-ordinate category as the base meaning (the taxonomic match). As in Experiment 1, the base meanings corresponded to natural kinds, such as animals and plants, and the polysemy matches corresponded to the food derived from those natural kinds (see Figure 2, “Word Extension Task”; Table 4). In the thematic-relation condition, one picture depicted a meaning that was thematically related to—but not polysemous with—the base meaning (the thematically related match) and the other picture was a taxonomic match. As in Experiment 1, the base meanings corresponded to living things, and the thematically-related matches corresponded to products created by those things (see Table 5).

TABLE 4
Critical Pictures Presented in the Polysemy Condition of Experiments 2 and 3

Training Phase	*Judgment Phase*
Corn (plant)	Polysemy Match: Corn (kernels); Taxonomic Match: Orange Tree
Chicken (animal)	Polysemy Match: Chicken (meat); Taxonomic Match: Duck
Egg (in unbroken shell)	Polysemy Match: Egg (Fried); Taxonomic Match: Pear
Broccoli (plant)	Polysemy Match: Broccoli (Food); Taxonomic Match: Tree
Coffee (Beans)	Polysemy Match: Coffee (Drink); Taxonomic Match: Almonds

TABLE 5
Critical Pictures Presented in the Thematic-Relation Condition of Experiments 2 and 3

Training Phase	*Judgment Phase*
Chicken (Animal)	Thematic-Relation Match: Egg; Taxonomic Match: Duck
Bird	Thematic-Relation Match: Nest; Taxonomic Match: Mouse
Cow	Thematic-Relation Match: Milk; Taxonomic Match: Zebra
Bee	Thematic-Relation Match: Honey; Taxonomic Match: Butterfly
Spider	Thematic-Relation Match: Web; Taxonomic Match: Caterpillar

Children only received a particular item if they had been able to accurately name the pictures that depicted the polysemous or thematically related meanings in a pretest. In the pretest, children in the polysemy condition were tested on six pairs of polysemous meanings (*broccoli*(plant)/*broccoli*(food), *chicken*(animal)/*chicken*(meat), *corn*(plant)/*corn*(food), *eggs*(in unbroken shells)/*eggs*(fried eggs), *coffee*(beans)/*coffee*(drink), and *turkey*(animal)/*turkey*(meat)), and children in the thematic-relation condition were tested on five pairs of conceptually-related meanings (*chicken/egg, bird/nest, cow/milk, bee/honey, spider/web*). We omitted the *fish* item from the polysemy condition (and added the *broccoli* item in its place) because very few children had been able to name the picture depicting its food meaning in Experiment 1. The pretest proceeded as in Experiment 1 except that children were not given sentence fragments to elicit production of the target words. Instead, on each trial, the experimenter simply showed the child a picture (the same picture that was used in the word extension task) and asked the child to name it. We made this modification because we wanted to ensure that children would be able activate the names of these pictures independent of any eliciting context.

Before receiving any critical items in the word extension task, the children received five warm-up items, which included three *same-category* control items and two *different-category* control items. The same-category control items were parallel to those used in Experiment 1 and measured children's tendency to extend a word to another referent from the same basic-level category. For example, in one trial, children were taught that *parma* referred to a key and then had to extend *parma* to either another key (the basic-level category match) or a knife (the different-category foil). We expected that children would reliably choose the basic-level category match on these trials if they understood the task. On the different-category control trials, children had to choose between two referents that were from different basic-level categories than the original referent of the novel word. For example, in one trial, children were taught that *toomba* referred to pizza and then had to extend *toomba* to either spaghetti or soup (See Appendix D for a list of the control items used). We expected that children would randomly choose between the presented referents: these items were included only to prevent children from expecting that one of the potential referents in the judgment phase was always drawn from the same basic-level category as the novel word's original referent. All novel words used in the judgment phases avoided overlap in phonological onset with the English names of the presented pictures.

After the warm-up items, children in each condition were shown between one and four critical items, depending on how many pairs of meanings they had identified in the pretest. On average, children in the polysemy condition received 3.53 critical trials, and children in the thematic-relation condition received 4 critical trials. The critical items were administered in a fixed order (e.g., in the polysemy condition, the *corn* item was always presented before the *chicken* item, which was always presented before the *eggs* item, and so on). In addition to these critical items, children were also tested on three additional same-category controls and three different-category controls. Finally, for each condition, we constructed two versions of the task that varied with respect to whether the pictures in the judgment phases of the trials were presented to the left or right of the child. All of the pictures used in the pretest and word extension task were located using a Google image search, printed in color, and approximately 4" x 6".

Shape similarity rating study

A number of studies have followed up on the results of Markman and Hutchinson (1984) and have suggested that children's early word extension is not based on taxonomic relations, but instead on whether objects have a common shape (see, e.g., Landau, Smith, & Jones, 1988). In this view, children appear to extend words according to taxonomic relations only because objects from a common taxonomic category tend to have similar shapes (e.g., robins and sparrows). Consistent with this, those studies that have pitted taxonomy against shape have found a developmental trend in which children initially extend words based on shape (and across taxonomic category), and only extend based on taxonomy (and across objects having different shapes) as they get older (see, e.g., Imai, Gentner, & Uchida, 1994).[7]

To test the possibility that children's word extension in the polysemy group would be best explained by shape, we elicited ratings from a group of 15 native English-speaking adults (Mean age = 21; Range = 19-24). For each of the critical trials that could appear in the polysemy condition, participants rated the similarity in shape between a picture that depicted the base meaning, that is, the second exemplar used in the training phase of the trial, and the pictures that depicted the taxonomic match and the polysemy match, respectively. Participants also rated the similarity in shape between the pictures used in the same-category control trials; that is, they rated the similarity in shape between a picture depicting the base meaning (again, the second exemplar used

[7] An alternative possibility is that children *do* have a taxonomic bias, but initially use shape as a cue to common taxonomic category (see Bloom, 2000; Markson, Diesendruck, & Bloom, 2008). In this view, children may overcome their reliance on shape as they gain more ontological knowledge, for example, as they understand the deeper, nonobvious properties that determine whether something is a member of a particular kind. In this way, evidence for a shape bias can be reconciled with the idea that children hold a taxonomic assumption about the meanings of words.

in the training phase) and the pictures that depicted the basic-level category match and different-category match, respectively. Participants gave their ratings on a 1 (very different shape) to 7 (very similar shape) scale.

RESULTS AND DISCUSSION

In the critical trials, our dependent measure was the proportion of times children chose the polysemy match or thematically related match over the taxonomic match. Children in the polysemy condition reliably chose the polysemy matches over the taxonomic matches, preferring to extend the novel words between the taxonomically different meanings of polysemous words, $M = .84$, $SE = .04$; $T = 0$, $n = 14$, $p < .001$. Ten of 12 children chose the polysemy match in the *broccoli* item, 3 of 7 in the *chicken* item, 3 of 4 in the *coffee* item, 14 of 15 in the *corn* item, and 14 of 15 in the *egg* item.[8] Thus, even though children could have extended the novel labels taxonomically, for example, from one plant to another, they did not, and instead shifted the labels across taxonomic categories, for example, to describe the food derived from the plant. This finding suggests that children do not treat the taxonomically different meanings of familiar polysemous words as unrelated words that each encode a single taxonomic category: if they did so, they should have preferred to extend the novel words taxonomically. Instead, children may have extended the novel words to the taxonomically different meanings of the polysemous words because they relate these meanings within lexical structure.

Our results suggest that children's taxonomically flexible extension was specific to the relation between natural kinds and the food derived from them. In contrast to children in the polysemy condition, children in the thematic-relation group did not extend the novel words across taxonomic categories, from living things to the products they create: they showed no reliable preference for the thematically related matches relative to the taxonomic matches, $M = .42$, $SE = .08$; $T = 52$, $n = 12$, *ns*. Seven of 15 children chose the thematically related match in the *bee/honey* item, 9 of 15 in the *bird/nest* item, 3 of 14 in the *chicken/egg* item, and 4 of 15 in the *cow/milk* item, and 1 of 1 in the *spider/web* item. A Mann-Whitney test comparing the performance of children in the polysemy and thematic-relation groups showed that children in the polysemy group were significantly less likely than children in the thematic-relation group to select the taxonomic matches, $U = 29.5$, $n = 30$, $p < .001$. Children in both groups, however, grasped the task: they were each at ceiling at choosing the basic-level category match on the same-category control trials, suggesting that they were able to shift the novel words between objects from the same basic-level category (polysemy group: $M = 1.0$, Wilcoxon $T = 0$, $n = 15$, $p < .001$; thematic-relation group: $M = 1.0$, $T = 0$, $n = 15$, $p < .001$).

The extension of children in the polysemy condition also cannot be explained by a shape bias. Consistent with an intuition that taxonomically related objects are similar in shape, adults rated pictures of things belonging to the same basic-level categories (drawn from the same-category control trials) as highly similar in shape (M = 6.38, SD = .5) and significantly more similar than pictures of things belonging to different basic-level categories ($M = 3.21$, $SD = .47$), $t(14) =$

[8] The lower rate of extension to the polysemy match in the *chicken* item may stem from the fact that young children often fail to understand where chicken meat comes from (see Experiment 1).

26.74, $p < .001$. However, the pictures depicting taxonomically-different polysemous meanings (e.g., a corn plant and corn kernels) were not rated as being more similar in shape than the pictures depicting taxonomically-related meanings (e.g., a corn plant and an orange tree). Rather, the pictures of the taxonomic matches were rated as being more similar in shape to the pictures of the base meanings ($M = 4.6$, $SD = .67$) than were the pictures of the polysemy matches ($M = 2.97$, $SD = 1.05$), $t(14) = 6.63$, $p < .001$.

The performance of children in the thematic-relation group diverges from that reported in Markman and Hutchinson (1984): children in their studies reliably extended novel words for things such as animals (e.g., a cow) to taxonomic matches (e.g., a pig) over thematically related matches (e.g., milk). One reason children in the thematic-relation group may not have exhibited a taxonomic bias is because, unlike Markman and Hutchinson, we taught children the meanings of the novel words with not one but two exemplars from the basic-level category (e.g., children were taught that *darpa* referred to two different pictures of chickens). These additional basic-level exemplars could have given the children additional evidence—relative to the children in Markman and Hutchinson's study—that the novel words should be linked to basic-level categories. Indeed, previous studies have shown that presenting multiple basic-level exemplars for a novel label reduces the likelihood that the label will be extended beyond the basic-level, to higher-level taxonomic matches (Liu, Golinkoff, & Sak, 2001; Xu & Tenenbaum, 2007). This could help explain why children in the thematic-relation group chose randomly between the taxonomic matches and thematically related matches.

Together, the results of Experiment 2 show that children prefer to extend a novel word that has labeled one meaning of a polysemous word (e.g., a corn plant) to label another, taxonomically different meaning of that word (e.g., corn kernels), even when they are not given evidence that the word can be used in that way, and are given the option of extending the word taxonomically. However, a drawback of the method used in Experiment 2 is that it may have provided evidence that the novel word *could* be extended beyond its initial basic-level category (e.g., beyond corn plants). This is because children were asked to choose between items that do not belong to this category (e.g., corn kernels and an orange tree). Thus, children in the polysemy group could have initially linked the novel words to single, taxonomically coherent categories, and may have only extended them beyond the basic-level because the task required them to do so.

EXPERIMENT 3

Here we used a mutual exclusivity task to explore whether children spontaneously extend novel words between the taxonomically different meanings of polysemous words, in the absence of any evidence they can be extended. In one form of a mutual exclusivity task (see, e.g., Diesendruck & Markson, 2001), children are presented with two items for which they do not know labels, and are taught that a novel word labels one of those items (e.g., *blicket*). They are then asked to choose the referent of a second novel word (e.g., "Give me the *wug*"). Children tend to choose the previously unlabeled item, presumably excluding the item that already has a label on the grounds that it should not have a second.

In a critical trial of Experiment 3, children in the polysemy condition were taught, as in Experiment 2, that *darpa* referred to a chicken. But then we prompted children to choose between the polysemy match—the chicken meat—and the taxonomic match—the duck—by using a *second* novel word: Give me the *balkor*! Critically, this method provides no evidence that the first novel word can be extended beyond its initial basic-level meaning: children are not prompted to extend this word. Thus, if children require evidence to extend the first novel word beyond its basic-level meaning, they should choose randomly between the polysemy and taxonomic matches when choosing the referent of the second novel word. If, on the other hand, children spontaneously expect that a word that has labeled one meaning of a polysemous word will also label its other, taxonomically distinct meaning, they should expect the first novel word to label not just its original meaning, but also the polysemy match. This should lead them to exclude the polysemy match as the meaning of the second novel word because the first novel word already labels it, and instead choose the taxonomic match (see Figure 2, "Mutual Exclusivity Method"; Figure 3).

As in Experiments 1 and 2, we compared children's possible extension between polysemous meanings to their extension between thematically related but nonpolysemous meanings. We also included an additional control group to test for extension between homophones, such as *bat*[baseball] and *bat*[animal]. If the ability to extend a novel label between polysemous meanings is mediated by the phonological overlap of those meanings, then children should extend novel labels between homophonous meanings. They should thus think that taxonomic matches are better candidate referents for the second novel labels than homophone matches. But if extension between polysemous meanings occurs because those meanings are related within lexical structure, it should not occur between homophones, which are thought to correspond to unrelated lexical items. Children may thus treat homophone matches as potential referents for the second novel words.

Method

Participants

The participants were 45 children (22 girls), between the ages of 3;11 and 6;3 (mean age 5;1). An additional ten children participated but were excluded for missing the initial warm-up items that were used to evaluate their understanding of the task (9), or for lack of cooperation (1). Of the children included in the present analyses, 15 (9 girls) participated in the polysemy condition, ranging in age from 4;0 to 6;2 (mean age 5;2), 15 (7 girls) participated in the thematic-relation condition, ranging in age from 3;11 to 6;3 (mean age 5;0), and 15 (6 girls) participated in the homophone condition, ranging in age from 4;0 to 6;0 (mean age 5;3). Children were either brought into the lab or recruited from and tested at daycares or museums in the Cambridge, Massachusetts, or La Jolla, California, areas.

Materials and procedure

The materials and procedure were the same as those used in Experiment 2 with the exception that a mutual exclusivity task was used instead of a word extension task. As in Experiment 2, each of the trials included a training phase and a judgment phase. The training phase of each trial proceeded as before: for example, children in the polysemy condition were taught that a novel word (e.g., *darpa*) labeled a meaning that was depicted in two example pictures (e.g., pictures of chicken animals). However, the children were then asked to choose the referent of

TABLE 6
Critical Pictures Presented in the Homophone Condition of Experiment 3

Training Phase	*Judgment Phase*
Bat (Baseball)	Homophone Match: Bat (Animal); Taxonomic Match: Shovel
Knight	Homophone Match: Night; Taxonomic Match: Doctor
Nail (Finger)	Homophone Match: Nail (Tool); Taxonomic Match: Hair
Bow (Ribbon)	Homophone Match: Bow (Arrow); Taxonomic Match: Hat
Pitcher (Object)	Homophone Match: Pitcher (Baseball); Taxonomic Match: Spoon
Flour	Homophone Match: Flower; Taxonomic Match: Corn Kernels
Mouse (Computer)	Homophone Match: Mouse (Animal); Taxonomic Match: CD
Pepper (Condiment)	Homophone Match: Pepper (Vegetable); Taxonomic Match: Butter

a *second* novel label. Children were then presented with the two pictures as before, and their choice was recorded (see Figure 2, "Mutual Exclusivity Method"; see Tables 4, 5, and 6 for a list of the critical items administered in the polysemy, thematic-relation, and homophone conditions[9], respectively; see Appendix C for a list of the control items). As before, children only received a particular critical item if they had been able to accurately name the pictures that depicted the critical pair of meanings in a pretest. On average, children in the homophone group received 3.2 critical trials, children in the polysemy condition received 3.3 critical trials, and children in the thematic-relation condition received four critical trials.

RESULTS AND DISCUSSION

Children in each of the three groups readily chose the different-category matches on the same-category control trials, suggesting that they spontaneously extended the first novel words between items from the same basic-level category (polysemy group: $M = .91$, $SE = .04$; $T = 0$, $n = 15$, $p < .001$; thematic-relation group: $M = .87$, $SE = .05$; $T = 3$, $n = 15$, $p < .001$; Homophone group: $M = .93$, $SE = .01$, $T = 0$, $n = 13$, $p < .001$). On the critical trials, our dependent measure was the proportion of times children chose the taxonomic match, as this indicated whether children in the three groups had spontaneously extended the first novel word to the polysemy, thematically related, or homophone matches, respectively. Children in the polysemy group chose the taxonomic match reliably more often than chance, $M = .75$, $SE = .06$; Wilcoxon $T = 2$, $n = 11$, $p < .005$. 12 of 12 children chose the taxonomic match in the *broccoli* item, 3 of 8 in the *chicken* item, 0 of 1 in the *coffee* item, 12 of 14 in the *corn* item, and 9 of 14 in the *egg* item. However, children in the thematic-relation and homophone groups did not choose the taxonomic matches reliably more often than chance (Thematic-relation group: $M = .52$, $SE = .06$; $T = 25$, $n = 10$, *ns*; Homophone group: $M = .53$, $SE = .02$; $T = 16$, $n = 8$, *ns*). In the thematic-relation condition, 10 of 15 children chose the taxonomic match in the *bee/honey* item, 6 of 14 in the

[9] Some of the homophones we tested are etymologically related to one another, for example, *pepper*[condiment] and *pepper*[vegetable]. However, because children are unlikely to recognize such relations, we included these items as homophones.

bird/nest item, 8 of 15 in the *chicken/egg* item, and 7 of 15 in the *cow/milk* item, and 0 of 1 in the *spider/web* item. Finally, in the homophone condition, 7 of 12 children chose the taxonomic match in *bat*[baseball]/*bat*[animal] item, 3 of 5 in the *bow*[ribbon]/*bow*[arrow] item, 2 of 5 in the *flour/flower* item, 7 of 10 in the *knight/night* item, 2 of 6 in the *mouse*[computer]/*mouse*[animal], 0 of 3 in the *nail*[finger]/*nail*[tool], 4 of 6 in the *pepper*[condiment]/*pepper*[vegetable], and 1 of 1 in the *pitcher*[object]/*pitcher*[baseball].

To test whether children in the polysemy group chose the taxonomic match more often than children in the thematic-relation and homophone groups, we computed a difference score for all children by subtracting the proportion of times they chose the taxonomic match on the critical trials from the proportion of times they chose the different-category match on the same-category control trials. This method takes into account individual differences among children in their understanding of the mutual exclusivity task. There were smaller difference scores in the polysemy condition compared to the thematic-relation condition, $U = 63$, $N = 30$, $p < .05$, and the homophone condition, $U = 52.5$, $N = 30$, $p < .05$.

Together, these results suggest that children expect words for natural kinds to also label the food derived from those natural kinds. Critically, children in the polysemy group did not receive any evidence that the first novel labels could be extended beyond their initial basic-level meanings, in contrast to in Experiment 2. This suggests that the children themselves expected these labels to extend across taxonomically different meanings. To our knowledge, this is the first use of the mutual exclusivity method to infer the extension of words to untrained meanings. Our results indicate that such spontaneous extension cannot be explained by the presence of phonological overlap between polysemous meanings (i.e., because it does not occur across homophonous meanings) and does not reduce to the presence of just any conceptual relation between meanings (i.e., because it does not occur across thematically-related but non-polysemous meanings).

GENERAL DISCUSSION

A taxonomic constraint could facilitate word learning because it would correctly bias children against considering unnatural word meanings that span different taxonomic categories, for example, *chicken* and *egg* (Markman, 1989). However, although words tend to label kinds, they are also often polysemous and label multiple, taxonomically different kinds, for example, *chicken*[animal] and *chicken*[meat]. The present studies tested different formulations of how a taxonomic constraint might interact with how children represent the meanings of polysemous words.

A first possibility is that children construct form-meaning pairings in line with the taxonomic constraint, that is, by linking a single word form with a single kind, and then simply list these pairings in the lexicon. Across our three experiments, we show that this account incorrectly predicts that children will treat the taxonomically different meanings of polysemous words as unrelated words. Instead, we show that children expect that a novel word that has labeled one known meaning of a polysemous word will also label another, taxonomically different meaning of that word. Employing different methods in each of our studies, we show that children adopt this expectation spontaneously, in the absence of any evidence that the novel label can be extended across taxonomic categories, and even when they have the option of instead extending it taxonomically.

In Experiment 1, we found that children accept statements that extend a novel word from one meaning of a polysemous word (e.g., *corn*[plant]) to the other, taxonomically different meaning of that word (e.g., *corn*[food]). Experiment 2 showed that children prefer to extend novel words between the taxonomically different meanings of polysemous words (e.g., between *corn*[plant] and *corn*[food]), even when they can instead extend them between taxonomically-related items from the same super-ordinate categories (e.g., between a corn plant and an orange tree). Finally, Experiment 3 showed that children spontaneously expect a novel word that has labeled one meaning of a polysemous word to also label its other, taxonomically different meaning—leading them to exclude this as the meaning of a second novel word. Together, these studies suggest that children do not represent the taxonomically different meanings of polysemous words as multiple, unrelated lexical items, but instead systematically relate them within lexical structure. For example, the different meanings of polysemous words could be housed within common, structured representations (Pustejovsky, 1995), or could be represented separately but linked to one another by rule-like structures (see, e.g., Copestake & Briscoe, 1995).

In addition to suggesting that children's lexical representations support taxonomic flexibility, our studies indicate that children place constraints on their flexibility. In each of our studies, children did not extend a novel word that had labeled a living thing—for example, a chicken—to label an item produced by that thing—for example, an egg (see Rabagliati et al., 2010, for evidence regarding children's understanding of constraints on other forms of polysemy). Experiment 3 also indicated that children do not extend words between taxonomically different meanings that share the same phonological form, but are otherwise conceptually unrelated (e.g., between homophones, like *bat*[baseball] and *bat*[animal]).

Together, our findings are incompatible with a version of the taxonomic constraint in which, for children, all words that label multiple kinds are represented as unrelated words that each encode a single kind. Instead, we suggest that although a taxonomic constraint may apply to how children initially acquire form-meaning mappings, it does not govern how children ultimately represent those pairings. By age four, children relate the taxonomically different meanings of familiar polysemous words within lexical structure.[10] Of course, because our studies only probed children's understanding of one form of polysemy—words for natural kinds and the food derived from them—we cannot generalize this conclusion to how children represent all forms of polysemy. At minimum, however, the results of Srinivasan and Snedeker (2011) indicate that this conclusion extends to how four-year-olds represent another, different form of polysemy—words for objects and their abstract content, such as *book* and *video*.

The present studies also do not speak to the productivity of the representations that children have formed. One possibility is that children capture the flexibility of familiar polysemous words such as *corn* without abstracting the underlying generalization that words referring to natural kinds can also refer to the food derived from them. For example, for each polysemous word, children could construct a lexical island encoding only the flexibility of that word (see Tomasello, 2003, for a related proposal about verb meaning and argument structure). Alternatively, children could form productive structures encoding the taxonomically cross-cutting relations that define *classes* of polysemous words (e.g., natural kind/food, object/content, etc.), allowing these

[10] Throughout, for the sake of simplicity, we have discussed lexical accounts of polysemy, but it is also possible that the structures supporting polysemy operate only at the conceptual level. In this view, the relations that license polysemy may be more relevant or noteworthy to us than other relations, thus explaining patterns of polysemic extension (see e.g., Nunberg, 1979, 1995; Fauconnier, 1984; Papafragou, 1996). See Rabagliati, Marcus, and Pylkkanen, 2011, for a discussion of lexical and conceptual accounts of polysemy.

relations to generalize to novel cases, for example, such that a word for a novel plant can be used to refer to its food. Because our studies only tested children's interpretation of familiar polysemous words, they do not decide between these two possibilities.

Previous studies have suggested that by adulthood, at minimum, productive structures support polysemy. After being taught novel words referring to novel meanings, adults more often accept—and are better able to process—extensions of novel meanings that follow existing forms of polysemy, compared to conceptually related extensions that do not (Murphy, 1997, 2006; Frisson & Pickering, 2007; Rabagliati et al., 2010). Evidence that young children over-extend words in ways that are consistent with attested forms of polysemy provides preliminary evidence that children may also deploy productive structures (Bowerman, 1983; Clark, 1982; Rabagliati et al., 2010).

Critically, if productive structures support polysemy early in life, they could play a complementary role to the taxonomic constraint in word learning. For example, after mapping an unfamiliar word to a specific kind—a process guided by the taxonomic constraint—children could make inferences about the other, taxonomically different kinds that the word can be extended to—a process guided by the structures supporting polysemy. This balance of labor would preserve the original motivation for the taxonomic constraint: children would need to focus only on taxonomic relations when constructing the initial form-meaning pairing.

Productive structures supporting polysemy could arise during development in different ways. One possibility is that such structures are constructed by abstracting patterns over sets of individual meanings of polysemous words. For example, after encountering a sufficient number of polysemous words that alternate according to the same relation (e.g., *corn, broccoli, lettuce, coffee*, etc.), the child could abstract a productive structure encoding that relation. Such a process may not require explicit reflection on similarities between polysemous words, but could instead occur implicitly—e.g., similarly to the processes that support the acquisition of morphological rules. A second possibility is that productive representations of polysemy are scaffolded by innate structures. For example, some studies have documented that infant concepts of space, number, and time overlap with one another (Laurenco & Longo, 2010; de Hevia & Spelke, 2010; Srinivasan & Carey, 2010), potentially preparing language learners to anticipate the flexible uses of polysemous words such as *long, short*, and *big*.

The degree to which forms of polysemy are universal could inform our understanding of the nature and development of the structures supporting polysemy. To the extent that languages differ with respect to polysemy, the structures supporting polysemy may be constructed, for example, by abstracting patterns from familiar word use. This would allow children to learn and, in the process maintain, the divergent forms of polysemy that different languages employ. On the other hand, to the extent that there are universals with respect to polysemy, there may be innate constraints on the structures supporting polysemic extension. Such structures would constrain children's initial hypotheses about how the meanings of words can shift, such that forms of polysemy that are in line with these hypotheses—and thus readily learnable—become universal.

Unfortunately, there have been no systematic cross-linguistic studies of polysemy, although some examples of variation have been reported (Kamei & Wakao, 1992; Nunberg & Zaenen, 1992). By exploring these cross-linguistic data, we may gain not only a better understanding of polysemy but also a better understanding of human ontology, as it is expressed by words. The presence of systematic polysemy suggests that in addition to categorizing entities into a taxonomy, we flexibly relate entities in other ways. In what respects is this latter aspect of ontological knowledge uniform across linguistic communities, and in what respects does it vary?

CONCLUSIONS

On one form of the taxonomic constraint, children should represent the taxonomically different meanings of polysemous words as unrelated words that each encode a single kind. The present studies provide evidence against this version of the taxonomic constraint, showing that children expect that a word that has labeled one meaning of a familiar polysemous word will also label its other, taxonomically different meaning. We suggest that although children are guided by the taxonomic constraint when constructing form-meaning pairings, they systematically relate these pairings within lexical structure.

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APPENDIX A: EXAMPLES OF CRITICAL ITEMS IN EXPERIMENT 1

Example of a Critical Item from Polysemy Condition

Elmo: You don't know what *timas* are? Ill show you! This is a tima (*Pointing to prop of chicken animal*)! A *tima* has a beak and feathers and it makes a cockadoodledoo sound in the morning. *Timas* lay eggs too! Can we hear the story about *timas* now?

Experimenter: Oh okay, I think I can tell you that story! Now, this is a story about Zoe. Let's see what she's doing today!

Zoe has decided to go outside for a walk in the countryside. After walking for a little bit, she comes to a farm. And look at what she sees! Look at that bird! (*Show chicken animal*) It has a beak and some feathers here. Zoe decides to take it and give it some food to eat. And now, she is going to take it with her and put it in this coop over here (*Zoe puts chicken in coop*). Now its in its coop!

But now, Zoe is tired of walking and she's going home. She has gotten hungry so she is going to cook some food for herself. She's getting the grill ready for cooking! See? There's the grill! Now she's starting to cook, and she's going to put some meat on the grill! (*Show chicken meat*). It's a drumstick, and she's going to keep on grilling it. It looks so yummy!

What happened in this story, Elmo?
Elmo: I know, Zoe put the *tima* on the grill!

Example of a Critical Item from Thematic-Relation Condition

Elmo: You don't know what *timas* are? Ill show you! This is a *tima*! (*Pointing to prop of chicken animal*) A *tima* has a beak and feathers and it makes a cluck cluck cluck sound. Can we hear the story about *timas* now?

Experimenter: Oh okay, I think I can tell you that story! Now, this is a story about Zoe. Let's see what she's doing today!

Zoe has decided to go outside for a walk in the countryside. After walking for a little bit, she comes to a farm. And look at what she sees! Look at that bird! (*Show chicken animal*) It has a beak and some feathers here. Zoe decides to take it and give it some food to eat. And now, she is going to take it with her and put it in a nicer place, on the grass. Look, now its on the grass!

But now, Zoe is going to the supermarket. Look at what she's buying from the supermarket!

See that? (*Show egg*) Its white, and it has a smooth and round shell. Now Zoe's going to put it in her box, and take it home. Look, now its in her box!

So Elmo, what happened in this story?
Elmo: I know what happened, Zoe put the *tima* in the box!

APPENDIX B: EXAMPLES OF DIFFERENT-CATEGORY AND SAME-CATEGORY CONTROL ITEMS IN EXPERIMENT 1

Example of a Different-Category Control Item

Elmo: You don't know what *gulicks* are? I'll show you! This is a *gulick* (*pointing to prop of crayon*). You can draw pictures with it, and they come in all kinds of pretty colors. This *gulick* is purple, and you can hold it in your hand like a pencil. Can we hear the story about *gulicks* now?

Experimenter: Oh, okay, I can tell you a story about *gulicks*!! So this story is about Zoe. Let's see what she is doing today!

Zoe is at home and she wants to draw a picture! Look, Zoe is looking for something to draw with. Now she's made her choice (*Zoe picks up crayon*). And now she's drawing her picture!

Now, she's all done and she's going to put the thing she was drawing with away in a box (*Zoe puts crayon in box*). Look, now its in its box!

But now, Zoe wants to do something else because she's bored. She's going to find something to read. Now she's made her choice (*Zoe picks up book*). Look, now she's reading it!

But now Zoe's all done and she's going to put thing she was reading on top of the table (*Zoe puts book on table*). Look, now its on top of the table!

What happened in this story, Elmo?
Elmo: I know what happened! Zoe put the *gulick* on the table!

Example of a Same-Category Control Item

Elmo: You don't know what *gazzers* are? I'll show you! This *gazzer* is black (*pointing to prop of dog*). See? It has really nice and soft fur. And look! It has some gray fur on its feet! Can we hear the story about *gazzers* now?!

Experimenter: Oh okay, I can tell you a story about *gazzers*! This story is about Big Bird. Let's see what he's doing today!

Big Bird is going away on vacation and wants to give his pets away to his friends before he leaves. First, he's going to go to Zoe's house (*Bring out Zoe*). And look at the pet he's bringing with him (*Big Bird holding prop of small dog*). Its so small and cute! Now Big Bird is going to give his pet to Zoe! Zoe loves playing with this pet!

But now Big Bird is going to go over to Cookie Monster's house (*Bring out Cookie Monster*). And look at the pet he's bringing with him (*Big Bird holding prop of big dog*). Its so big! Now Big Bird is going to give the pet to Cookie Monster. Cookie Monster loves playing with this pet!

What happened in this story, Elmo?
Elmo: I know what happened! Big Bird gave the *gazzer* to Cookie Monster!

APPENDIX C: CONTROL ITEMS OF EXPERIMENT 1

Item	*Acted-Out Events*	*Statement*
	Different-Category Controls	
(*Gulick* = Crayon)	Zoe puts the crayon in the box; puts the book on the table	"Zoe put the gulick on the table!"
(*Doba* = Ball)	Prairie Dawn puts the ball in the box; puts the pencil on the table	"Prairie Dawn put the doba on the table!"
(*Mink* = Lego)	Prairie Dawn puts the lego in the box; puts the cup on the table	"Prairie Dawn put the mink on the table!"
(*Gluck* = Baseball Bat)	Cookie Monster puts the baseball bat in the box; puts the marker on the table	"Cookie Monster put the gluck on the table!"
	Same-Category Controls	
(*Gazzer* = Dog)	Big Bird gives a dog to Zoe; gives another dog to Cookie Monster	"Big Bird gave the gazzer to Cookie Monster!"
(*Toomba* = Box)	Ernie gives a box to Big Bird; gives another box to Zoe	"Ernie gave the toomba to Zoe!"
(*Dirk* = Car)	Zoe puts a car on the table; puts another car in the box	"Zoe put the dirk in the box!"
(*Dax* = Pen)	Big Bird puts a pen in the box; puts another pen on the table	"Big Bird put the dax on the table

APPENDIX D: CRITICAL PICTURES PRESENTED IN THE FILLER ITEMS OF EXPERIMENTS 2 AND 3

Training Phase	*Judgment Phase*
Different-Category Fillers	
Apple	Different-Category 1: Ball Different-Category 2: Book
Pizza	Different-Category 1: Spaghetti Different-Category 2: Soup
Cereal	Different-Category 1: Grapes Different Category 2: Blueberries
Cat	Different-Category 1: Goat Different-Category 2: Sheep
Ice Cream	Different-Category 1: Bread Different-Category 2: Popcorn
Same-Category Fillers	
Key	Same-Category: Key Different-Category: Knife
Chair	Same-Category: Chair Different-Category: Table
Shoe	Same-Category: Shoe Different-Category: Shirt
Horse	Same-Category: Horse Different-Category: Elephant
Button	Same-Category: Button Different-Category: Necklace
Cheese	Same-Category: Cheese Different-Category: Canteloupe