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## **The Implications of Polysemy for Theories of Word Learning**

### **Abstract**

Word learning is typically studied as a problem in which children need to learn a single meaning for a new word. And by most theories, children's learning is itself guided by the assumption that a new word will have only one meaning. However, the majority of words in languages are polysemous, carrying multiple related and distinct meanings. Here, we consider the implications of this disjuncture. As we review, current theories predict that children should struggle to learn polysemous words. And yet research shows that young children readily learn multiple meanings for words and represent them in qualitatively similar ways to adults. Moreover, polysemy may facilitate word learning, by allowing children to use their knowledge of familiar meanings of a word to learn its other meanings. These findings motivate a new perspective on word learning that recognizes polysemy as a fundamental feature of language, instead of treating it as an edge case.

*Keywords:* word learning; polysemy; ambiguity; lexical semantics; language development

## **The Implications of Polysemy for Theories of Word Learning**

If you look in any dictionary, you will find that most words express a variety of different meanings. In English, for example, it has been estimated (Rodd et al., 2002) that 7% of words are *homophonous*, carrying multiple unrelated meanings (e.g., *bank* refers to a financial institution or side of a river). And 84% of words are *polysemous*, expressing multiple related senses of meaning (e.g., *chicken* labels a kind of animal or meat; *glass* labels a material or artifact). This tendency is particularly pronounced for frequent words (Piantadosi et al., 2012): for example, a child can *run* a race, a politician can *run* a campaign, a parent can *run* a bath, and a car's engine can *run* smoothly.

Surprisingly, even though most words are ambiguous, research has largely characterized word learning as a problem in which children must learn a unique meaning for each word (e.g., Markman, 1989; Yu & Smith, 2007; Trueswell et al., 2013). We suggest that by simplifying the object of study in this way, researchers have inadvertently formulated incomplete and biased theories. Research over the past decade has begun to explore how children learn and represent ambiguous words, yielding findings counter to the predictions of dominant theories, and providing evidence that polysemy—in particular—facilitates lexical development.

### **What do existing theories predict about the acquisition of ambiguous words?**

Word learning presents problems of induction, both in determining the referent of a new word and how the word should be extended beyond its initial referent (Quine, 1960). For example, a child that hears “Look at the *lizard!*” may have no way of determining whether *lizard* refers to the lizard, as opposed to another object in the scene, a property of the lizard, or an event involving it. Even if the child determines that the word refers to the lizard, they will still have to refine their meaning for the word to match how other speakers in their linguistic community use it (e.g., to refer only to lizards).

A chief goal for theories of word learning has been to explain how children solve these inductive problems. By some accounts, children’s initial hypotheses are constrained by innate, language-specific biases (Markman, 1989), such as the taxonomic constraint, which holds that a word will map onto a single category within a structured taxonomy. Other accounts propose that domain-general associative learning processes give rise to children’s inductive biases, leading them to expect, for example, that a new object label will be extended among objects of the same shape (Smith, 2001). Relatedly, models of “cross-situational word learning” (e.g., Yu & Smith, 2007) propose that children learn referents and extensions by tracking associations between words and possible referents across exposures (e.g., noticing that *dog* is most often used in the presence of dogs). Finally, socio-pragmatic accounts emphasize that children reason about a speaker’s intentions—using cues like eye gaze—to determine a word’s most likely referent (Tomasello, 2001).

These proposals present plausible solutions for how children might learn unambiguous words. But they predict that children should struggle to learn ambiguous words, because they *presuppose* that children’s task in learning a new word is to learn its single, most likely meaning. For instance, under models of cross-situational learning (Yu & Smith, 2007), correct word-referent mappings emerge from competition between potential referents, such that observing “chicken” paired with chicken meat counts *against* an association between “chicken” and chickens. Similarly, under alternative, hypothesis-testing models (Trueswell et al., 2013), children postulate falsifiable hypotheses about a word’s referent on each exposure; this means that a child who hypothesizes that “chicken” refers to chickens will abandon this hypothesis when “chicken” is used in the presence of chicken meat, with no animals present. Thus, both kinds of models predict that children should struggle to learn multiple meanings for words; at

best, if children can learn one meaning, it would be the most frequent one, because this would be verified across the most exposures or statistically dominate through competition.

Existing theories which hold that learners assume that a new word will be extended among items of the same category (Markman & Hutchinson, 1984), also suggest that children should struggle to learn ambiguous words. Many ambiguous words violate this assumption, because they label items from ontologically-distinct categories (e.g., *bat* labels a kind of animal or baseball equipment). Moreover, based on the related proposal that children use a shared label to categorize items together (Waxman & Markow, 1995), ambiguous words might lead children to develop a single meaning that encompasses the different uses of the word (e.g., *chicken* refers to a single category including both chickens and chicken meat). A prominent Bayesian model—which incorporates the one-word-for-one-category constraint in its formalization—makes a similar prediction (Xu & Tenenbaum, 2007). This model proposes that children use the observed distribution of exemplars for a word to infer that word’s extension (if *fep* has labeled a dalmatian, labrador, and poodle, it probably means *dog* as opposed to *dalmatian* or *animal*). Under this model, children should assume that an ambiguous word that has labeled items from ontologically-distinct categories (e.g., baseball *bat* and animal *bat*) will label a superordinate category encompassing those items (Dautriche et al., 2016; Srinivasan & Snedeker, 2014), as opposed to two distinct categories.

Although some have proposed that all of a polysemous word’s senses are derived from a single, broad meaning (e.g., via pragmatic reasoning; Carston, 2002; Ruhl, 1989), this idea has been criticized on both logical and empirical grounds. For example, it is unclear what single meaning a word like *chicken* might have that would allow it to capture what is common across its semantically-heterogeneous senses (which refer to an animal, meat, cowardly person, and

game), without being so vague as to allow the word to be used in a wholly-unrestricted way (Klein & Murphy, 2001). Moreover, evidence suggests not only that adults separately represent homophones (Levelt, 1989), but also that they separately represent the senses of some polysemous words (Klein & Murphy, 2001). Thus, if children initially develop single, broad meanings for ambiguous words—as predicted by existing theories—they would need to revise these representations over the course of development.

### **Are ambiguous words difficult for children to learn?**

In sum, existing theories predict that children should struggle to learn ambiguous words. They may only learn the single most frequent use of an ambiguous word; or, if they are able to learn multiple uses, they may represent them using a single, overly-broad meaning.

Some earlier work provided evidence that children have difficulty learning homophones. These studies assessed homophone learning by testing whether children could override a familiar meaning for a word to learn a novel, unrelated meaning for that word (e.g., learning that *rope* can refer to a spade): even 7 and 8-year-olds struggled to learn these additional “pseudo-homophones” (Mazzocco, 1997; Peters & Zaidel, 1980). But more recent work suggests that children can learn new pseudo-homophones when they are introduced in distinctive syntactic/semantic contexts, perhaps because this minimizes competition with familiar meanings. For instance, although 20-month-olds struggle to learn that the noun *dog* also labels a novel animal, they have little difficulty learning that the verb *eat* labels that animal (Dautriche et al., 2018). Other research finds that preschoolers may even be *better* at learning a new pseudo-homophone than learning an entirely new word with the same meaning, perhaps because in the former case, children can rely on an already-learned sound sequence (Storkel & Maekawa, 2005).

Research probing children's knowledge of familiar words also suggests that they are not limited by a bias to learn one meaning for each word. By preschool, children comprehend and produce multiple meanings for many polysemous words, including words that label physical media and their content (heavy/interesting *book*; Srinivasan & Snedeker, 2011), natural kinds and their derived food (thirsty/tasty *chicken*; Srinivasan & Snedeker, 2014), physical containers and their contents (wash/stir the *pot*; Rabagliati et al., 2010), instruments and their uses (pick up the *shovel* / *shovel* the snow; Srinivasan et al., 2017), and more. And recent work shows that even toddlers understand multiple meanings for polysemous words (e.g., bottle vs. baseball *cap*; Floyd et al., 2019).

Also contrary to existing theories, children do not seem to build overly-broad meanings that encompass the different uses of ambiguous words. In one study, 5-year-olds who were introduced to ontologically-distinct exemplars for a novel word (e.g., *fep* labeling snakes and monkeys), later resisted extending the word to intermediate exemplars, suggesting that they did not think the word referred to a superordinate category that encompassed the training exemplars (Dautriche et al., 2016). Motivated by these findings, a recent proposal relaxes the assumption that a word will label a single category, and suggests that children can use a number of cues to guess that a word has multiple, distinct meanings (Dautriche et al., 2018). An updated model of cross-situational word learning similarly allows learners to hypothesize multiple meanings for a word (Stevens et al., 2017).

But these proposals do not go far enough, because they do not address how children might build lexical representations that differentiate between whether a word has related or unrelated meanings—and thus distinguish between polysemy and homophony. And yet there is evidence that, like adults (Klepousniotou et al., 2008), even preschoolers represent this distinction (Srinivasan & Snedeker, 2011). For example, when taught a novel label for a familiar

homophone (e.g., *blicket* = baseball bat), preschoolers resist extending the label to the other homophone (animal bat), despite consistently extending novel labels between the meanings of polysemous words (e.g., between a chicken and chicken meat).

### **Could polysemy facilitate word learning?**

The findings reviewed above challenge existing theories of word learning, because they suggest that children are able to learn multiple meanings for words, and represent them similarly to adults. More generally, these theories fail to explain why ambiguity—and polysemy in particular—is so widespread. If polysemous words were difficult to learn, then these words should have been eliminated from the lexicon over time because they would have been difficult to transmit culturally.

We suggest that polysemy may be widespread because it *facilitates* communication and word learning (Srinivasan & Rabagliati, 2015; Ramiro et al., 2018). Imagine a speaker who wishes to communicate an idea that they do not have a conventional label for (e.g., that an orchestra sounds less sonorous than usual); it may be easier for them to get their message across by re-using an existing word with a related meaning (it sounds *skinny*) than by re-using a word with an unrelated meaning or by inventing an entirely new word (it sounds *wuggy*). Similarly, it may be easier for children to learn a new word meaning when they can draw on their knowledge of the word's other, related meanings (as in the case of polysemy), compared to if the word's other meanings were unrelated homophones, or if the word was entirely novel. Thus, polysemy may be commonplace—and much more frequent than homophony—because it makes the lexicon easier to acquire and transmit culturally.

Recent research shows several ways in which children can use polysemy to facilitate word learning. First, children can use their prior knowledge of a word's meaning(s) to guess the likely referent of a new word use. In one study, three-year-olds who learned that a novel verb



(*wugging*) labeled a novel action in which a tool acted upon a substance later expected that when the word was used as a noun (*wug*), it would label the tool rather than the substance, even though the action had been equally associated with both (Srinivasan et al., 2017; Lippeveld & Oshima-Takane, 2015). This inference mirrors a systematic English pattern, by which words like *hammer* and *brush* can label tools and their characteristic functions (Clark & Clark, 1979). Children can also use polysemy to guess new referents when no predictable semantic pattern exists. For example, English-learning toddlers expect *cap* to refer to the lid of a jar rather than an unrelated distractor; here, children likely generalize based on similarity or association from their knowledge of the *baseball* and *bottle cap* senses of the word, since parallel semantic relations do not exist for other English words (Floyd et al., 2019).

The ability to use a familiar word sense to restrict the reference of a new sense could be particularly valuable when the target referent is difficult to identify. One recent study found that preschoolers who were taught a spatial meaning for a novel adjective (*daxy* = thin) leveraged this knowledge when the adjective was later used metaphorically, to refer to pitch (expecting a *daxy* sound to be high in pitch, consistent with pitch metaphors in other languages), without receiving any training (Starr et al., 2020). Critically, children struggled to learn the pitch meaning on its own, suggesting that learning the spatial meaning first was beneficial. Thus, children's use of metaphorical mapping—which could draw on pre-existing cross-domain associations documented in infants (de Hevia et al., 2014; Srinivasan & Carey, 2010)—could be a powerful tool for learning abstract word meanings.

A second major route through which polysemy could facilitate word learning is by constraining children's hypotheses about the extension of a new word. Imagine a child who has learned that *glass* refers to a material, who then observes an object called *a glass*. Although

children typically extend new object labels based on shared shape (Landau et al., 1988), they could guess that the new meaning of *glass* will be defined in part by material, such that other *glasses* will be made of glass, conforming to how adults use this word. Indeed, one recent study (Srinivasan et al., 2019) found that when preschoolers were taught a name for a material that was then re-used to label an object (*some dax* for the material; *a dax* for the object), they were more likely to override the shape bias and extend the object label based on material, compared to when they learned different labels for the material and object (*some wug*; *a dax*). This effect of polysemy arose regardless of the order in which children learned the material and object meanings of the word, suggesting not only that an already-learned meaning can affect children's construal of a new word meaning, but also that learning a new word meaning can alter children's understanding of previously-learned meaning(s).

Finally, polysemy may even allow children to spontaneously anticipate that new word meanings exist (Clark, 1982). Recall the study discussed above, in which preschoolers learned that a novel action, in which a tool acted on a substance, was called *wugging*, and then guessed that *wug* referred to the tool rather than the substance (Srinivasan et al., 2017). In a different condition, children were asked to select the referent of a *second, distinct* word (Show me the *kiv*): here, children reliably chose the substance. It appears that children spontaneously expected the word for the action to refer to the tool (similar to how words like *hammer* and *shovel* are used), without receiving any evidence for this meaning; children may have then used this inferred meaning to make a mutual exclusivity inference (Markman & Wachtel, 1988), and guess that the second word (*kiv*) could not label the tool. Thus, even before children observe the different ways in which a new word can be used, they can guess its possible meanings, in accordance with systematic polysemy.

Because the advantages described above each depend on a word having related meanings, it follows that it should be easier for children to learn polysemous words than homophones. Indeed, one study found that 4.5- to 7-year-olds were better able to learn novel polysemous words than homophones; moreover, this advantage persisted even after a week-long delay (Floyd & Goldberg, 2020; Srinivasan et al., 2019). Thus, polysemy may not only help children build a lexicon, but may even help them maintain one over time.

### **Toward a polysemy-centered theory of word learning**

Contrary to the predictions of classical and contemporary theories, children can leverage multiple learning opportunities offered by polysemy. We therefore need new models that can explain how children (1) learn that a word has distinct meanings and (2) use their knowledge of one meaning of a word to make inferences about its other meaning(s).

To begin, existing theories need to explain how children determine whether a new word use corresponds to an additional meaning. A child who knows that *chicken* refers to an animal should not assume that the use of *chicken* to label meat is noise, or evidence against the animal meaning. We suggest that learners must not only track the referents of the words they observe, but also the contexts in which those referential acts occur (Dautriche & Chemla, 2014; Zettersen et al., 2018). The different senses of words are conditioned on their grammatical environment (*a chicken* versus *some chicken*), lexical environment (the meaning of *chicken* differs depending on whether the *chicken* is *thirsty* or *roasted*), and even their social environment (e.g., British and American parents use *pants* to mean different things). Thus, by examining evidence for robust dependencies between words, referents and contexts, children could infer whether a word has one meaning, or several (Dautriche et al., 2018). Previously-documented heuristics, like the taxonomic assumption, could then be applied at the level of contextual representations: e.g., such that *chicken* labels one category in its animal context and another in its meat context.

Although tracking contexts can help explain how children guess whether a word is ambiguous, it does not help explain the learning advantages conferred by polysemy. As described before, children employ a diverse array of strategies to infer new word meanings from familiar meanings. Such inferences are currently unaccounted for, even by recent models that allow learners to postulate multiple meanings for a word (e.g., Stevens et al., 2018). On these models, word meanings lack internal structure, preventing the learner from noticing shared features across the meanings of words (Floyd & Goldberg, 2019); moreover, these models lack mechanisms that would allow learners to capture systematic relations among word meanings (e.g., the animal-meat alternation).

Thus, we suggest that children must develop informationally-rich, structured word meanings. Such representations could support children's ability to use similarity or association to learn new word senses that do not conform to regular patterns (e.g., guessing that a baseball *cap* will bear similarities to a bottle *cap*). And these representations could also help explain why children spontaneously expect words to alternate in ways that reflect systematic polysemy (e.g., expecting words to label tools or their functional uses). Extending prior theory (Pustejovsky, 1995), we suggest that lexical items incorporate distinct facets of conceptual knowledge—e.g., regarding an entity's function, origin, part-whole and material composition, and what kind of thing it is—that interact with context in ways that give rise to and constrain polysemy, including its regular patterns. For example, words like *hammer* and *shovel* may have information about their physical properties foregrounded when used as nouns and about their function foregrounded when used as verbs. One consequence of this proposal is that children may not need to learn *which* semantic relations give rise to systematic polysemy in their language (Srinivasan et al., 2017): once children have learned facets of a new word's meaning (e.g., the function of a *hammer*), they may spontaneously anticipate its different, related senses. This proposal contrasts

with alternative accounts, highlighting areas for future inquiry. Children might instead gradually construct knowledge of the semantic relations that license systematic polysemy, by attending to how individual words are used and analogizing across exemplars (Murphy, 2007). Other accounts reject the idea of rich word meanings, instead proposing that word meanings provide minimal cues to the occasion-specific meanings that listeners infer via socio-pragmatic reasoning (Carston, 2002; Falkum, 2015).

Finally, the acquisition of polysemy also holds key implications for the relationship between linguistic and conceptual development. Studies of category learning have found that infants (and older children) use labels to group items together (Waxman & Markow, 1995), even when items are dissimilar (Plunkett et al., 2008). Yet, as reviewed before, ambiguous words do not lure preschoolers into creating unusually broad categories, suggesting that by this age, do not blindly use a shared label as a placeholder for a category. One possibility is that preschoolers apply a one-word-for-one-category assumption, but only at the level of contextual representations; it remains to be seen whether younger children similarly take context into account. Importantly, we also note that learning that the same word can label multiple, distinct concepts could potentially help children discover how those concepts are related. For instance, some parents have noted that their children discovered the relation between animals and meat when they noticed that they share the same name (Srinivasan & Snedeker, 2014).

### **Conclusion and future directions**

Because most words are polysemous, children will often be learning a new meaning for a word, as opposed to an entirely new word. Yet research has typically ignored this issue, leading to theories which predict that children should struggle to learn polysemous words. Here, we have reviewed recent work suggesting that polysemy does not hinder, but instead facilitates word

learning. These findings motivate a new perspective that recognizes polysemy as a fundamental feature of lexical development, instead of treating it as an exception.

Many open questions remain. For instance, it is unclear whether the learning advantages of polysemy extend to the earliest stages of language acquisition. It remains possible that infants cannot learn multiple meanings for a word, and are guided by a one-word-for-one-category bias that they later abandon. We also currently know little about how children are exposed to polysemy in their environment. It is possible that caregivers limit ambiguity when speaking to children; alternately, they may frequently employ polysemy to facilitate communication. Finally, we need to better understand how children use their knowledge of familiar word senses to learn new senses. An open question here is the degree to which children's inferences are learned from experience with polysemy in their language.

To address these questions, and build more comprehensive theories, we will also need to go beyond experiments, and analyze how polysemy is used in naturalistic contexts. This requires an evidence base that does not currently exist. Existing corpora of caregiver-child conversations are not annotated with word senses, making it impossible to know, e.g., whether "chicken" refers to the animal or meat. Developing sense-annotated corpora will enable larger-scale studies of polysemy, with the potential to transform theories of word learning.

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