Learning language from within: Children use semantic generalizations to infer word meanings

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Abstract
One reason that word learning presents a challenge for children is because pairings between word forms and meanings are arbitrary conventions that children must learn via observation—e.g., the fact that “shovel” labels shovels. The present studies explore cases in which children might bypass observational learning and spontaneously infer new word meanings: By exploiting the fact that many words are flexible and systematically encode multiple, related meanings. For example, words like shovel and hammer are nouns for instruments, and verbs for activities involving those instruments. The present studies explored whether 3- to 5-year-old children possess semantic generalizations about lexical flexibility, and can use these generalizations to infer new word meanings: Upon learning that dax labels an activity involving an instrument, do children spontaneously infer that dax can also label the instrument itself? Across four studies, we show that at least by age four, children spontaneously generalize instrument-activity flexibility to new words. Together, our findings point to a powerful way in which children may build their vocabulary, by leveraging the fact that words are linked to multiple meanings in systematic ways.

1. Introduction
One reason that word learning presents a challenge for children is that the relation between a word form and its meaning is arbitrary (Saussure, 1916/2011). There is no principled reason, for example, that English speakers use the word “shovel” to label shovels, as opposed to hammers or combs: This is merely one among many conventions that children must learn, either through direct, ostensive evidence or indirectly through overhearing (Akhtar, 2005). Here, we explore whether, in some cases, children might bypass observation to learn from within, by spontaneously inferring new word meanings. In particular, we ask whether children can exploit lexical flexibility: The systematic use of words to encode multiple, related meanings (Barner & Bale, 2002; Copeland & Briscoe, 1995; Pustejovsky, 1995). For example, many of the same English root morphemes can be used to label instruments, as nouns, and activities involving those instruments, as verbs (e.g., shovel, hammer, mix/mixer, wash/washer; Adams, 1973; Clark & Clark, 1979; Jespersen, 1942; Marchand, 1969; see Table 1 for other examples of lexical flexibility). The present studies explore young children’s use of semantic generalizations about lexical flexibility to bypass observational learning: Upon learning one meaning of a new word via observation (e.g., that dax labels an activity), can children spontaneously infer another possible meaning of the word that follows a generalization (e.g., that dax can label the instrument itself)?

Lexical flexibility characterizes most words of moderate to high frequency (Nerlich, Todd, Herman, & Clarke, 2003), and is widespread in English (Chomsky, 2001; Copeland & Briscoe, 1995; Lakoff, 1987; Nunberg, 1979; Ostler & Atkins, 1992; Pustejovsky, 1995, 1998) and in other languages (Kamei & Wakao, 1992; Peters & Peters, 2000; Srinivasan & Rabagliati, 2015; Youn et al., 2016). Flexible uses of words can take many different forms, including metaphor (the use of a word from one semantic domain to describe another; e.g., “Christmas is approaching”), metonymy (using a word to label an item or something associated with that item; e.g., the White House made an announcement), or morphological conversion (extending a word to another grammatical category; e.g., “She shoveled the snow”; Table 1). Although these various kinds of flexibility can be distinguished (see, e.g., Cruse, 2004).

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Table 1
Patterns of lexical flexibility in English.

<table>
<thead>
<tr>
<th>Instrument for Activity</th>
<th>Agent for Activity</th>
<th>Substance for Transfer to Goal</th>
<th>Animal for Meat</th>
<th>Object for Representative Content</th>
<th>Space for Time</th>
<th>Body Part for Object Part</th>
<th>Material for Artifact</th>
<th>Object for Aperture</th>
<th>Place for Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>(shovel, hammer, wash/washer, etc.)</td>
<td>(nurse, boss, bake/baker, sing/singer, etc.)</td>
<td>(water, paint, salt, etc.)</td>
<td>(chicken, lamb, turkey, etc.)</td>
<td>(book, magazine, newspaper)</td>
<td>(long, on, around)</td>
<td>(leg, arm, back, etc.)</td>
<td>(glass, tin, iron, etc.)</td>
<td>(door, window, goal, etc.)</td>
<td>(White House, Wall Street, City Hall, etc.)</td>
</tr>
<tr>
<td>She has a shovel / She shoveled the snow</td>
<td>She is the new boss / She bossed her employees around</td>
<td>There water is warm / He watered the plants</td>
<td>The chicken is well-fed / The chicken is well-salted</td>
<td>They spilled coffee on the book / They think it is an interesting book</td>
<td>The table is long / The movie is long</td>
<td>He broke his leg / That chair has a wooden leg</td>
<td>There broken glass on the floor / He drank water from the glass</td>
<td>They installed a new door / The man walked through the door</td>
<td>The White House has been renovated / The White House announced a new policy</td>
</tr>
</tbody>
</table>

1 Of course, there are exceptions to these regular patterns: e.g., broom does not label an action involving brooms. Exceptions to patterns can be thought of as "irregular" words that block a regular pattern (see e.g., Pinker, 1991, for a similar argument in the domain of morphology). Flexible patterns can be blocked by synonymy (e.g., to broom is blocked by to sweep), and by homonymy (e.g., we can summer or winter in Paris, but we cannot spring or fall there because those words have other meanings; see, e.g., Barner & Bale, 2002, 2005; Clark, 1987, 1993; Clark & Clark, 1979). The presence of exceptions does not preclude the need for explaining "regular" words, or the fact that regular patterns can be generalized to new words.

2 This account would predict that, in some cases, children will over-generalize flexible patterns, e.g., such that broom is used to denote sweeping and cutter used to denote a knife. As we review below, such overgeneralizations have been documented both in production and comprehension.

3 Some flexible words (referred to as "irregular polysemy": Apresjan, 1974) do not appear to participate in predictable, generalizable patterns. For example, the word arms can label a body part or weapons, and board can label a physical object or administrative organization. Insofar as these words do not appear to fall into larger patterns, children would not be able to use semantic generalizations to acquire them.

The present study explores whether children can infer new form-meaning pairings by exploiting lexical flexibility, and thus by learning language from within. To do so, children need to understand two properties of the language they are learning: (1) The semantic relations that license regular lexical flexibility in their language (e.g., between instruments and activities, animals and meat, etc.), and (2) The word-formation devices through which lexical flexibility is expressed in their language, i.e., the ways in which the word-form must be transformed, if at all, as it expresses different meanings (e.g., through affixation). But how might children’s understanding of these two properties of language develop? It is clear that children have to learn the word-formation devices that express lexical flexibility in their language, given that these devices are differentially employed across languages. For example, in English, new word meanings are often expressed via zero-derivation – i.e., without any changes to existing word-forms – as in the case of nouns derived from verbs (three jumps; two swings, etc.) and verbs derived from nouns (shovel the snow; button the shirt, etc.). English also often makes use of suffixes to form new nouns from verbs (He used a mixer; She is a teacher, etc.). By contrast, zero-derivation is less common in Semitic languages like Hebrew. In Hebrew, noun and verb forms are often related by a common 3- or 4-consonant root, and differ with respect to the vowels that populate the root. For example, the verb grow in Hebrew, gadal, can be nominalized as gdala (Berman, 1999; Ravid & Avidor, 1988).

The above discussion suggests that children have to learn which word-formation options are available and productive to express lexical flexibility in their language. But how does children’s understanding of the semantic relations that license lexical flexibility develop, e.g., their understanding that the same root can be used to denote an instrument and its associated activity? One possibility is that, just as word-formation devices vary from language to language, the semantic relations that license lexical flexibility also differ, and thus need to be learned by children. If true, this would constitute a substantial learning challenge for children, since there is in principle an unbounded number of possible semantic relations between word meanings, most of which will not provide a basis for lexical flexibility in a particular language. For example, although English permits many animal words to label their derived meat (chicken, lamb) and fur (mink, chinchilla), it does not permit these words to label other animal products (e.g., eggs, milk, etc.) or other items associated with animals (e.g., barn, hay, etc.). In face of such limits, and in absence of prior constraints on their hypotheses, learners might require a great deal of exposure to flexible words in the input to learn which semantic relations license flexibility in their language, and might thus only gradually construct semantic generalizations about flexibility.

The account described above – in which children have to learn which semantic relations license lexical flexibility in their language from the linguistic input – would predict that semantic generalizations regarding flexibility should be gradually abstracted from concrete exemplars. A related account of how children form linguistic generalizations can be found in usage-based theories of how children learn abstract syntax-semantics mappings: By these theories,
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