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The importance of lexical verbs in the acquisition of spatial prepositions: The case of *in* and *on*



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ABSTRACT

The prepositions *in* and *on* appear early in children's descriptions of simple containment and support relations, such as "apple in the bowl" and "cup on the table". However, mature use of these basic terms extends across a very broad range of object configurations, raising the question of whether children and adults share the same underlying semantic space, and if so, how children's use of *in* and *on* comes to match that of adults. With a new battery containing diverse object configurations, we asked how 4 and 6 year-olds and adults distribute basic spatial expressions (*isin*, *is on*) and lexical verbs (*hang*, *attach*, etc.) across subtypes of containment and support. Our results reveal probabilistic distributions of *in* and *on* in both adult and child language, with similar distributions among adults and children for *in* but different patterns for *on*. Moreover, we find substantial differences in the use of lexical verbs across the two spatial domains and across ages. We propose that children and adults share a structured semantic space for both containment and support relations, but larger portions of this space are described by *in* and *on* early in development because alternative descriptions employing lexical verbs are inhibited. Using computational modeling along with experimental data, we link developmental changes in the scope of basic spatial expressions to increasing use of lexical verbs in parts of the space that reflect less central relations of containment or support. This result supports a nuanced view of spatial language acquisition that shifts the focus from how children learn basic expressions to how they learn to distribute expressions of varying content and complexity across the semantic space.

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1. Introduction

It has often been noted that all languages encode objects and their spatial relationships. Many languages have a limited set of closed-class terms dedicated to expressing these relationships (Landau & Jackendoff, 1993; Levinson & Wilkins, 2006; Talmy, 1985); in English, these include prepositions such as *in*, *on*, *above*, *under*, etc. Terms *in* and *on* appear in children's vocabulary quite early in development and have traditionally been assumed to map onto pre-linguistic concepts of containment and support (Clark, 1973, 1975; Johnston & Slobin, 1979). More recently, however, cross-linguistic studies have pointed to significant variability in the range of relations that are encoded by *in/on* and their counterparts in other languages (Bowerman & Pederson, 1992; Pederson et al., 1998), leading some to suggest that there may be no 'core' concepts underlying these terms (Levinson & Wilkins, 2006; Levinson, 2003). Moreover, developmental studies have

shown that acquisition of these terms is far from complete by age 3 (Gentner & Bowerman, 2009), reinforcing the idea that the underlying semantic space may be far more complex than previously thought and suggesting that this space is organized by the meaning of language-specific lexical items rather than by pre-linguistic distinctions.

In this paper, we present a new approach to understanding the representation and acquisition of *in* and *on*. Departing from previous approaches, we track children's and adults' use of these and other terms across a quite broad range of object configurations. The relative frequencies of basic spatial expressions and lexical verbs across the configurations are shown to have systematic patterns across the age groups, a finding that is consistent with a structured and developmentally stable conceptual space. What might appear to be a conceptual reorganization can instead be attributed to the increasing accessibility of lexical verbs, which gradually supplant the basic spatial prepositions when the latter fail to express important semantic distinctions. The result is a novel approach to the development of spatial language, in which the probabilistic distribution of prepositions and lexical verbs reflects both a core conceptual organization for spatial configurations

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and growth of the lexicon available to describe such configurations.

2. Background

The acquisition of the terms *in* and *on* has long been of interest to researchers because of their acknowledged centrality to the representation of objects and their spatial relationships. As noted earlier, much of the literature has assumed that early acquisition of these terms is rooted in pre-linguistic understanding of the concepts ‘containment’ and ‘support’ (Bowerman, 1996; Casasola, 2005, 2008; Clark, 1973; Johnston & Slobin, 1979; *inter alia*). On this view, these concepts would support the ability to map the words *in* and *on* to configurations where physical containment and support are readily understood—e.g., apples in bowls and cups on tables (Hespos & Baillargeon, 2001; Hespos & Spelke, 2004, 2007; Needham & Baillargeon, 1993).

Despite the putative centrality of these configurations, however, *in* and *on* cover a surprisingly broad semantic terrain: *in* can be used to encode the relationship “apple in a bowl” or “marbles in a box”, but also “hole in a sock” and “plug in a socket”—instances that do not obviously instantiate the core sense of ‘containment’. Similarly, *on* can be used to encode the relationship of “cup on a table” or “book on a desk” but can also be used to express the relationship of “stamp on envelope” and “pendant on neck”—again, not obviously central embodiments of ‘support’. Many scholars have noted such breadth of usage, which has made it notoriously difficult to define the meanings of prepositions considered in isolation (e.g., Bennett, 1975; Feist, 2000; Herskovits, 1986; Regier, 1995).

These broad usage patterns present two significant questions. The first concerns the conceptual and semantic terrain occupied by *in* and *on*. Are there any ‘core’ distinctions underlying children’s and adults’ use of these prepositions? Although classical theories of spatial term acquisition assume this, cross-linguistic studies of spatial language have emphasized that there is considerable variation in the mapping between basic spatial terms and sets of spatial configurations, leading some to question whether such universal cores exist at all (Bowerman & Choi, 2001, 2003; Khetarpal, Majid, & Regier, 2009; Levinson & Wilkins, 2006). However, it is entirely possible that spatial cores exist within broad classes of spatial relationships (e.g. containment, support), and that the variation observed across languages pertain largely to non-core relationships within those classes. It is also possible that the degree of variation observed for non-core relationships varies over different classes of relationships.

The most pertinent study comes from Gentner and Bowerman (2009), who tested 2–6 year-olds learning English or Dutch on their mastery of terms encoding containment and support. Children in both language groups mastered *in* rather early, extending it to eight different containment scenes (e.g., “cookie in bowl”, “candle in bottle”). This suggests that there may be a core notion of containment underlying uses of English *in* and its equivalent in Dutch. The class of support relationships appeared to show more variability. Children learning English also applied *on* across a broad range of support types including support from below (e.g., cookie on plate), hanging (e.g., clothes on a line), and encirclement (e.g., necklace on a neck). Children learning Dutch also mastered cases of support from below quite early (encoded by *op* in Dutch) but lagged behind for other terms encoding different kinds of support (e.g., *aan* for “clothes on a line”, *om* for encirclement). This finding suggests that there may also be a core for support (support from below, mastered early by both groups) but also that the non-core relationships (other than support from below) may interact with the available lexicon differently across languages.

The second question concerns the mapping between this conceptual/semantic space and linguistic expressions other than basic prepositions. If there are core instances within each domain, contrasted with more marginal configurations, it could be that this structure is reflected in the distribution of lexical verbs that encode aspects of containment and support. Although the basic locative expression—the closed class spatial term used alone or with a light verb, the copula (e.g., *be in/on* for English, Gentner & Bowerman, 2009; Levinson & Wilkins, 2006)—may be used primarily for central configurations, a large, open class of lexical verbs exists to block the use of *X is in/on Y* for other configurations. For example, if shown a coat on a hook, speakers might describe the configuration with *on*, but it is also possible that they could block the preposition with a different, richer expression, e.g., “the coat is hanging on a hook”.

To date, studies of *in* and *on* and their equivalents in other languages have typically reported the use of the basic locative expression. These studies have reported either proportions of use of these expressions across spatial relation scenes, or modal adult use of the basic locative expression (Levinson & Wilkins, 2006), limiting the degree to which we can assess and generalize the relative roles of spatial prepositions and lexical verbs in describing these scenes. In particular, such analyses limit our ability to determine whether there is a core set of configurations that closely maps to the basic use of *in* and *on* (i.e., *is in/on* in English, following Levinson & Wilkins, 2006) and whether for configurations lying further from the *in/on* core, lexical verbs are used. In the current studies, we move beyond modal basic expression use to examine fine-grained use of both basic preposition-based expressions as well as lexical verb expressions. Our approach builds on typological observations from a number of semantic domains (see Bresnan, Dingare, & Manning, 2001; Coventry, Griffiths, & Hamilton, 2014; Givón, 1979) in which a categorical distinction in one language “is mirrored by a frequency-based distinction in other languages” (Bresnan & Aissen, 2002, p.88). In this way, we propose that meaningful conceptual distinctions among spatial relations are reflected in the relatively frequency with which adults and children use different expressions to encode them.

Our approach addresses these questions by using a novel battery of items for containment and support and analyzing adults’ and children’s use of basic spatial prepositions and lexical verbs as they describe where things are. Following previous work on spatial language development (Gentner & Bowerman, 2009; Johannes, Wilson, & Landau, 2012; Landau, Johannes, Skordos, & Papafragou, 2016), we chose to measure spatial descriptions from 4- and 6-year-old children. Children in these age groups make for interesting comparisons to adult language: they are able to felicitously describe a large sample of spatial scenes, but their descriptions do not always align with those of adult speakers. Our battery was structured after one developed for cross-linguistic studies of spatial language in English and Greek (Landau et al., 2016). We provide an overview here, with details in the Methods section. The logic of the battery was to provide participants with a wide range of object configurations that ranged from those that are intuitively the most central to the category to those that are considerably more marginal. For example, the containment battery included configurations showing an apple in a bowl and a hole in a sock; the support battery included configurations showing a cup on a table and a necklace on a neck. The range of configurations was structured as a set of subtypes suggested by existing batteries (e.g., Bowerman & Pederson, 1992) as well as the larger literature, which has suggested distinctions such as tight/loose fit within containment (e.g., Bowerman & Choi, 2003). Each of the subtypes was based on contrasts noted in pre-linguistic and cross-linguistic work on spatial categorization as well as theoretical accounts of spatial meaning. For containment, we hypothesized

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