The Changing Shape of Prepositional Meanings

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1. Introduction

How do children learn the meanings of words? Much research has focused on the initial acquisition of lexical items, with concomitant attention paid to early processes such as fast mapping (Carey, 1978), in which initial meanings are thought to be based on preexisting conceptual categories. Other research, however, suggests that meanings evolve beyond those represented at the time of initial acquisition, both for verbs (Gentner, 1978) and for nouns naming common artifacts (Andersen, 1975; Ameel, Malt, & Storms, in press). This evolution of meaning is compatible with findings that word meanings in adults are complex (Feist, 2000, in press; Feist & Gentner, 2003).

Complexity of meaning is, in turn, compatible with a feature-based view of lexical semantics. What might the evolutionary trajectories of the features look like? Are features added (Clark, 1973), with new features limiting the range of application of the word? Or are they subtracted (Nelson, 1974) as the child modifies his or her initially over-specific concept to match the community’s use of the word? Or is emphasis shifted amongst existing features (Mervis, 1987) as the child discovers which features are important from an adult perspective?

In order to address this issue, we need a way to chart the influences of individual features on word use across developmental time. To do this, we can adapt methods used to study interacting factors in complex meanings in adults (Labov, 1973) for use with children of varying ages. Using English spatial prepositions as an example domain, I will outline such a study. In addition to providing additional evidence that word meanings change across the course of language acquisition, the results of the study will demonstrate that this method is a viable means for assessing the developing roles of a complex set of interacting features that together influence adult word use.

2. A case study: English spatial prepositions

In part because space is the source domain for many metaphors (Lakoff, 1987), and in part because spatial relations are objectively observable in the...
world (Feist, 2000), spatial prepositions have attracted much attention in the linguistics and cognitive science literature. Investigations into the semantics of spatial relational terms across languages have suggested that they encode a variety of factors of the scenes they are used to describe, including geometric (e.g., Herskovits, 1986; Landau & Jackendoff, 1993), functional (e.g., Carlson-Radvansky, Covey, & Lattanzi, 1999; Vandeloise, 1991) and qualitative physical factors (e.g., Bowerman & Choi, 2001; Talmy, 1988).

Geometric factors reflect the topology of the scene, including specifics of the shapes of the located object, or Figure, and the reference object, or Ground, and information about contact or inclusion relations holding between them. Geometric approaches to the semantics of spatial prepositions in English (e.g., Herskovits, 1986) tend to stress that the Figure must be located at the interior of the Ground (which, as a result, must have an interior) for an appropriate use of in, while the Figure must be in contact with the surface of the Ground (which, as a result, must have a surface) for an appropriate use of on. By placing the Figure in contact with the surface of the Ground, then manipulating the concavity of the Ground such that the surface in contact with the Figure becomes an interior, one can manipulate the extent to which the geometry portrayed fits the requirements of either in or on, as illustrated in Figure 1. The Ground in Figure 1a has high concavity, resulting in the presence of an interior which would allow the use of in; the Ground in Figure 1b has low concavity, resulting in the existence of a flat surface which is in contact with the Figure, allowing the use of on.

![Figure 1: Two scenes differing in the concavity of the Ground](image)

Functional factors thought to be important to the semantics of spatial prepositions include the typical function of the Ground and the extent to which the Ground is fulfilling this function. With specific reference to in and on, Vandeloise (1991) argues that the French preposition dans, which is a translation equivalent to in, is defined in terms of the functional relation of containment. Similarly, he argues that the preposition sur (translation equivalent to on) is defined in terms of the functional bearer/burden relation. In both cases, reference is made to the Ground fulfilling a function for which it was designed, either as a container or as a supporting surface.

Finally, qualitative physics refers to the actual and expected forces which are thought to be acting on the Figure and the Ground. Such forces include constraint of location (Coventry & Garrod, 2004), either in one dimension (e.g., support against gravity) or in more than one dimension (e.g., constraint of
movement in all directions on the horizontal). Feist (in press) argues that the animacy of the entities, which results in differences in their ability to exert volitional control on the locations of themselves and others, has a direct influence on the qualitative physics of the scene. For example, an animate Figure object such as a firefly is able to move about, entering and exiting possible spatial configurations with other objects at will; an inanimate object such as a coin has no such ability. Thus, configurations involving a firefly as Figure can be expected to be less stable than ones involving a coin. Conversely, an animate Ground, such as a hand, can exert volitional control over the locations of other objects, affording greater stability than an inanimate Ground such as a dish.

3. Children’s changing prepositional meanings

3.1 Method

The current study of spatial preposition use in English-learning children was based on a previous study with adults (Feist, 2000, in press; Feist & Gentner, 2003), in which participants viewed spatial scenes (see Figures 2 and 3) and were asked to say whether the Figure was in or on the Ground. I will briefly describe the experimental manipulations and findings here, noting changes introduced for the current study; for details, see Feist (2000).

Based on the observation that, with increasing curvature, a supporting surface can become an interior, variation in the geometry of the Grounds was achieved by presenting each Ground at three levels of curvature. These ranged from flat (thereby absent any interior and consonant with the meaning of on) to very curved (suggestive of an interior and consonant with the meaning of in). The Figure was in each case put in contact with the surface of the Ground in a single location (see Figures 2 and 3). This change in geometry per se was found to influence usage of in and on: adult speakers of English were more likely to choose in to describe the scenes as the concavity of the Ground increased.

As Labov (1973) demonstrated that noun choices to label artifacts resembling cups, bowls, and vases are influenced by the function that the object fulfills (e.g., holding coffee, flowers, or mashed potatoes), functional information about the Ground was manipulated via the noun used to refer to the inanimate Ground object1. As noted above, the English preposition in (and its equivalents in other languages; cf. Vandeloise 1991) may rely in part on the Ground functioning as a container for the Figure (Coventry, Carmichael, & Garrod, 1994; Coventry & Garrod, 2004), while the preposition on does not. Thus, the labels used for the inanimate Ground implied varying degrees of containerhood, including bowl, dish, plate, slab, and rock. Taken in isolation, the noun bowl tends to denote objects that function as containers; the noun plate, objects that function as surfaces (and bearers of burdens); and the nouns rock and slab, afunctional objects. The fifth noun, dish, is a superordinate of both

1. In each case, the animate Ground was referred to as a hand.
bowl and plate and is therefore expected to have a function that is ambiguous between a container and a surface: a dish might sometimes be considered a container and other times a supporting surface. This manipulation of the label for the inanimate Ground influenced adults’ preposition choice: the use of in was greatest when the inanimate Ground was labeled as a bowl, and was successively lower as the label implied less typical containment use.

In order to focus attention on the functional information implied by the label, only the two unambiguous functional labels, plate and bowl, were used in the current study with children.

Because of its direct influence on the expected stability of a spatial configuration, we investigated the role of qualitative physics by varying the animacy of the entities in the scene. Each of the scenes in the stimulus set depicted either an animate Ground (a human hand) or an inanimate Ground (a dishlike tray), paired with either an animate Figure (a firefly) or an inanimate Figure (a coin). Each of these manipulations influenced adults’ preposition use, with in being used more often when animacy implied more stability. In the case of the Ground, this occurred when the animate Ground was shown, as a hand is able to constrain the location of another entity; for the Figure, this occurred when the inanimate Figure was shown, as a coin is unable to exert control over its own location.

### 3.1.1 Participants

16 preschool-aged children (mean age 56.5 months), residing in the Evanston, IL area, and 8 13-year-old children (mean age 161 months), residing in the Lafayette, LA area volunteered for the study. Each child received a small toy to thank them for their participation.

### 3.1.2 Materials

The twelve pictures from Feist (2000) were used in this study. These pictures depicted two Grounds (an ambiguous dishlike tray and a hand) paired with two Figures (a firefly and a coin) at three levels of concavity. Example stimuli are shown in Figures 2 and 3.2

![Figure 2: Dishlike tray paired with firefly at three concavity levels: low (approximately flat), medium, and high (deeply curved)](image-url)

2. Stimuli shown in the experiment were full color.
Figure 3: Hand paired with firefly at three concavity levels: low (approximately flat), medium, and high (deeply curved)

In addition to the twelve experimental stimuli, participants were shown three pictures that were good examples of *in* (a rabbit in a cage, flowers in a basket, and groceries in a bag) and three good examples of *on* (a puppet on a table, an apple on top of a pile of books, and a mouse on a mousepad). These served as training and catch trials in the experiment.

### 3.1.3 Procedure

Stimuli were randomized and presented individually on a computer screen, interspersed with four catch trials and preceded by two training trials. For each picture, participants were asked whether the Figure was *in* the Ground or *on* the Ground. Stimuli remained on the screen until the participant made a response.

### 3.1.4 Design

I used a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) x 3 (concavity) x 2 (labeling condition: *plate* or *bowl*) x 2 (age: preschool or 13 years) design. As in the previous study with adults, Ground, Figure and concavity were varied within subject and labeling condition was varied between subjects, with each participant being presented with only one of the two labels for the inanimate Ground.

### 3.1.5 Results

In order to ensure that the children had command of the terms in question, data from children who incorrectly labeled more than one of the training/catch trials were excluded from the analysis. This resulted in the exclusion of two preschool-aged children in the *bowl* condition.

In contrast to the previous work with adults (Feist, 2000, in press; Feist & Gentner, 2003) there was no significant effect of concavity, either for 13-year-old children (mean proportion *in* responses = 0.5 at all three concavity levels), or for preschoolers (mean proportion *in* responses = 0.36 for low and medium concavity levels and 0.3 for high concavity, $F(2,36) = 0.34, p > .5$) (Figure 4).
Figure 4: Proportion in responses for the three concavity levels for each of the age groups, averaged across both Figures, both Grounds, and both labeling conditions. Adult data from Feist (2000) is included for reference.

The influence of function differed across the ages sampled here, as evidenced by an interaction between the Ground, the labeling condition, and age ($F(1,18) = 11.18, p < .005$). Upon closer examination, it became apparent that the 13-year-old group, like the adults in the earlier study (Feist, 2000, in press; Feist & Gentner, 2003), were influenced by the labeling condition only when responding to pictures depicting the inanimate Ground, $F(1,6) = 9.52, p < .05$ (Figure 5). Unlike this pattern, however, an across-the-board increase in the use of *in* in the *bowl* condition ($M = .5$) relative to the *plate* condition ($M = .14$) was observed for the preschoolers, $F(1,12) = 4.36, p = .06$ (Figure 6).
Figure 5: Proportion in responses for the two Ground objects in the two labeling conditions for 13-year-old children, averaged across both Figures and all three concavity levels. The wavy bars represent responses from children in the bowl condition; the straight bars represent responses from children in the plate condition.

Figure 6: Proportion in responses for the two Ground objects in the two labeling conditions for preschool children, averaged across both Figures and all three concavity levels. The wavy bars represent responses from children in the bowl condition; the straight bars represent responses from children in the plate condition.

The influences of qualitative physical factors similarly showed changes across the developmental window sampled here. As with adults, 13-year-olds
were more likely to use *in* to describe pictures showing the animate Ground than the inanimate one. Preschoolers, on the other hand, showed the opposite pattern (Figure 7), $F(1,18) = 5.92, p < .05$.

![Figure 7: Proportion *in* responses for the two Ground objects for each of the age groups, averaged across both Figures, all three concavity levels, and both labeling conditions. Adult data from Feist (2000) is included for reference.](image)

While there was no significant effect of the animacy of the Figure on children’s use of *in* and *on* ($F(1,18) = .12, p > .3$), there was a non-significant trend in the responses of the older group of children (Figure 8), mirroring the small but significant effect found with adults. The fact that this trend was absent in the responses of the younger children suggests that this factor may enter the meanings of *in* and *on* around the age of the older group.

![Figure 8: Proportion *in* responses for the two Figure objects for each of the age groups, averaged across both Grounds, all three concavity levels, and both labeling conditions. Adult data from Feist (2000) is included for reference.](image)
Finally, an effect evident in the children’s data which is missing from the adult results is an interaction between the animacy of the Figure and the animacy of the Ground (Figure 9) whereby fireflies are described as in hands more often than in plates and bowls, while coins are described as in plates and bowls more often than in hands, $F(1,18) = 4.64, p < .05$. This may be evidence for an influence of qualitative physics, as in each case the use of in is greater for the more stable configuration, although in this case the stability is determined by the Figure-Ground complex rather than by the properties of the two entities individually (as observed in adult usage). Fireflies, which can enter and exit the configuration, are more likely to remain as pictured if the Ground can prevent their departure, as a hand can. Coins on the other hand, which are unable to move themselves, are more likely to remain as pictured if there is no possibility of movement of either the Figure or the Ground, hence the increased stability when paired with the inanimate Ground.

![Figure 9: Proportion in responses for the two Figure objects as paired with the two Ground objects, averaged across all three concavity levels, both labeling conditions, and both age groups.](image)

4. Discussion and Conclusions

As with work examining children’s uses of nouns (e.g., Ameel et al., in press) and verbs (e.g., Gentner, 1978), the present study found evidence for evolution of meaning beyond initial acquisition. Taking the point of view that the endpoint of lexical acquisition is complex meaning, within which real-world use is influenced by multiple features of the scenes described, the stimuli in this study were created by orthogonally varying each of a small number of features found to influence adult spatial preposition use in English. Through this, the results may begin to shed light on the changing roles of each of these features in the development of adult spatial prepositional meanings.

Three possible ways in which the featural make-up of adult meanings might change across the course of development were considered: 1) features are added
as children’s meanings evolve (Clark, 1973); 2) features are deleted as meanings evolve (Nelson, 1974); or 3) the emphases placed on the various features shift as meanings evolve (Mervis, 1987). The evidence from this study supports viewing the evolution of meaning as the result of a refinement of the features involved in the meanings of the terms, including both a shifting emphasis between features (Mervis, 1987) and the addition of features (Clark, 1973).

The shifting emphasis on existent features can be seen in the changes in the use of in response to the labeling condition, whereby the younger children appear unable to accurately tailor their use of this functional information to just those scenes within which the information is relevant, but the older children, like the adults in Feist’s (2000, in press, Feist & Gentner, 2003) study, only show a shift in their use of in due to the labeling condition for those pictures which depict the inanimate Ground. In addition, the shifting emphasis is evident in the change from the animacy interaction seen in children to the mature adult attention to the animacy of the Figure and the animacy of the Ground individually, a trend toward which is evident in the data from the 13-year-olds but not from the preschool children.

However, shifting emphasis cannot be the whole story, as it appears that not all of the features that influence preposition use in adults are likewise influential in children’s preposition use. Notably, the lack of effect of geometry at either age, as compared to the robust effect of geometry observed in adults, suggests that this feature must be added to the meanings to arrive at mature usage. While it could be argued that perhaps the changes in concavity in the Ground objects in this set of stimuli are just not sufficient for children to shift their use of the prepositions in and on, this begs the question, as the concavity changes were salient and compelling enough to influence adult usage patterns, while having no effect on children’s usage. Further research will be necessary to understand when and how concavity enters into the meanings of in and on in English speakers.

While the current study has provided evidence supporting the views that meaning development involves a shift in emphasis between existent features and the addition of further features, it must be noted that this study is as yet quite preliminary. Indeed, while the study provided a close examination of the roles of geometric, functional, and qualitative physical features in children’s uses of English spatial prepositions, the ages sampled are quite far from one another in developmental time and the participant groups are small. Thus, although the study provided evidence for meaning change into later childhood, the course of change remains unclear. Further research, including a finer-grained set of age groups with more children in each group, will be required to more clearly chart the development of mature, complex meanings in this domain.
References


