The Role of Parent Gesture in Children's Spatial Language Development

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1. Introduction

Several lines of research indicate that spatial language is related to spatial thinking (e.g., Casasola, Bhagwat & Burke, 2009; Gentner & Loewenstein, 2002). With respect to language acquisition, recent studies indicate that the amount of spatial language parents use with their children is a significant predictor of children's later spatial language use (Pruden & Levine, in preparation), which, in turn, predicts children's performance on nonverbal spatial tasks such as mental rotation and block design (Pruden, Levine, & Huttenlocher, in preparation, 2009). Our interest in the factors that predict spatial language and spatial skill is motivated by research showing that performance on spatial tasks is a significant predictor of success in science, technology, engineering and mathematics (i.e., the STEM disciplines) even after controlling for verbal and mathematical ability (Humphreys, Lubinski, & Yao, 1993; Wai, Lubinski, & Benbow, 2009).

The overarching goal of the present study was to investigate whether input that includes gesture along with spatial language has added value in predicting children's acquisition of spatial language over and above input that includes spatial language alone. There are several reasons to expect that this may be the case. First, with respect to language acquisition in general, children are sensitive to the gestures of others in both conversational and pedagogical situations (Goldin-Meadow, 2003). At home, parents' gestures predict children's gestures and, in turn, their vocabulary size (Rowe & Goldin-Meadow, 2009). In instructional situations, children learn more from spoken instruction if it is accompanied by gesture than if it is not (Church, Ayman-Nolley, & Mahootian, 2004; Valenzeno, Alibali, & Klatzky, 2003). Moreover, children can learn from gesture even when it conveys information that is not conveyed in speech (Singer & Goldin-Meadow, 2005). Second, gesture may be particularly good at conveying spatial information as it itself is highly spatial and thus has the potential to highlight and enhance the spatial information encoded in speech. That is, gesture may be particularly well suited to helping the child acquire spatial language because, unlike language, it easily captures the continuous nature of spatial information. For example, when talking about a "tall building," it is possible to provide cues to the meaning of the word "tall" by producing an over-the-head gesture, or by pointing to the top of the building. Finally, parents routinely produce gestures along with their spatial talk, providing children with the opportunity to learn from gesture (Levine, Ratliff, Huttenlocher, & Cannon, under review).

In the present study, we examined parent spatial talk, and the gestures that accompanied this talk, produced during naturalistic interactions at home. We also examined the child's use of spatial language during these interactions. For both parents and children, we focused on three categories of spatial talk: dimensional adjectives (e.g., *big, little, tall, short*), shape terms (e.g., *circle, square*), and spatial features (e.g., *straight, curved, bent, flat*). We addressed two specific questions: (1) Do parents differ in the amount of gesture used during spatial language? (2) If so, do differences in how often parents use spatial language with gesture, compared to how often they use it without gesture, provide added value in predicting children's spatial language production?

2. Methods

2.1. Participants

The study sample consisted of 52 parent-child dyads (26 boys; 26 girls) participating in a larger longitudinal study of language development at the University of Chicago. Parent-child dyads participating in this longitudinal study were chosen to be representative of the economic and racial diversity of families in the greater Chicago area (Table 1). All children were monolingual English speakers.

Table 1. Demographic information for the 52 families.

	White (not Hispanic)	Black or African-American	Hispanic or Latino	Asian	More than one race	Total
Less than $15,000	1	3	0	0	0	**4**
$15,000-$34,999	1	2	1	0	2	**6**
$35,000-$49,999	2	2	2	0	0	**6**
$50,000-$74,999	6	0	1	2	1	**10**
$75,000-$99,999	12	0	1	0	2	**15**
$100,000 or more	8	2	0	0	1	**11**
Total	**30**	**9**	**5**	**2**	**6**	**52**

2.2. Procedure

Parent-child dyads were videotaped every 4 months beginning when the children were 14 months of age and ending when the children were 42 months of age. This schedule resulted in a total of eight recording sessions (i.e., at 14-, 18-, 22-, 26-, 30-, 34-, 38-, and 42-months). Visits took place in the homes of participating families with each session lasting for approximately 90 minutes, resulting in approximately 12 hours of video for each parent-child dyad. During each session, parents were asked to engage in their normal everyday activities. Activities frequently included toy play, book reading, and interactions involving meals and snacks.

Parent and child speech and gesture were transcribed from the videotapes. Transcription reliability was assessed by having a second trained research assistant code 20% of the transcripts. Discrepancies were discussed and reliability was reached when the two coders agreed on 95% of the speech utterances and gesture codes.

Spatial Language Coding. For this study, we targeted only those utterances containing three types of spatial words: dimensional adjectives, words describing spatial features or spatial properties, and shape terms. Dimensional adjectives describe the size of objects, people or spaces and included words like *big, little, tall,* and *short*. Spatial feature and spatial property terms describe non-dimensional aspects of both 2-D and 3-D objects and included words like *edge, corner, flat, curvy,* and *bumpy*. Shape terms are labels for standard recognized enclosed 2-D and 3-D spaces and included terms like *circle, square,* and *cube*. Spatial utterances were identified through a targeted search for these words within the transcripts. Non-spatial usages of these words were not included in our analyses (e.g., *a big problem, a long time, etc.).* A coding system developed by Cannon, Levine and Huttenlocher (2007) was used to code spatial language.

We calculated the total number of spatial utterances (i.e., utterances containing at least one spatial word) that the parents produced during the 8 sampling sessions (from child-age 14 to 42 months), along with the total number of non-spatial utterances that the parents produced during the same time period. Although parents sometimes used more than one spatial word in a single spatial utterance, these words were not counted separately as the unit of analysis we used was the utterance. We also calculated the total number of different spatial words (types) that the children produced during the 14 to 42 month period. We used types, rather than tokens, of spatial words as our child measure of spatial language, as our goal was to explore the effect of parental input on child spatial vocabulary.

Gesture Coding. All deictic and iconic gestures that occurred in the context of parents' spatial utterances were coded. Deictic gestures indicate entities by pointing to a person, object, or location, or by holding up an object (Bates, 1976). In the context of spatial utterances, deictic gestures often highlight the meaning of the spatial word (e.g., pointing to the highest point on an object when using the word *tall,* or pointing to a corner of an object when using the word *corner*). Iconic gestures, on the other hand, typically represent attributes or actions associated with objects or events (e.g., tracing an arc in the air to indicate a curved path or surface; Acredolo & Goodwyn, 1988). Our analysis included both deictic and iconic gestures as these kinds of gesture have the greatest potential for grounding spatial language and conveying spatial information. As an example of a deictic gesture during spatial language, the parent says, "this has a straight side," while pointing to a straight-sided puzzle piece. As an example of an iconic gesture during spatial language, the parent says, “it’s big,” while spreading her hands apart to indicate a big object; or “the edge of the mirror,” while using her hand to trace the square shape of the mirror frame in the air. Utterances that were accompanied by other types of gestures (e.g. conventional gestures such as “thumbs up”) were considered utterances without gesture for our purposes.

3. Results

For each parent, we calculated the total number of spatial utterances produced through child-age 42 months. These utterances were divided into two categories: (1) spatial utterances produced with gesture, and (2) spatial utterances produced without gesture. For each child, we calculated the total number of spatial types produced through 42 months.

Do parents vary in their use of gesture with spatial language?

We found that parents varied widely in how often they produced gestures along with their spatial utterances (Table 2). Some parents never gestured when talking about space, whereas others gestured 44% of the time when talking about space.

Table 2. Descriptive Statistics for Parent and Child Spatial Utterances.

	M	*SD*	*Minimum*	*Maximum*
Parent spatial utterances without gesture	103	79	4	333
Parent spatial utterances with gesture	22	21	0	96
Percentage of parent spatial utterances with gesture	16%	9%	0%	44%

Does parent gesture during spatial language predict child spatial language?

The number of spatial utterances parents produced along with gesture by child-age 42 months was positively correlated with children’s cumulative spatial types from 14 to 42 months, even after controlling for parents’ spatial utterances without gesture and parents’ non-spatial utterances (partial correlation r^2=.15, p<.01). Figure 2 depicts the relation between parent’s spatial utterances accompanied by deictic or iconic gesture and children’s spatial types at 42 months.

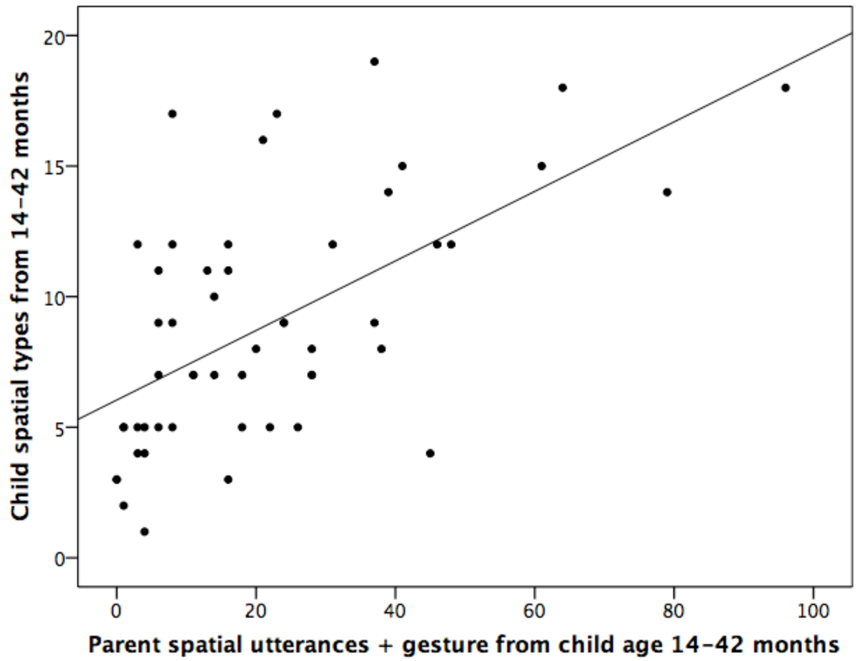

Figure 2. A scatter plot depicting the relation between parents' cumulative spatial utterances with accompanying gesture at 42 months and children's cumulative spatial types at 42 months.

In an effort to further understand the effect of parent gesture on children's later spatial language use, we conducted multiple linear regressions with parent spatial utterances with gesture, parent spatial utterances without gesture, and parent non-spatial utterances as predictors of children's spatial types (Table 3). Model 1 showed that the total number of parent spatial utterances that were accompanied by gesture significantly predicted children's spatial types from 14 to 42 months and accounted for over 34% of the variance in children's spatial types (β = .60, p < .001). Models 2 and 3 show that parent spatial utterances with gesture remained a significant predictor of child spatial types even after we controlled for parent spatial utterances without gesture and parent non-spatial utterances.

Table 3. Linear regression models using parent spatial utterances with and without gesture and parent non-spatial utterances from child age 14-42 months to predict children's cumulative spatial types from 14-42 months; $^{**}p < .01$, $^{***}p < .001$.

	Child Spatial Types by 42 months Parameter estimate (standardized β)		
	Model 1	Model 2	Model 3
Parent spatial utterances *with gesture*	0.60***	0.64**	0.65**
Parent spatial utterances *without gesture*		-0.05	-0.19
Parent *non-spatial utterances*			0.18
R^2 statistic (adj.)	34.4%	33.1%	33.2%

4. General Discussion

Pruden and colleagues (Pruden & Levine, in preparation; Pruden et al., in preparation, 2009) showed that parents vary in the use of spatial language with their children. Our findings add to this result, showing that parents also vary in their use of gesture within the context of spatial language. Most importantly, our findings showed that the number of spatial utterances accompanied by gesture parents produced predicted the number of spatial types their children produced, even after controlling for parent spatial language without gesture and parent non-spatial language.

Gestures that are produced along with spatial language could aid children's acquisition of spatial language in several ways. Gesture could serve to draw attention to the speaker's words and thus increase retention of the information conveyed in those words. If this is the role that gesture is playing, it should facilitate acquisition in all domains, not just the spatial domain.

However, unlike language, gesture is well suited to capturing the continuous information of the spatial world. Gesture may therefore be even more helpful in the context of spatial words than in other contexts. For example, gesture has the potential to play a targeted role in the acquisition of spatial language by illustrating the spatial notions reflected in speech—producing a curved gesture while saying that the puzzle piece is *curved* could help the child figure out what the word *curved* means. Although we have shown that parent gesture use in the context of spatial language predicts children's use of spatial terms, we would need to compare the effect of gesture use in other domains to determine whether gesture plays a special role in fostering the development of spatial words.

Our findings demonstrate that parent gesture produced in the context of spatial talk is related to children's spatial language. However, this relationship is correlational: the findings do not show that parent gesture produced along with spatial talk plays a causal role in fostering child spatial language. Our current research attempts to explore the causal role between these variables by manipulating the input children receive in a spatial context—puzzle play. Some children will receive language that focuses on spatial aspects of the puzzle pieces (e.g., the shape of the pieces); others will receive language that focuses on non-spatial aspects (e.g., the color of the pieces). We will, in addition, vary whether the language the children hear is accompanied by gesture, resulting in four conditions: spatial language with gesture, spatial language without gesture, non-spatial language with gesture, and non-spatial language without gesture. We predict that children who hear spatial language with gesture will produce more spatial talk, and do better at putting puzzles together, than children who hear spatial language without gesture (and, of course, than children who hear non-spatial language without gesture). The interesting question is what happens to children who hear non-spatial language with gesture. Can gesture provide useful spatial information when it is used on its own without the relevant speech, or must it be used along side speech to be effective?

Our findings suggest that gesture has the potential to play a powerful role in teaching children about space. Future work is needed to determine whether gesture reaches this potential.

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