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Encouraging Spatial Talk: Using Children's Museums to Bolster Spatial Reasoning

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Abstract

Longitudinal spatial language intervention studies have shown that greater exposure to spatial language improves children's performance on spatial tasks. Can short naturalistic, spatial language interactions also evoke improved spatial performance? In this study, parents were asked to interact with their child at a block wall exhibit in a children's museum. Some parents were instructed to emphasize formal shape terms, others to emphasize spatial goals, and some were not provided scripts. Children were presented with a series of spatial reasoning tasks before and after this parental interaction, and the amount and type of spatial language during the training session was coded for parents and children. We found that (a) parents significantly increased their spatial language use when prompted, (b) children and parents used different types of spatial language in each of the scripted conditions, and (c) children's spatial language during the interaction, and not parents', predicts children's subsequent improved puzzle performance.

Spatial skills encompass the abilities to transform and remember well-structured visual images and to mentally manipulate three-dimensional structures (Brosnan, 1998; Carroll, 1993; Uttal & Cohen, 2012; Wai, Lubinski, & Benbow, 2009). People frequently exercise these abilities from cutting a pizza to locating oneself on a map (Jirout & Newcombe, 2014; Verdine, Golinkoff, Hirsh-Pasek & New-combe, 2014a). From an educational perspective, spatial skills are important because they support formal mathematical abilities (Gunderson, Ramirez, Beilock, & Levine, 2012; Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014c; Verdine et al., 2014a).

As a building block for spatial skills, exposure to spatial talk—which refers to shapes, patterns, sizes, and locations—in early development is critical (Verdine et al., 2014a). The quantity of parent spatial language correlates with children's spatial language use, and predicts children's performance on nonverbal spatial tasks (Pruden, Levine, & Huttenlocher, 2011; see also Levine, Ratliff, Hutten-locher, & Cannon, 2012; Szechter & Liben, 2004; Verdine et al., 2014b). Evidence suggests spatial language supports stronger spatial reasoning. First, children's understanding of spatial relations terms such as *right* and *left* results in a more accurate integration of both self-reorientation within an environment and successful use of spatial landmarks (Hermer-Vazquez, Moffet, & Munkholm, 2001).

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Additionally, preschoolers are more accurate on a spatial mapping test when spatial relations terms are applied to the mapping (Loewenstein & Gentner, 2005).

In addition to spatial language, spatial play (i.e., blocks, puzzles) facilitates spatial skills development in young children (Casey & Bobb, 2003; Verdine et al., 2014a). Jirout and Newcombe (2015) found that the quantity of children's spatial play reported by parents correlated with children's scores on a block design task. Spatial play, specifically block play, requires children to manipulate objects, consider dimensions, and understand relative locations (Jirout & Newcombe, 2015; Verdine et al., 2014a). While spatial language and block play independently facilitate spatial abilities, they are stronger when combined (Casey et al., 2008). Block play naturally facilitates parental spatial language (Ferrara, Hirsh-Pasek, Newcombe, Golinkoff, & Lam, 2011), which emphasizes spatial relations between blocks (e.g., *on top of, next to*; Verdine et al., 2014b). In one block play intervention (Casey et al., 2008) kindergarteners completed pre- and posttests measuring their spatial skills. Only students who heard verbal instructions that integrated spatial language while playing improved on their posttest performance. Thus, parents and educators must work to integrate spatial language into joint spatial play.

Guided play effectively incorporates spatial language into playtime. During guided play, adults actively direct play, ask open-ended questions, coplay with children, and comment on their discoveries. Alternatively, during didactic instruction, caretakers communicate educational objectives to children who play a passive role (Weisberg, Hirsh-Pasek, & Golinkoff, 2013). Guided play encourages joint verbal exchanges between parents and children (Hirsh-Pasek, Golinkoff, Berk, & Singer, 2008), which facilitate children's memory and recall for that task (Haden, Ornstein, Ecker-man, & Didow, 2001). Children's museums, which facilitate informal learning and emphasize the science, technology, engineering, and math (STEM) fields, are ideal locations for guided spatial play and spatial language use (Callanan, 2012; Callanan, Cervantes, & Loomis, 2011; Haden, 2010). Within museum settings parents are receptive to specific but easy-to-follow caregiver instruction (Benjamin, Haden, & Wilkerson, 2010), which supports children's learning both within and beyond the museum experience (Hayward & Hart, 2015; Wolf & Wood, 2012).

The current study aimed to promote guided spatial play within a museum setting. The exhibit used here was a block wall, composed of empty rectangular impressions fitted with smaller, removable rectangular and triangular foam pieces (see Figures 1 and 2). In its original form, this exhibit had minimal instruction and signage. This study investigated the effects of instructional language prompts on parent–child spatial language production and children's subsequent spatial cognition. Three conditions were included: non-scripted control, shape-language, and goal-language. The nonscripted condition captured how parent–child dyads naturally interacted at the exhibit without provided guidelines. The shape-language condition included prompts that explicitly discussed the shape blocks, their characteristics, and how they fit together within the rectangular impressions. This condition focused on formal shape terms; as is common with didactic instruction, it included a longer and more precise script (Weisberg et al., 2013), and was explicit in the lessons about shapes it promoted. Finally, the goal-language condition emphasized building with a purpose, by suggesting activities, such as building a mini city. The scripted prompts for this condition were shorter and less explicit than those for the shape-language condition. Its open-ended quality aimed to foster creativity, as guided play does (Weisberg et al., 2013).

The study evaluated if spatially relevant shape-language or goal-language instructions (a) increase parents' and children's spatial language and (b) prompt different types of spatial language. Further, it assessed the effects of spatial language exposure and production, generally and by type (goal- or shape-language) on three measures of children's spatial thinking (a variety of novel and familiar puzzles). By including the nonscripted control, we examined the impact of encouraging spatial language on spatial cognition. Through the two experimental conditions we investigated how goals compared with specific shape language differentially impact spatial language production. Starting in preschool, spatial abilities are predictive of mathematical abilities (Verdine et al., 2014c). Since early mathematical abilities have cascading effects on children's later formal mathematics performance and eventual career choices (for a review see Watts, Duncan, Siegler, & Davis-Kean, 2014), we focused on 4-year-old children in the current study.

Children completed pre- and posttests of spatial reasoning, with a brief intermediary parent–child interaction at a block wall exhibit. Parent–child dyads were randomly assigned to one of three conditions: shape-language, goal-language, and nonscripted. The overall amount and types of parent and child spatial language produced were measured. Based on previous findings, we predicted that scripted parental guidance would positively impact children's performance (relative to no scripting), due to heightened joint spatial focus.

Method

Subjects

A total of 104 four-year-olds, *M* = 4.4 years, standard deviation (*SD*) = 3.5, *R* = 47–59 months (63 females) were recruited with their caregiver at the Children's Museum of Manhattan. Dyads consisted of 83 mothers and 28 fathers. The participating population reflected the makeup of the surrounding urban area: 32% Hispanic, 51% Caucasian, 23% Black, 10% Asian, and 16% "other race." Parent–child dyads were randomly assigned to one of three conditions: 37 dyads in the nonscripted, 39 in shape-language, and 35 in goal-language. All parents and children were fluent in English. A total of 38 dyads were also fluent in other languages (Spanish, Urdu, Polish, Russian, Lithuanian, French, Japanese, Hindi, Irish, and Swedish). A total of 7 dyads were excluded due to experimenter error (1) or refusal to complete the task (6).

Design

Each parent–child dyad was randomly assigned to one of the three conditions: shape-language, goal-language or non-scripted control. The block area in CMOM's PlayWorks exhibit consisted of rectangular impressions from which provided foam blocks could be removed and reinserted, and a space on the floor for block building (see Figures 1 and 2). In the nonscripted condition, parents were asked to play with their child at the block wall. In the shape-language condition, which included instructions on how to use the rectangular impressions and blocks in tandem with one another, parents were given interaction prompts that highlighted shape terms and part-whole relationships (e.g., "By putting two purple squares together we can make a rectangle"). In the goal-language condition, parents were given prompts emphasizing building spatial structures without discussing the shapes themselves to foster uninhibited use of the exhibit's materials (e.g., "How about you try to make a mini New York City with the blocks?," "Leave spaces for roads, and cars."). (See the appendix for the exact prompts provided to parents.)

Procedure

Pretests—Child participants completed three puzzles on a rectangular rug near the exhibit. Puzzles were based on examples from the Woodcock-Johnson–III Tests of Cognitive Abilities Spatial Relations subtest (Woodcock, McGrew, & Mather, 2001; see Figure 1), but were enlarged and transformed into puzzles to fit the interactive needs of the museum setting. The purpose of the pretests was to obtain baseline levels of each child's spatial competence before the 3-min dyadic interaction. Pretest 3, in particular, aimed to measure children's performance on the first administration of a challenging spatial puzzle, which required using rotation to fit together two different shapes. In comparison, pretest 1 did not require rotation and pretest 2 required rotation of identical shapes. Puzzles were made of a 15 cm by 15 cm square piece of foam poster board, with a colored piece of foam laid on top creating the puzzle shape outline. A set of six black foam pieces of varying shapes accompanied each puzzle square, and was placed on a 50 cm by 142 cm white piece of foam poster board. The pieces chosen and the time (seconds) it took for children to choose the correct pieces were recorded. Before each puzzle, the experimenter said: "Look at all of these pieces. When I say go, I want you to grab the pieces that make this whole puzzle piece. Once you grab a piece, you can try it in the puzzle. Ready, set, go!" The puzzle tests ended when they were accurately completed.

Dyadic Interaction at Exhibit—All parent–child dyads were given 3 min at the exhibit. Parents in the experimental conditions were provided a set of flashcards suggesting language to use and ways to engage with their child. Parents could choose to emphasize those prompts within the set of provided flashcards that most appealed to them. During the interaction, parent–child dyads were recorded on a voice recorder (Olympus VN-722PC). To measure parent education level, parents circled highest degree earned on a short questionnaire (*some high school, finished high school, some college, finished college,* and *postcollege degree*). Additionally, parents indicated if their child was fluent in any languages other than English.

Posttests—Children completed three spatial tasks. The first two posttests followed the same procedure as the pretests. First, the last puzzle from the pretest (pretest 3) was read-ministered (posttest 1), to examine whether the expertise developed before the interaction was carried over postinter-action (*cognitive savings*). Second, a novel puzzle (posttest 2), similar to posttest 1, was presented. Finally, children were given a related but distinct posttest, based on the Wechsler Preschool and Primary Scale of Intelligence Block Design subtest (Wechsler, 2012). After the researcher presented a familiarization script about the nature of the blocks and how to fit them together,[1] children were asked to match the top of their blocks to a presented picture, and were told to stop when they felt their blocks and the picture matched. Posttests 2 and 3 aimed to evaluate if the amount of spatial language produced by parents and/or children during the interaction would relate to children's performance on a novel task. At the conclusion of the study, the child was given a small gift for participating.

Spatial Language Coding—The transcripts were analyzed for child and parental spatial language using the categories of the University of Chicago spatial language coding system (Cannon, Levine, & Hutten-locher, 2007). Words within the categories of spatial locations (e.g., *in, out, with, up*), deictic terms (*here, there, where*), dimensions (*big, little, small*), spatial features or properties (*sides, angles*), shapes (*squares, triangles*), continuous amount (*all, more, pieces*) and spatial orientations or transformations (*turn, rotate*) were identified. Three coders, blind to condition, transcribed the voice recordings. Two of the researchers coded all of the transcripts, resolving disagreements along the way. One researcher naïve to the hypotheses of the study coded 30% of the transcripts; agreement between the original coders and the reliability coder was .98. Following transcription each participant (parents and children) was given a raw score of number of spatial language words, and percent of spatial language out of total words spoken.

Puzzle performance evaluation—Puzzle performance was evaluated live during the pretest and posttest. Performance was judged based on the time (seconds) it took for children to accurately complete each puzzle. Once the experimenter said “go!,” the stopwatch was started, and it was stopped when both puzzle pieces were correctly placed within their frame. The time (seconds) to completion was recorded after each puzzle.

Results

Influence of Condition on Language Use

For our first set of analyses, we examine whether the instructions for parent-led spatial interactions were effective in eliciting spatial language, and whether certain instructions elicited particular types of spatial language terms more so than others. Table 1 summarizes this first set of analyses, including means and standard deviations of usage of each spatial term by condition and age (adult/child; with the standard error of the mean (*SEM*) in italics).

The overall number of words spoken by parents and children, the number of spatial terms spoken by parents and children, and the number of each type of spatial term (spatial dimensions, shapes, location/direction, orientation/transformation, continuous amount, deictics, spatial features, pattern) for parents and children were entered as dependent variables in a multivariate analysis of variance (MANOVA), with gender (female, male) and condition (nonscripted, shape-language, goal-language) as between-subjects variables, and parental education level (some high school, finished high school, some college, finished college, and postcollege degree) as a covariate. Due to the museum's geographic location the sample was biased towards highly educated parents (M =3.93, SD = 1.06, R = 1–5 education

[1]The script was as follows: “See these blocks? Some sides are all red, some are all white, and some are red and white. Look at these pictures of the tops of my blocks. Watch me, I'm going to make the tops of my blocks look like these pictures. So first this block needs to be all white on top and this next block needs to be half red and half white. How do I make the half red and half white block look just like the picture? I have to turn the right block so that the red side is on the top, like this and the white side is on the bottom, like this. Now all I have to do is push the two blocks together so that they are touching side-by-side just like the pictures.

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level). Since this variable can impact spatial language it was important that it be factored into the model as a covariate even if it could not be manipulated directly. Child's gender had a significant effect on the total number of continuous amount terms produced by the child ($F(1, 97) = 4.6$, $p = .03$); although both groups very rarely used these terms, boys were more apt to do so (.46 continuous amount words on average for boys vs. .15 for girls). The experimental condition had a significant effect on the children's overall number of words ($F(2, 97) = 3.7$, $p = .028$), overall number of spatial terms ($F(2, 97) = 6.9$, $p = .002$), shape terms ($F(2, 97) = 12.5$, $p < .001$), location terms ($F(2, 97) = 6.04$, $p = .003$), and deictic terms ($F(2, 97) = 6.6$, $p = .002$). Children used the most shape terms in the shape-language condition ($F(2, 101) = 6.8$, $p = .002$; see Table 1). Condition also had a significant effect on the overall number of words ($F(2, 97) = 20.73$, $p < .001$), and spatial terms used by parents ($F(2, 97) = 48.4$, $p < .001$), specifically the spatial dimension terms ($F(2,97) = 12.8$, $p < .001$), shape terms ($F(2,97) = 78.1$, $p < .001$), location terms ($F(2, 97) = 4.31$, $p = .016$), continuous amount terms ($F(2, 97) = 5.68$, $p = .005$), and spatial feature terms ($F(2, 97) = 35.97$, $p < .001$). Overall, parents used more shape terms in the shape-language condition ($M_{\text{Nonscripted}} = 11.26$ words [$SEM = 1.76$], $M_{\text{shape}} = 40.91$ words [$SEM = 2.92$], $M_{\text{goal}} = 19.17$ words [$SEM = 2.05$], $F(2, 101) = 44.36$, $p < .001$; see Table 1). (Total words spoken are used throughout the manuscript.[2])

Exploratory linear regression analyses indicate that the total words spoken by parents did not predict general child language use ($\beta = .11$, $t(102) = 1.15$, $p = .255$), but parent spatial language use predicted child spatial language use ($\beta = .30$, $t(102) = 3.15$, $p = .002$). Despite lacking scripts, parents in the nonscripted condition did interact with their child at the block wall. Of those 37 parents, all but one parent spoke at least 20 words ($M = 148.64$ words [$SEM = 18.08$]) and all parent-child dyads spoke at least 15 words during the allotted interaction time ($M = 193$ [$SEM = 17.42$]). These patterns indicate that the experimental scripts encouraged parents and children to talk more than they normally would have, and that the amount and type of spatial talk differed as a function of scripted condition type.

Effect of Condition on Posttest Performance

For the second set of analyses, we examine whether children's ability to finish a previously completed puzzle differed as a function of the intervening experimental condition. We also tested the influence of condition on their ability to perform two other spatial puzzles: a novel Woodcock-Johnson puzzle (posttest 2), and a Wechsler block puzzle (posttest 3).

The children's time to complete posttest 1 was put into a repeated-measures ANOVA with session (pretest 3, posttest 1) as a within-subjects variable, condition (nonscripted, shape-language, and goal-language) and gender (female, male) as between-subjects variables, and parental education level as a covariate. There was the expected main effect of session ($F(1, 97) = 4.83$, $p = .03$, $J_p^2 = .05$), with the puzzle taking longer the first time than the second (18.6 s vs. 7.5 s, $p < .001$). The three conditions did not differ from each other overall in

[2]When the analyses above are computed using proportion of spatial terms out of total words, instead of raw total words, the effects remain significant. The experimental condition had a significant effect on children's use of spatial terms ($F(2,97) = 3.75$, $p = .027$). Additionally, when the proportion of spatial terms used by parents out of the total words spoken by parents was used, the experimental condition also had a significant effect on parent's use of spatial terms ($F(2,97) = 21.938$, $p < .001$).

average time to complete puzzles (10.7 s for nonscripted, 12.2 s for shape-language, and 16.3 s for goal-language: $F(2, 97) = 1.37$, $p = .26$, $J_p^2 = .03$). Additional contrasts (Bonferroni-corrected) of pre- to posttest performance indicate the children exhibited faster puzzle completion at posttest relative to pretest in only the shape-language (17.0 s vs. 7.3 s; $M_{\text{difference}} = 9.67$ s, $SD = 4.65$ sec, $p < .01$) and goal-language conditions (25.3 s vs. 7.3 s; $M_{\text{difference}} = 18.08$ s, $SD = 4.88$ s, $p = .04$). However, this faster puzzle completion at posttest was not seen in the nonscripted condition (13.6 s vs. 7.8 s; $M_{\text{difference}} = 5.83$ s, $SD = 4.65$ s, $p = .21$). Thus we only observe a significant improvement in completion of a challenging, previously presented puzzle, for children in the experimental conditions (see Figure 3).

To examine whether children in the experimental conditions would perform differently on other spatial measures, and not simply a repeat of a previous puzzle, we conducted a univariate analysis of variance (ANOVA) over the time to complete posttest 2—a novel puzzle—with condition and gender as between-subjects factors, and parent education level as a covariate. There was no significant main effect of condition ($F(2, 97) = .806$, $p = .450$, $J_p^2 = .016$), or gender ($F(1, 97) = .255$, $p = .615$, $J_p^2 = .003$); children did just as well in the nonscripted (33.4 s [$SEM = 3.6$]) condition as in the shape-language (27.9 s [$SEM = 3.6$]) and goal-language (33.8 sec [$SEM = 3.8$]) conditions. We also examined performance on one trial of the Weschler block task (posttest 3; Wechsler, 1967), entering time to completion into a univariate ANOVA with condition and gender as between-subjects variables and parent education level as a covariate. There were no effects of the covariate ($F(1, 97) = 1.9$, $p = .17$, $J_p^2 = .019$) or of condition ($F(2, 97) = .35$, $p = .70$, $J_p^2 = .007$); children took similar amounts of time in the nonscripted (17.6 [$SEM = 1.8$]), shape-language (16.7 [$SEM = 1.8$]), and goal-language (18.9 [$SEM = 1.9$]) conditions. There was a main effect of gender ($F(1, 97) = 14.5$, $p < .001$, $J_p^2 = .13$); girls (13.6 sec [$SEM = 1.4$]) were faster than boys (21.9 [$SEM = 1.7$]).

Influence of Spatial Language Production on Posttest Performance

One of our main questions was to what degree spatial language produced by the parent and/or the child, irrespective of assigned condition, as coded by the *Spatial Language Coding Manual,* predicted children's improvement on a spatial puzzle (Cannon et al., 2007). To investigate this question, we conducted a series of simultaneous regression models predicting children's improvement between pretest 3 and posttest 1, examining gender and parental education level (in model 1), different types of parental spatial language (entered as a block of variables in model 2), and child's usage of different types of spatial language (entered as a block of variables in model 3). We found that children's spatial language (model 3) was the only measure of used spatial language that predicted improvement on the posttest puzzle 1 ($F(18, 85) = 3.0$, $p < .001$); the adjusted R^2 for model 3 was .26. Specifically, when controlling for parental education, gender, and parental spatial language input, the child's use of spatial dimension terms ($\beta = .29$, $t = 3.04$, $p = .003$), shape terms ($\beta = -.34$, $t = -2.78$, $p = .007$), and deictics ($\beta = .44$, $t = 4.64$, $p < .001$) predicted how much more rapidly they could solve a previously presented challenging puzzle. (Note that the use of shape terms was negatively related to improvement, perhaps reflecting the purely repetitive aspect of saying a straightforward shape term such as *square* when the parent said “square.”)

Discussion

These results indicate that a short spatial language interaction, including shape- or goal-language, can encourage greater spatial language production by parent–child dyads and improve children's subsequent puzzle performance. Engaging with children through guided play, while emphasizing spatial terms and relationships, improves their performance after a delay on a repeated puzzle. We term this improvement *cognitive savings:* expertise from completing a difficult task (pretest 3), that carried over to repeating this same task (posttest 1) after a delay. Cognitive savings, resulting in a quicker time to complete the identical posttest puzzle, were observed following the shape-language and goal-language interactions in comparison to the nonscripted group, which lacked explicit prompts. Critically, parents in the nonscripted condition used less spatial language and were less verbal overall. As follows, children in the nonscripted group produced significantly less spatial terms than children in the experimental conditions. Further, they did not significantly improve in puzzle performance. This heightened posttest performance, seen only in the experimental groups, illustrates how encouraging and prompting active verbal participation in playful and educational interactions facilitates the transfer and recall of learned information at a later time (Boland, Haden, & Ornstein, 2003; Fisher, Hirsh-Pasek, Newcombe, & Golinkoff, 2013; Haden, 2010).

Importantly, improved puzzle performance was only predicted by children's spatial language production. Because children in the experimental conditions used more spatial language than in the nonscripted condition, these higher levels of parent spatial language prompted children in the experimental conditions to use spatial language at the exhibit, leading to cognitive savings in puzzle performance. This is in line with the findings from Pruden et al.'s (2011) longitudinal study of parent and child spatial language. They found that child spatial language production mediated the positive relationship between parent spatial language use and child's performance on spatial tasks. Additionally, child spatial language production was a significant predictor of their later spatial thinking. The current study and Pruden et al. (2011) suggest that parent spatial language is valuable in its encouragement of child spatial language production. It is likely that children's spatial language use facilitates their attention to spatial information, allowing them to better encode and understand spatial features and relations (Gentner, 2003; Gentner, Simms, & Flusberg, 2009).

The current study exemplifies the variety of ways that parents can use language to bolster their child's spatial thinking. Cognitive savings were seen in both the shape-language and goal-language conditions. However, we attribute the individual success of these conditions to different aspects of the provided prompts, specifically in regard to language used by the dyad. The shape-language condition was effective in motivating parents to use a large quantity of spatial language with their children, encouraging children to produce more spatial language terms in this condition relative to the other two conditions. The goal-language condition was effective in encouraging child-led spatial play and conversation at the exhibit. Children in this condition produced more words overall than children in the shape-language condition, and more spatial language than children in the nonscripted condition.

The effects of both experimental conditions demonstrate that effective guidance can be flexible and tailored to the preferences of individual dyads. Both didactic and open-ended prompts can promote parent–child spatial language production. Moreover, spatial language use may lead to a heightened focus on spatial reasoning that benefits spatial cognition. Work of this type allows us to pinpoint effective and realistic messages to relay to parents, to engender interactive situations that improve spatial reasoning. Overall, this study suggests that the creation of naturalistic and engaging learning situations, guided by empirical work on developmental psychology, can bolster critical spatial reasoning abilities in young children.

Appendix Shape-Language Script

1. Emphasize the idea that each shape has its own identity.
   - **a.** "Look at this triangle. It has three sides, and is a full shape. This triangle is a whole."
   - **b.** "Look at this square. It has four sides, and is a whole. You can pick up the square and hold the square, and that square is its own shape."
   - **c.** "Look at this rectangle. It has four sides, and is a whole. This rectangle is one shape. Just like you are one person."
2. Encourage your child to place the different sized shapes into the large blue squares to fill in the box.
   - **a.** "How about you use all of the different shapes here to completely fill in one of the big blue squares on the wall?"
3. Talk about filling in the square.
   - **a.** "Look we can make one big square using all of the little shapes. These little shapes, can make one whole big square. Lets put the shapes together in the big blue square."
   - **b.** "By putting two purple squares together, we can make one big rectangle. Can you do that?"
   - **c.** "By putting two of the triangles together, we can make one square. Can you do that?"
   - **d.** "Now keep filling in the big blue square."
   - **e.** *Once square is completely filled*—"Look we made one big square out of all the little shapes. Now we have one big whole square. Made of little whole shapes."
   - **f.** "High-five for finishing the square!"
4. Emphasize creativity.

a. "Can you make other designs with the shapes? Maybe you can make one whole house using each of the shapes. Or do you have any other ideas?"

b. As they create their own designs, make sure to point out each different shape that is making up the *whole* picture. For example, if they make a house point out the triangle and the square.

Goal-Language Script

1. Tell your child to build a tower.

    a. "How about you build a big tower using all of the different blocks? Keep building it until you have made it as high as possible."

    b. As they build keep complimenting the tower—"WOW this looks amazing!"

2. Once they finish the tower you can tell them to knock it down.

    c. "Now you can knock down your tower by pushing it or using the other blocks to knock it down."

3. Suggest building a wall with the blocks, and seeing which shapes can fit through different cracks in that wall.

    d. "How about you build a wall with the blocks? Leave some cracks in the wall, and try to see which shapes fit in those cracks."

4. Suggest that your child builds a mini city.

    e. "How about you try to make a mini New York City with the blocks? You can design different buildings, and where they go. You can even leave spaces for roads, and cars. Maybe you can create some stores, some offices, some homes, and some restaurants."

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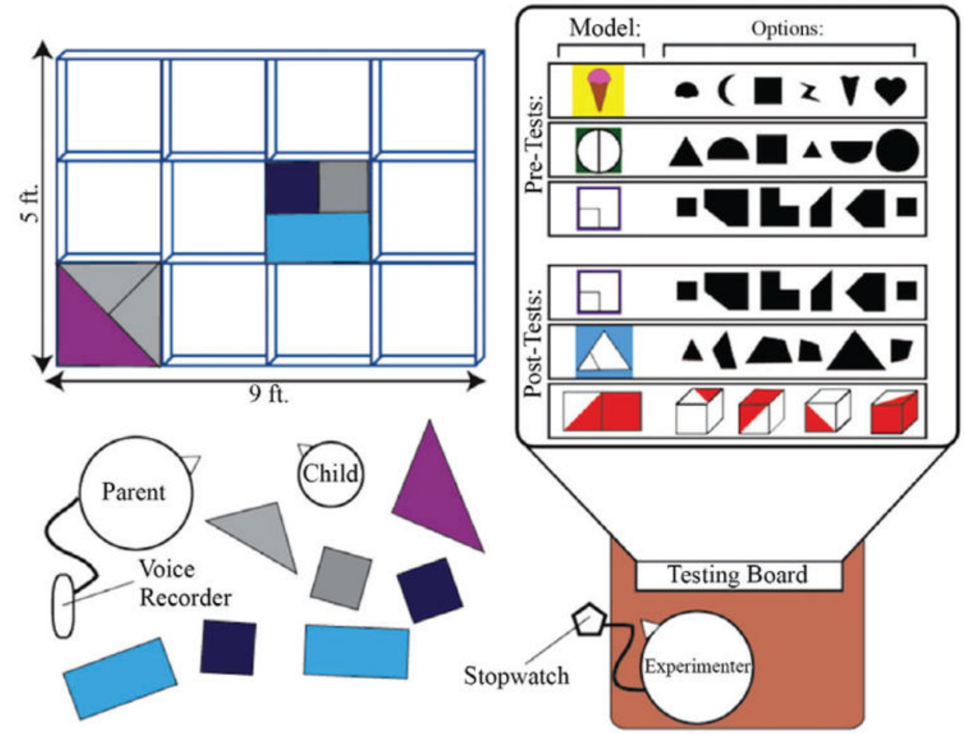

Fig. 1.
Schematic of the experimental setup, and pre- and posttests.

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Fig. 2.
Photograph of the block wall exhibit.

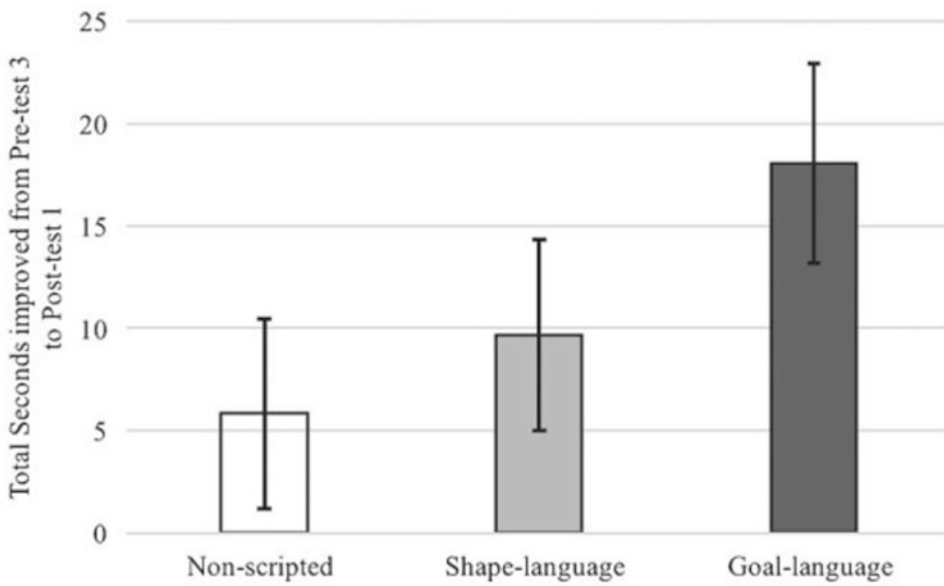

Fig. 3.

The amount children improved from pretest 3 to posttest 1 after dyadic interaction at the museum exhibit. Improvement was measured by the decrease in time (seconds) to completion for posttest 1 in comparison to pretest 3. Only children in the shape-language and goal-language conditions significantly improved in their performance.

Table 1

Spatial Language Productions by Child-Parent Dyads During the 3-Min Interactive Session at the Museum's Shape Wall Exhibit

Condition	Overall number of words	Overall number of spatial terms	Spatial dimension	Shape	Location or direction	Orientation or transformation	Continuous amount	Deictic	Spatial features	Patterns
Average number of word types and terms—child										
Nonscripted	36.80 *(5.63)*	2.03 *(0.69)*	0.32 *(0.25)*	0.57 *(0.38)*	*0.44(0.17)*	0.03 *(0.02)*	0.07 *(0.13)*	0.40 *(0.20)*	0.05 *(0.07)*	0.03 *(0.08)*
Shape language	31.98 *(5.63)*	**5.43*** *(0.69)*	0.85 *(0.25)*	**3.12***,** *(0.38)*	0.09 *(0.17)*	0.00 *(0.02)*	0.35 *(0.13)*	0.29 *(0.20)*	0.21 *(0.07)*	0.17 *(0.08)*
Goal language	**53.28**** *(5.90)*	**4.95*** *(0.73)*	1.01 *(0.26)*	1.10 *(0.40)*	**0.96**** *(0.18)*	0.00 *(0.02)*	**0.50*** *(0.13)*	**1.26***,** *(0.21)*	0.06 *(0.07)*	0.05 *(0.08)*
Average number of word types and terms—parent										
Nonscripted	148.64 *(18.08)*	10.96 *(2.29)*	1.16 *(0.61)*	*2.34(1.17)*	3.23 *(0.68)*	0.08 *(0.05)*	0.80 *(0.44)*	*2.97 (0.53)*	0.30 *(0.30)*	0.09 *(0.10)*
Shape language	**311.62*** *(18.08)*	**41.51***,** *(2.29)*	5.52* *(0.61)*	**20.96*** *(1.17)*	**6.04*** *(0.68)*	0.09 *(0.05)*	**2.86*** *(0.44)*	3.31 *(0.53)*	**3.41***,** *(0.30)*	0.23 *(0.10)*
Goal language	250.65* *(18.95)*	18.29 *(2.40)*	**4.62*** *(0.64)*	3.49 *(1.23)*	4.93 *(0.71)*	0.00 *(0.06)*	2.17 *(0.44)*	2.72 *(0.55)*	0.22 *(0.32)*	0.15 *(0.10)*

Notes. Covariates appearing in the model are evaluated at the following values: Mean education level of parents = 3.93. Significant differences between the experimental and control conditions are noted with an asterisk and bold text and indicate significance at an alpha level of $p < .05$. Differences between the two experimental groups are noted with a double asterisk symbol and bold text and indicate significance at an alpha level $p < .05$. *SEM* are noted in italics underneath the mean.