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PARENTAL SUPPORTS FOR THE DEVELOPMENT OF CHILDREN'S SPATIAL SKILLS

A Thesis in

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by

Giulia A. Borriello

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The thesis of Giulia A. Borriello was reviewed and approved* by the following:

Lynn S. Liben
Distinguished Professor of Psychology
Thesis Advisor

Kristin Buss
Professor of Psychology

Janet van Hell
Professor of Psychology and Linguistics

Melvin Mark
Professor of Psychology
Head of the Department of Psychology

*Signatures are on file in the Graduate School

ABSTRACT

Spatial skills are correlated with individuals' success in science, technology, engineering and mathematics (STEM). Research finds positive correlations between parents' spatial behaviors and children's spatial abilities. Although the direction of causality has not been established, the correlation suggests that one possible intervention may be to encourage parents' active attempts to facilitate their children's spatial skill. This intervention strategy may be difficult to effect given that spatial skills are not taught explicitly in educational curriculum and many parents may not understand what they are. This study tested whether parents would show greater use of spatial scaffolding after being informed about the importance of spatial thinking and offered illustrative strategies. As hypothesized, mothers given this information used more spatial-guidance behaviors (e.g., spatial language and behaviors supporting vantage point and other spatial concepts) during dyadic play than mothers in a control condition. Moreover, a significant association was found between children's spatial language and condition, with this relation mediated by mothers' spatial language. These results indicate that parental spatial guidance is malleable, and this study consequently provides a necessary foundation for designing a fuller parent-delivered spatial intervention and testing its impact on children's spatial understanding.

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Chapter 1

Introduction

Spatial ability, “the ability to generate, retain, retrieve and transform well-structured visual images (Lohman, 1994a, p. 1000)” is an essential component of cognitive development that supports human functioning across the lifespan. Children use spatial skills to navigate their schools and neighborhoods, and use these skills later in life to drive to known and unknown locations, to succeed in college courses such as physics, chemistry, and engineering, and to perform simple everyday tasks like tightly packing a car trunk. Importantly, spatial skills underlie mathematical and scientific thinking and have been shown to predict achievement in science, technology, engineering, and mathematics (STEM) domains (Humphreys, Lubinski, & Yao, 1993; Shea, Lubinski, & Benbow, 2001; Wai, Lubinksi, & Benbow, 2009). Children’s spatial abilities have even been found to relate to children’s mathematics performance as young as age three (Wolfgang, Stannard and Jones, 2003; Verdine et al., 2013). This ability appears to be critical for success in various domains, however research shows that spatial skills vary, with some individuals performing high and others performing low (e.g., Halpern et al., 2007). Some people even show evidence of deficits of spatial thinking well into adulthood (Liben, 2006).

Fortunately, individual’s spatial skills seem to be capable of improvement over time via learning, practice, and training activities. A meta-analysis (Uttal et al., 2012) examining the malleability of spatial skills provided promising evidence that spatial skills are in fact malleable, and that spatial skill training may be able to enhance individuals’ spatial abilities.

Researchers have proposed a number of theories to explain the variation in spatial skills, from ones emphasizing biological processes such as the importance of sex hormones (e.g., Williams, Barnett, & Meck, 1990; Bushbaum & Heckin, 1980) to those emphasizing environmental processes such as the role of experience (e.g., Voyer, Nolan, & Voyer, 2000). One possibility is that frequent experiences in informal learning contexts (e.g., at home) may influence variations in children's spatial development. Vygotsky's sociocultural framework, which follows this line of thinking, proposes that children can gradually increase their knowledge via the zone of proximal development (Vygotsky, 1978), a concept which proposes the transformation of children's knowledge via shared social experiences with more capable adults. Using this theoretical framework, the present study hypothesizes that children's spatial thinking may increase via shared social interactions with parents, given that parents have more advanced knowledge of spatial concepts and may be able to guide children's spatial understanding during play.

Extensive literature has shown that parents can guide children's cognitive development in a number of ways. A plethora of research, for example, has examined parent-child interactions in relation to children's language and literacy development (e.g., Bus, van IJzendoorn, & Pellegrini, 1995; Cochran-Smith, 1983; DeBaryshe, 1993a). Meta-analyses have shown that parent-child joint book reading supports children's outcomes in language growth (e.g., vocabulary), emergent literacy, and reading achievement (e.g., Bus et al., 1995). Parental input during book reading seems to particularly support children's vocabulary development, given that books as a context provide a wider range of vocabulary than typical conversations (Sulzby; 1985). Vocabulary, in turn, seems to facilitate children's reading abilities (Sènèchal, LeFevre, Thomas & Daley, 1998). Earlier, more consistent exposure to joint book reading activities is thus related to greater gains in children's language and literacy development (Bus, et al., 1995).

There has been a large focus on family literacy in the United States and elsewhere for some time now, with programs reaching libraries, preschools, and elementary schools (Nickse, 1990). A number of researchers have created interventions aimed at encouraging parental input during shared book reading experiences. Studies (e.g., Whitehurst, Barnett, & Meck, 1988; Arnold, Lonigan, Whitehurst, & Epstein, 1994) have found that children whose parents were trained to use didactic behaviors during book reading displayed more advanced language abilities than children whose parents did not receive this training. These findings suggest that parental input during book reading interactions is malleable, and that this input can influence children's burgeoning literacy and language abilities. Parental input may thus serve as a mechanism for stimulating aspects of children's cognitive development.

Given that spatial skills appear to be malleable and seem to be affected by experience across the lifespan (e.g., Baenninger & Newcombe, 1989; Twyman, Newcombe & Gould, 2013; Uttal et. al., 2012), researchers have begun to urge interventions to promote spatial skills in early childhood (Newcombe, 2010). Given past research showing links between parenting and children's development in other cognitive domains (e.g., literacy) researchers are beginning to explore whether children's spatial achievements are also influenced by parents' spatial behaviors during parent-child interactions.

For example, Szechter and Liben (2004) observed interactions between parents and either 3 or 5 year old children during play with a book depicting numerous spatial-graphic representations across its pages, called Zoom. Children were also given spatial tasks to complete. Results showed that parents' spatial-graphic behaviors correlated with older children's performance on spatial-graphic comprehension tasks (younger children were excluded because they performed poorly on the tasks). Significant correlations were found between children's performance on the spatial tasks and parental strategies that highlighted spatial information (e.g., discussing how one object looked different from page to page due to a zooming effect) in the picture book. These results suggest that preschoolers whose parents use more spatial guidance during spatially rich activities may perform better on related spatial tasks, although as the authors note, it is also possible that children with better spatial skills elicit more spatial guidance from their parents.

One specific facet of spatial guidance is spatial language. Research has converged to find that spatial language and spatial thinking are indeed related (Casasola, Bhagwat, & Burke, 2009; Gentner & Lowenstein, 2002). Parents' spatial language is thought to facilitate children's spatial thinking. A number of studies, both correlational and experimental, have demonstrated the relation between children's exposure to parents' spatial language and children's own spatial language use, and the relation between children's spatial language and their performance on spatial tasks.

Pruden, Levine, and Huttenlocher, (2011) found considerable variability in the amount of spatial language parents produced around children during daily home interactions. Importantly, the quantity of spatial language parents used at home predicted the quantity of children's spatial language, once overall parent language was controlled for. Furthermore, children who produced more spatial language between 14 and 46 months performed better on spatial tasks given at 54 months. Spatial language thus appears an important facet of spatial guidance, as well as an aspect of spatial behavior that may facilitate children's spatial thinking.

Another important aspect of parental spatial guidance, one that, until recently, has not been explored much, is the context in which it occurs. Ferrara, Hirsch-Pasek, Newcombe, Golinkoff, and Lam (2011) randomly assigned parent-child dyads to one of three conditions: free play with blocks, guided play, or play with preassembled structures. Results showed that parents produced substantially higher proportions of spatial language in the guided play condition than in the other two conditions. Children also produced higher proportions of spatial language in the guided play condition than in the free play condition. Researchers also compared dyads' spatial language production in the building conditions to other dyads' spatial language during play with non-spatial activities (e.g., pretend play). Dyads' spatial-language production was significantly lower during activities that did not include spatial materials compared to any of the three block-play conditions. These results suggest parents and children produce more spatial language during parent-child play with activities that are spatially-oriented (e.g., block play) than with activities that are not spatially-oriented (e.g., play with puppets).

Another study (Levine, Ratliff, Huttenlocher, & Cannon, 2012) examined the relation between children’s early puzzle play and preschoolers’ spatial skills. Children and parents were observed at home in a six-session long study between the ages of 2 and 4 years old. Once children reached 4 years and 6 months old, they performed a spatial transformation task with two dimensional objects. The experimenters examined whether individual variations in the frequency and quality of children’s puzzle play would relate to their spatial skill performance at a later age. Results demonstrated that children who engaged in jigsaw puzzle play (as opposed to other forms of play, e.g., pretend play, book reading) scored higher on the spatial transformation task than children who played with other toys. For children who engaged in puzzle play, those who played with puzzles more frequently had higher scores on the spatial transformation task than those with less frequent puzzle play. These results suggest puzzle play positively correlates to preschooler’s spatial thinking skills. Together these findings suggest that play with spatial toys may be a rich context in which children can stimulate their spatial skills, especially with spatial guidance from parents.

While these studies show promise in the relation between parents’ spatial guidance and children’s spatial understanding during play interactions, most of these findings are merely correlational, and it remains unclear whether parents who provide more spatial guidance to children lead children to use more spatial behaviors (e.g., spatial language) and perform better on spatial tasks, or whether children who use more spatial behaviors and who perform better on spatial tasks lead parents to provide more spatial guidance. More research is consequently needed to determine parents’ ability to provide spatial guidance to children in informal settings. The current study aims to use an experimental design to target parents' spatial guidance and to test whether parents' are capable of providing children with increased amounts of spatial guidance during play. Secondarily, this study aims to test any indirect effects of parental spatial guidance on children's spatial behaviors during play.

Chapter 2

The Present Study

Given that past findings suggest parents' spatial input varies and also suggest the importance of spatial guidance for children's spatial ability (e.g., Pruden et al., 2011), the main question of the present study is whether parents' child-directed spatial guidance is malleable. If parental input is indeed a potentially important contributor to children's spatial ability, it is necessary to assess whether this factor can be enhanced to provide children with increased spatial input. This question is particularly interesting to address because many people do not seem to have a clear understanding of what spatial thinking is (Newcombe, 2010), which leads researchers to question whether parents would be capable of scaffolding these skills in a way similar to literacy and language skills. Many parents likely consider book-reading experiences beneficial to children's development, given the large focus on family literacy (Nickse, 1990) and that parent-child book reading experiences are considered normative and occur frequently at home (Bradley, Corwyn, McAdoo, & Coll, 2001). The same is not necessarily true for parents regarding their understanding of the importance of spatial skills. Due to the lack of knowledge about the importance of spatial abilities, a necessary first step in assessing the importance of parents' spatial guidance on children's spatial development is to assess whether an intervention geared toward increasing parents' didactic-spatial behaviors during play may be effective.

To test the malleability of parents' spatial guidance behaviors, mothers and their 4 to 6 year old children were invited to the lab and videotaped during joint play with spatial toys (e.g., jigsaw puzzles; building blocks). Prior to the manipulation the researchers obtained baseline spatial behaviors for both mothers and children during play with a set of jigsaw puzzles. After baseline play, mothers in the experimental condition (but not the control condition) received brief instructions explaining spatial thinking, its importance, and how it relates to STEM outcomes, as well as a short description about how to play in a spatial manner with toys. Mothers in the control condition were simply asked to play as they normally would with their children. The purpose of the spatial instructions was to assess whether mothers given information about spatial thinking would provide children with more spatial guidance during play (as compared to mothers in the control condition). Following the instructions, parent-child dyads engaged in play with a set of LEGO blocks and an accompanying booklet depicting various structures they had to build using the blocks.

One way mothers' spatial guidance behaviors were analyzed was by examining their use of spatial language during play with children. Moreover, a secondary aim of this work was to examine whether potentially increased spatial guidance from mothers influenced children's spatial behaviors during play. Children's spatial language was therefore examined during play as well. Because this was a one-session long intervention that lasted only one hour, the authors did not expect to see immediate changes in children's spatial performance as a result of the intervention. Thus, instead of obtaining measures of children's spatial abilities following play, the researchers decided to examine children's spatial language during play to assess whether mothers' spatial guidance had any impact on children's ongoing spatial behaviors during play. Mothers' and children's spatial language was measured during baseline play and during LEGO construction play.

In addition to spatial language, some other measures of mothers' spatial guidance behaviors were coded for during LEGO construction play as a way to test the effectiveness of mothers' ability to provide children with spatial guidance. Mothers' spatial guidance behaviors include picture-structure links, booklet-and structure alignment, and vantage point behaviors. Picture-structure links are comparisons mothers made across the blocks and the booklet which aided children's ability to build during spatial play. Booklet-and-structure alignment behaviors occurred when mothers attempted to align the orientation of a LEGO piece or structure with a model of that structure in the accompanying booklet. Vantage point behaviors occurred when mothers attempted to use play materials (block pieces or the booklet) to emphasize that objects look different depending on their orientation or depending on the orientation of the viewer. All of these behaviors (explained fully in the methods section) are strategies that mothers could provide to children during play as a way to explain and/or highlight spatial concepts.

Hypotheses

First, it was predicted that mothers and children's spatial language would not vary by condition during baseline play (prior to mothers' receiving instructions). Second, it was predicted that mothers in the experimental condition would produce more spatial language and spatial guidance behaviors (i.e., picture-structure links; booklet and structure alignment; vantage point) during play following the instructions (i.e., LEGO construction play) than mothers in the control condition. Finally, it was predicted that children in the experimental condition would produce more spatial language during play following the instructions (i.e., LEGO construction play) than children in the control condition, and that this association would be mediated by mothers' spatial language.

Chapter 3

Method

Participants

Mother-child dyads were recruited from a research database, which informs families of research opportunities occurring on a university campus, as well as from science fairs for children on a university campus. The research database was developed by Penn State University to establish connections with families near the university's campus who desire to participate in research regarding child development. Researchers sent letters describing the study procedures home to families with children in the appropriate age range for the study; a few days after letters were sent out to families, mothers were contacted by phone and were asked to participate. 33% of invited families from the research database who were contacted agreed to participate in the study. 15.8% of invited families from science fairs who were contacted agreed to participate. Eight mothers contacted the researchers requesting to participate after other mothers who had participated notified them of the study. The sample included 41 typically developing children (19 girls and 22 boys) and their mothers. Five dyads were excluded because children refused to participate or due to video malfunction. Children's age ranged from 4.21 years to 6.33 years, *M* (*SD*) = 5.23 years (.65).

According to mothers' reports, the sample was 85.4% European American, 7.3% Asian American, 4.9% Hispanic, and 2.4% African American (two children were adopted internationally).

Overview

Mother-child dyads were tested individually. Families were greeted and escorted by a researcher to a comfortably furnished testing room in the department of psychology. After mothers signed consent forms and children gave verbal assent for their participation, dyads played together with a set of jigsaw puzzles, described in more detail later. Mothers then received play instructions which varied depending on whether they were in the control or the experimental condition. Following instructions, dyads played together with more spatial toys. This paper focuses on dyads' play with one of play tasks, called LEGO construction play. During LEGO construction play, dyads received LEGO blocks and a booklet showing 10 constructions made using the same LEGO blocks. Dyads were asked to build the constructions from the booklet together. All play sessions were videotaped for future transcribing and coding.

Materials

Spatial Toys

Dyads played with two sets of toys, a set of two jigsaw puzzles and a set of building blocks with an accompanying booklet of constructions. The jigsaw puzzles (see Figure **3-1**) were identical, except that one had its image painted over to obscure the puzzle's representational meaning (a backhoe).Thus, for the painted puzzle, solution required use of the pieces' shapes and spatial features without reliance on picture cues normally available in a jigsaw puzzle.

Figure 3-1. Jigsaw puzzle set.

The collection of LEGO blocks (see Figure **3-2**) for LEGO construction play included blocks of different shapes and dimensions, cars and people pieces. Each page of the booklet dyads received displayed four photographs of one structure taken from different camera angles: an eye level view of the front side of the structure, an eye level view from the back side of the structure, an oblique angle of the front side of the structure, and an overhead (vertical) view of the top of the structure. The structures varied in difficulty: complexity of structures was determined by the number of blocks structures had, the number of horizontal levels and vertical planes structures had, and whether any blocks were only visible from one and not all viewing angles. Structures were ordered in the booklet from easy to hard. See Figure **3-3** to view a sample page of the booklet dyads received.

Figure 3-2. LEGO pieces.

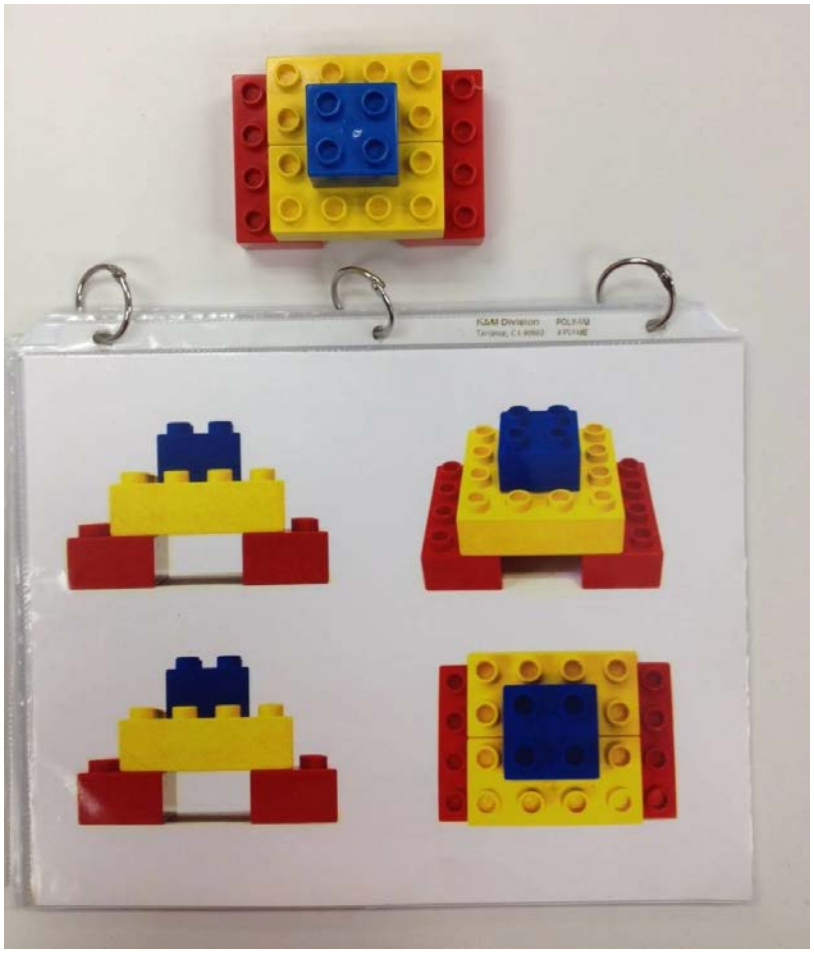

Figure 3-3. A model structure and a sample page from the LEGO construction booklet.

Instructions to Mothers

Mothers received different play instructions following baseline play based on whether they were assigned to the experimental condition or the control condition. Mothers in the experimental condition received spatial instructions which were brief, simple instructions that defined spatial thinking and provided various examples of how people rely on these skills in everyday life. (See Appendix A for full spatial instructions.) The instructions also emphasized that spatial skills may help their children to succeed in school (e.g., in mathematics, science and geography classes) as well as in STEM fields. Finally, mothers were informed that play may be one context in which children could strengthen spatial skills. They were shown a few different ways that a toy (the jigsaw puzzle used during baseline play) could be used during play to emphasize spatial characteristics of toy pieces (e.g., the size and shape of the pieces; how the pieces fit together). Mothers in the control condition were told to continue play with their children as they normally would.

Procedure

Baseline Play

This play period was used as a way for researchers to assess mothers' and children's baseline spatial language as they played with a spatial toy. Dyads played with a set of jigsaw puzzles for five minutes, and were instructed to play with the jigsaw puzzles as they normally would at home.

Instructions to Mothers

Following play with the jigsaw puzzles, mothers were then told they would play with more toys with their children. Before they received the remaining toys, mothers were told they would hear some instructions. Mothers assigned to the experimental condition received spatial instructions, while mothers in the control condition were told to continue playing with their children as they normally would. Children were in the room as mothers were given either instructions, but they began coloring with paper and crayons prior to mothers receiving instructions as a way to keep them entertained. Dyads were assigned to conditions by alternating dyads with boys and dyads with girls within similar age ranges to experimental and control conditions. This allowed researchers to maintain experimental and control conditions with children of roughly equivalent age and gender in each group.

LEGO Construction Play

Before being presented with the next play task, mothers in the experimental group were asked to keep in mind the information they had just learned about spatial thinking while those in the control condition were again reminded to just play the way they normally would with their children. Dyads then received the LEGO blocks set and its accompanying booklet. The researcher explained to mothers that the booklet contained 10 structures, with each page of the booklet containing one structure taken from four different camera angles. Mothers were told that each page of the booklet had a different structure on it, and the four camera angles depicting each structure were described to mothers. Dyads were instructed to play together and to try to build as many of the structures in the booklet as possible, using the booklet as a guide. They were given 10 minutes to build as many of the structures as they could.

Coding

Both mothers' and children's spatial language were coded. The current report addresses mothers' and children's spatial language during both jigsaw puzzle (baseline) play and LEGO construction play. A number of other spatial behaviors were also coded for mothers during the guided play task, including booklet-and-structure alignment, vantage point, and picture-structure links. All of these codes will be discussed in detail below. See Table 3-1 for a list of mothers' and children's spatial behaviors across play tasks.

Table 3-1. Mothers' and children's spatial behaviors during jigsaw play and during LEGO construction play.

Play Task	Participant	Spatial Behaviors Coded
Jigsaw Play		
	Mothers	Spatial Language
	Children	Spatial Language
LEGO Construction Play		
	Mothers	Spatial Language
		Booklet-and-Structure Alignment
		Vantage Point
		Picture-Structure Links
	Children	Spatial Language

Spatial Language

Both mothers' and children's speech during play was transcribed. Using transcripts from the play interactions, dyads' spatial language was coded for both baseline (i.e., jigsaw puzzle play) and LEGO construction play (i.e., post-instruction play). Dyads' spatial language during play was coded using the *System for Analyzing Children's Language about Space* (Cannon, Levine, & Huttenlocher, 2007; http://spatiallearning.org/media/silc_pdfs/resources/testsandinstruments/Spatial%20Language%20Coding%20Manual%201-10-12.pdf). Coders identified terms and phrases that fell within the following spatial categories of this system (definitions are taken directly from Cannon et al., 2007):

(1) Shapes– words which describe the standard or universally recognized form of enclosed two- and three- dimensional objects and spaces. For example: shape, triangle, circle, rectangle, octagon etc.

(2) Spatial Dimensions- words that emphasize the size of objects, people or spaces. For example: size, small, long, tall, big, tiny etc.

(3) Spatial features and properties- words that describe the features and properties of two- and three-dimensional objects, spaces, people, and the properties of their features. For example: bent line, curvy, edge, side etc.

(4) Orientation and Transformation- words that describe the relative orientation or transformation of objects and people in space. For example: direction, turn, flip etc.

(5) Location and Direction- words that describe the relative position of objects, people and points in space. For example: at, on, beneath etc.

(6) Deictics: words that are place deictics/pro-forms (i.e., these words rely on context to understand their referent). For example: here, there, where, etc.

Coders imported transcripts into the program, CLAN (Computerized Language ANalysis; http://childes.psy.cmu.edu/clan), to calculate the number of spatial words (*spatial tokens)* each mother and child produced during both play periods. The CLAN program was also used to edit transcripts in order to code for spatial language within the transcripts. Coders added a line of code (%cod:) under each line of a transcript where a spatial word (e.g., "top") or utterance, a combination of words in a phrase that expressed only one spatial concept (e.g., “on the bottom”), occurred and specified the type of spatial language category that word or utterance was: deictic, dimension, location, orientation, shape, or spatial feature. Another way to code spatial language was for coders to attach a code for the spatial language category directly to the word or utterance in the transcript. Potentially spatial words with non-spatial usages (e.g., “right” in “you’re right!”) were excluded from these analyses. To determine when exclusions occurred, coders referred to a list of phrases using words with non-spatial usages in the original coding system (Cannon et al., 2007). Only words that were spatial in context were included.

For each play task, researchers calculated the total number of individual spatial words and utterances every mother and child used. In order to control for the total amount of speech participants produced, researchers took dyad members’ total amount of speech during play into consideration using a ratio when examining dyads’ total amount of spatial talk. The ratio compared dyads' total amount of spatial talk (spatial words + spatial utterances) to their total amount of speech used (spatial words + spatial utterances + non-spatial words). Proportions of mothers’ and children’s spatial language were calculated for each play task.

Reliability: Spatial Language

Mother’s and children’s speech were transcribed during both jigsaw puzzle play and LEGO construction play. Two research assistants independently transcribed dyads’ speech during each play activity. A third coder compared both transcripts and made final decisions on any discrepancies between transcribers.

Regarding spatial language, two independent coders double coded all spatial language from the transcripts. Inter-rater reliability was above 0.80 for spatial language on all transcripts (in both play tasks). Any coding discrepancies across the two coders were discussed and resolved for final versions of coding.

Picture-Structure Links

During the LEGO construction play task with building blocks, researchers coded events in which mothers or children drew an explicit connection between the structure they were building and the picture of the structures (in the booklet) that they used to guide their building. Picture-structure links were coded when a dyad member used a verbal reference connecting a picture and structure (e.g., "Does your building look like the picture?"), a physical reference connecting a picture and structure (e.g., pointing to the booklet), or a combination of verbal and physical links (e.g., "Look they match" while pointing back and forth between a structure and picture).

Reliability: Picture-Structure Links

Two research assistants coded videos independently. Prior to coding final versions of files, coders achieved a high level of agreement (K=0.95) for coding mothers' picture-structure links. To ensure that coders remained reliable as they coded final versions of files, continuous reliability checks were conducted during coding. Inter-rater reliability remained high throughout coding.

Booklet-and-Structure Alignment

This spatial guidance behavior involved specific connections mothers would make about the way that structures and the booklet pictures aligned in space. That is, researchers coded every incident whereby a mother turned the booklet or the structure they were building so that structure and pictures of that structure in the booklet were oriented in the same direction. The frequency of mothers' booklet-and-structure alignment behaviors was calculated.

Reliability: Booklet-and-Structure Alignment

Two research assistants coded videos independently. Prior to coding final versions of files, coders achieved a high level of agreement (K=0.83). After reaching high inter-rater reliability, researchers double coded all videos for mothers' alignment behaviors. Any coding discrepancies across coders were discussed and resolved for final versions of coding.

Vantage Point

A final spatial guidance behavior involved whether mothers made reference to the concept of vantage point during LEGO construction play with building blocks. Vantage point behaviors were coded each time mothers attempted to convey the idea (verbally or via gesture) that the way an object looks differs depending on the object's orientation or viewer's (or photographer's) position. Mothers' vantage point explanations often involved using a structure dyads were building from the booklet, however this was not necessary. Here is a fictional illustration of a mother using a structure to discuss vantage point: "How do we make it look like that one (a picture in the booklet)…you have to you flip it (the structure)." Mothers who simply had discussions about the concept of vantage point with their children without referring to the booklet and its various pictures would also be credited for a vantage-point behavior. What follows next are two fictional illustrations of a mother discussing vantage point without involving the booklet: A mother tells her child, "an ice cream cone looks different to us if we flip it from one side to the other"; or a mother uses a LEGO piece itself to show that if it was turned from one side to another or looked at by a person from various locations in space it would look different.

Reliability: Vantage Point

Two research assistants coded videos independently. Prior to coding final versions of files, coders achieved a high level of agreement (K=0.85) for coding mothers' vantage point behaviors. To ensure that coders remained reliable as they coded final versions of files, continuous reliability checks were conducted during coding. Inter-rater reliability remained high throughout coding.

Chapter 4

Results

Preliminary Analysis

Given the history of gender differences in spatial skill (Levine et al., 1999; Masters & Sanders, 1993; Quinn & Liben; 2008; Vasta & Liben, 1996), preliminary analyses were conducted to examine evidence of gender differences. Because no gender differences were found, child gender was omitted from the analyses reported below.

Overview

Results are presented in two sections. The first describes analyses for spatial behaviors of both mothers and children during the baseline activity. The second describes analyses of mothers' spatial behaviors during the LEGO construction play task, including mothers' spatial language, booklet-structure alignments, vantage point behaviors, and picture-structure links. The second section also describes analyses for children's spatial language during the LEGO construction play task.

Baseline Spatial Behaviors

Mothers' Spatial Language

An independent-samples t-test was conducted to compare mothers' baseline spatial language use in the experimental and in the control conditions prior to the manipulation. As hypothesized, no significant difference was found between mothers' spatial language in the experimental (M= .06, SD= .028) and control (M=.06, SD= .037) conditions; $t(39)= 0.43$, $p = 0.671$ (see Figure **4-1**). As illustrated in Table 4-1, there was a wide range of variation in mothers' language, spatial or otherwise. See Table 4-2 for a breakdown of mothers' mean spatial language by the six spatial language categories coded for: deictic, dimension, location/direction, orientation/transformation, shape, and spatial feature/property.

Table 4-1. Descriptive statistics for mothers' and children's spatial language across play tasks.

		Mean Words (SD)	Range	Minimum	Maximum
Jigsaw Puzzle Play	Mother				
	Total Words	312.27 (112.312)	435	78	513
	Spatial Words	19.85 (12.19)	49	0	49
	Child				
	Total Words	121.85 (56.38)	238	10	248
	Spatial Words	7.37 (5.70)	25	0	25
LEGO Construction Play	Mother				
	Total Words	861.59 (255.65)	1152	397	159
	Spatial Words	70.68 (30.28)	115	23	138
	Child				
	Total Words	255.22 (129.24)	612	86	698
	Spatial Words	17.83 (12.35)	56	4	60

Table 4-2. Mothers' mean number of spatial words/utterances by category across play tasks.

Spatial Language Category	Jigsaw Puzzle Play (SD)	LEGO Construction Play (SD)
Deictic	5.32 (4.81)	12.54 (8.77)
Dimension	.83 (1.28)	11.27 (10.22)
Location/direction	9.00 (5.87)	30.32 (15.34)
Orientation/transformation	1.12 (1.76)	3.41 (4.59)
Shape	1.29 (1.40)	5.32 (8.93)
Spatial feature/property	2.29 (3.24)	7.83 (5.71)

Children's Spatial Language

An independent-samples t-test was also conducted to compare children's baseline spatial language in the experimental and control conditions. As hypothesized, the t-test found no significant differences between experimental (*M*= .06, *SD*= .04) and control (*M*= .06, *SD*= .03) conditions; t(39)= 0.07, p = 0.941 (see Figure **4-3**). See Table 4-1 for descriptive information about children's spatial and non-spatial language. Table 4-4 displays children's mean spatial language split into the six spatial language categories coded for: deictic, dimension, location/direction, orientation/transformation, shape, and spatial feature/property.

Spatial Behaviors during LEGO Construction Play

Mothers' Spatial Language

An independent samples t-test tested the hypothesis that mothers' spatial language would be higher in the experimental condition than in the control condition. Results found that mothers in the experimental condition (*M*= .09, *SD*= .03) used significantly more spatial language during play than mothers in the control condition (*M*= .07, *SD*= .02); t(39)= 2.50, p = .017 (see Figure **4-1**).

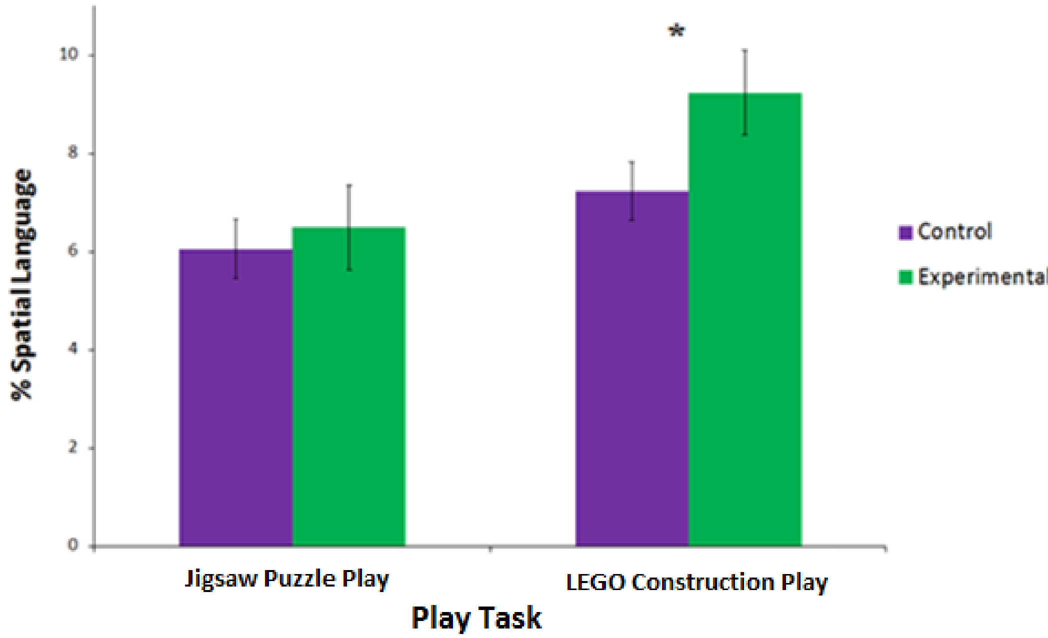

Figure 4-1. Percentage of mothers' spatial language in jigsaw puzzle play and in LEGO construction play as a function of condition (control or experimental).
(Note: *p=.017)

See Table 4-1 for descriptive information regarding mothers' spatial language and non-spatial language. Table 4-2 displays mothers' mean spatial language split into the six spatial language categories coded for: deictic, dimension, location/direction, orientation/transformation, shape, and spatial feature/property.

Mothers' Booklet-and-Structure Alignment Behaviors

An independent samples t-test was conducted to test the hypothesis that mothers' alignment behaviors would be higher in the experimental condition than in the control condition. The t-test found that mothers in the experimental condition produced significantly more alignment behaviors during play (*M*= 10.35, *SD*= 6.81) than did mothers in the control condition

(*M*= 6.05, *SD*= 4.06); t(35)= 2.38, *p* = .023 (see Figure **4-2**). See Table 4-3 for descriptive information regarding mothers' booklet-and-structure alignment behaviors.

Mothers' Vantage Point Behaviors

An independent samples t-test compared mothers' vantage point behaviors across conditions. As hypothesized, the t-test found that mothers in the experimental condition produced significantly more vantage point behaviors during play (*M*= 7.50, *SD*= 6.24) than did mothers in the control condition (*M*= 3.10, *SD*= 2.85); t(23.22)= 2.75, *p* = .011 (see Figure **4-2**). See Table 4-3 for descriptive information regarding mothers' vantage point behaviors.

Mothers' Picture-Structure Links

Finally, an independent samples t-test was conducted to test the hypothesis that mothers in the experimental condition would produce more picture structure links than mothers in the control condition. The test found that mothers in the experimental condition produced significantly more picture-structure links during play (*M*= 11.89, *SD*= 6.87) than did mothers in the control condition (*M*= 7.80, *SD*= 4.98); t(36)= 2.12, *p* = .041 (see Figure **4-2**). See Table 4-3 for descriptive information regarding mothers' picture-structure link behaviors.

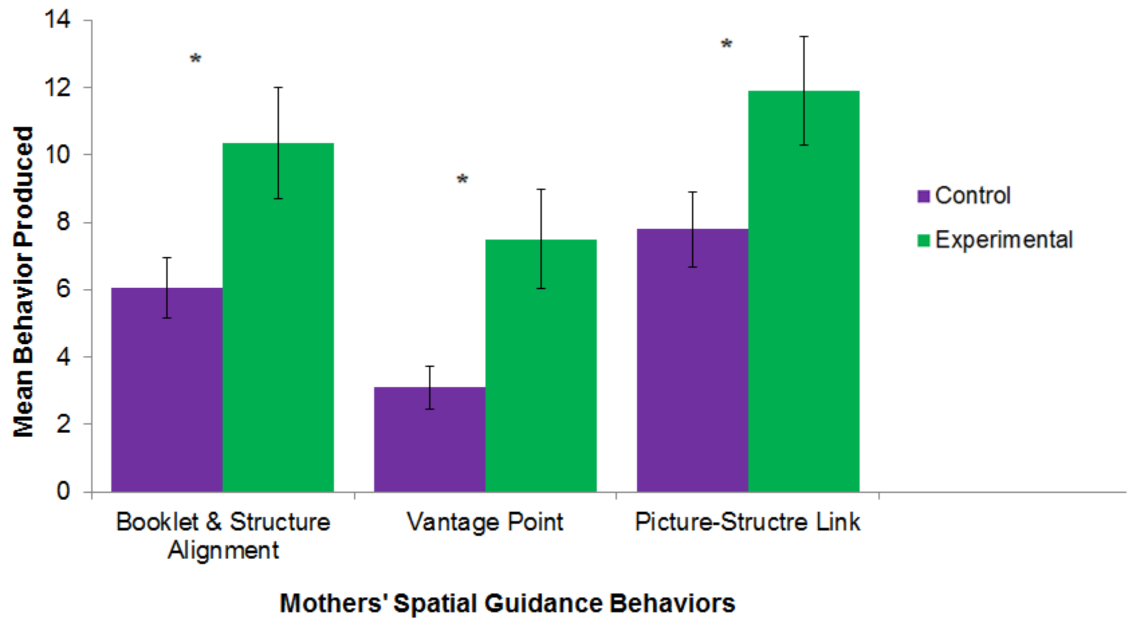

Figure 4-2. Mothers' spatial guidance behaviors: booklet-and-structure alignment, vantage point, and picture-structure link in LEGO construction play as a function of condition (control or experimental).
(Note: *p<.05)

Table 4-3. Descriptive statistics for mothers' spatial guidance behaviors during LEGO construction play by condition.

Mothers' Spatial Guidance Behavior	Condition	Mean Behavior Produced (SD)	Range	Minimum	Maximum
Booklet-and-Structure Alignment	Control	6.05 (4.06)	17	1	18
	Experimental	10.35 (6.81)	28	0	28
Vantage Point Behaviors	Control	3.10 (2.85)	9	0	9
	Experimental	7.50 (6.24)	20	0	20
Picture-Structure Links	Control	7.80 (4.98)	20	0	20
	Experimental	11.89 (6.87)	28	0	28

Children's Spatial Language

It was also predicted that children in the experimental condition would produce more spatial language than children in the control condition. To compare children's spatial language an independent sample t-test was conducted. Analyses found that children in the experimental condition produced significantly more spatial language than children in the control condition, $t(39)= 2.10$, $p = .043$ (see Figure **4-3**). As Table 4-1 illustrates, children's spatial language varied considerably. Table 4-4 shows children's mean spatial language divided into the six spatial language categories coded for: deictic, dimension, location/direction, orientation/transformation, shape, and spatial feature/property.

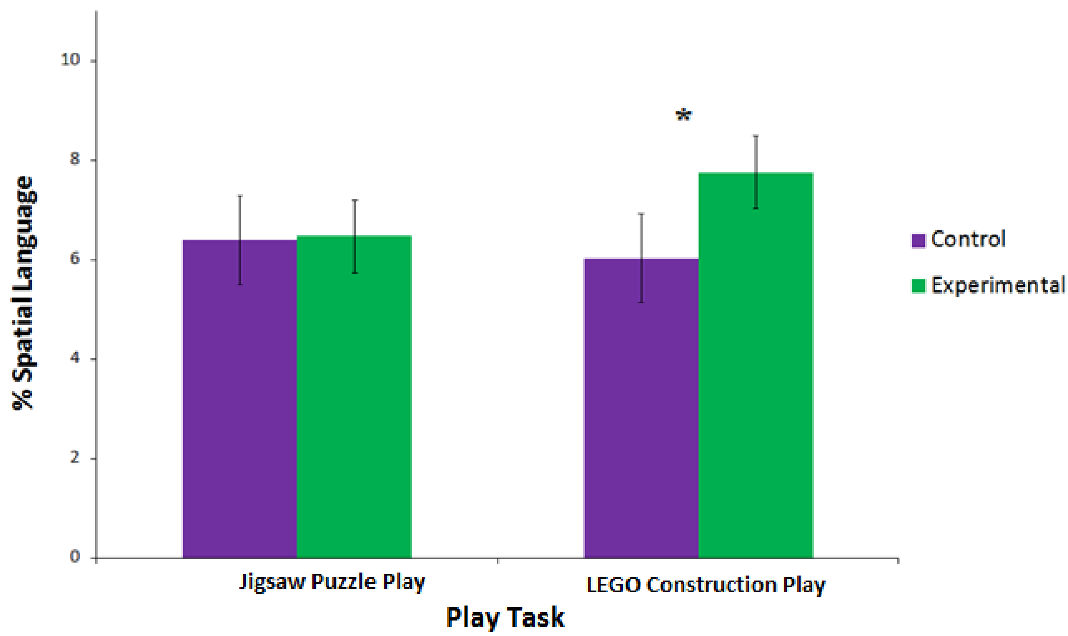

Figure 4-3. Percentage of child spatial language in jigsaw puzzle play and in LEGO construction play as a function of condition (control or experimental).
(Note: *p=.043)

Table 4-4. Children's mean number of spatial words/utterances by category across play tasks.

Spatial Language Category	Jigsaw Puzzle Play (SD)	LEGO Construction Play (SD)
Deictic	3.73 (3.76)	4.88 (3.76)
Dimension	0.34 (0.73)	3.44 (3.50)
Location/direction	2.61 (3.01)	6.24 (5.95)
Orientation/transformation	0.22 (0.53)	0.83 (1.69)
Shape	0.22 (0.69)	1.37 (3.56)
Spatial feature/property	0.24 (0.49)	1.07 (1.42)

It was predicted that this difference in children's proportion of spatial language by condition was mediated by mothers' spatial language. To test this hypothesis, a mediation analysis was performed using the standard approach developed by Baron and Kenny (1986). First, a linear regression was performed to test the relation between the predictor variable (condition) and the outcome variable (children's spatial language). Analyses found that condition was significantly related to children's spatial language ($\beta = .32$, $t(40) = 2.09$, $p = .043$). Second, a linear regression was conducted to test the relation between the predictor variable (condition) and the proposed mediator (mothers' spatial language). Analyses found that condition was significantly related to mothers' spatial language ($\beta = .37$, $t(40) = 2.50$, $p = .017$). Third, a linear regression was conducted to test the relation between the proposed mediator (mothers' spatial language) and the outcome variable (children's spatial language). Analyses found that the relation between mothers' spatial language was significantly related to children's spatial language ($\beta = .45$, $t(40) = 3.13$, $p = .003$).

Because the linear regressions described above (see Figure **4-4**) were independently significant, a multiple regression was tested including condition and mothers' spatial language as independent variables and children's spatial language as the outcome variable. The overall model was significant, ($F(2, 38) = 5.57$, $p = .008$). Analyses found that the relation between the proposed mediator, mothers' spatial language, and the outcome variable, children's spatial language, remained significant even when condition was controlled for (β= .38, t (38)= 2.50, p= .017). Although the direct association between the independent variable, condition, and the outcome variable, children's spatial language, was significant (see Figure **4-4**), once the proposed mediator was included as an additional independent variable in the model and controlled for, the relation between condition and children's spatial language was no longer insignificant (β= .18, t(38)= 1.14, p= .261). These results suggest full mediation (see Figure **4-5**).

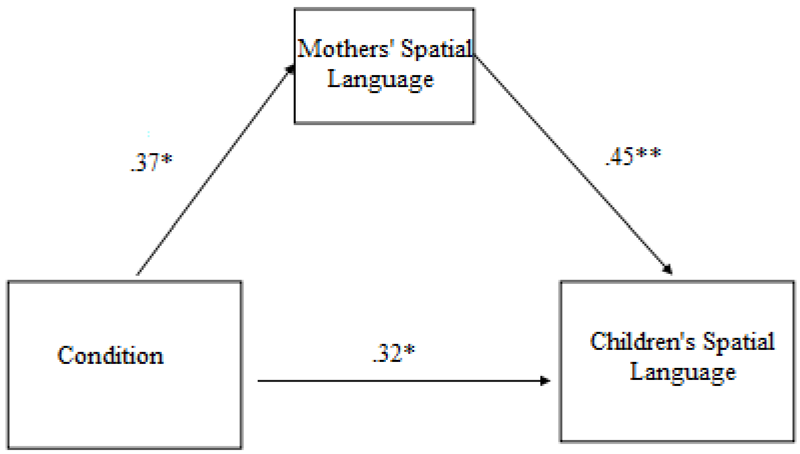

Figure 4-4. Mediation model predicting children's spatial language by condition. Numbers provided are standardized regression coefficients.
(Note: *p < .05; **p < .01)

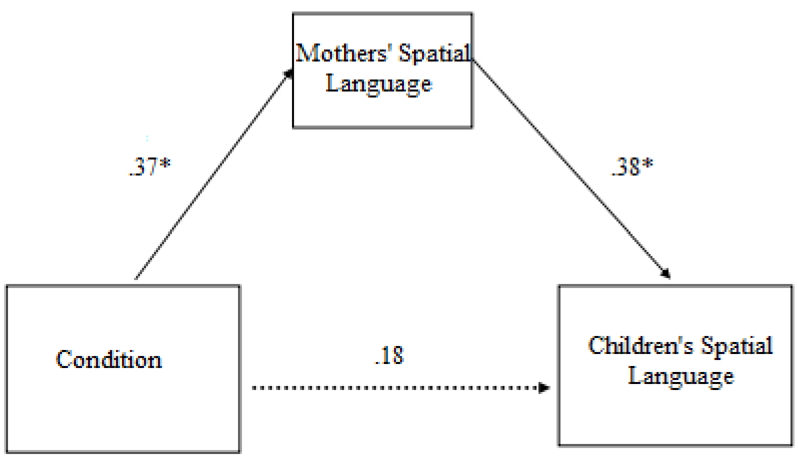

Figure 4-5. Full mediation model predicting children's spatial language by condition. Dark lines indicate significant paths while the dotted line indicates a path that is no longer significant. Numbers provided are standardized regression coefficients.
(Note: *p< .05)

Chapter 5

Discussion

The purpose of this study was to investigate whether mothers' spatial guidance behaviors during play with children are malleable. As predicted, providing mothers' with instructions regarding spatial thinking and its importance led them to use more spatial guidance during play with children (as compared to mothers who did not receive these spatial instructions). Mothers in the experimental condition (those receiving spatial instructions) used more spatial language and produced more spatial guidance behaviors (i.e., picture-structure links; booklet and structure alignment; vantage point behaviors) during play with children than did mothers in the control group. All of these behaviors highlighted spatial aspects of the play materials dyads used and highlighted spatial concepts more generally (e.g., vantage point). The results of this study provide evidence that parents' spatial guidance behaviors during play with children are indeed malleable, and consequently provide support for the idea that one way to facilitate children's spatial abilities is via support from parents in interactive play contexts.

Although this intervention did not intend to target children directly, the study's secondary aim was to investigate whether increased spatial guidance from mothers may indirectly influence children's spatial behaviors. As predicted, the relation between children's spatial language and condition was found to be fully mediated by mothers' spatial language. These findings suggest that mothers' spatial language accounted for the association between condition (the predictor variable) and children's spatial language (the outcome variable) in play following the instructions. Because the instructions led mothers in the experimental condition (but not in the control condition) to increase their spatial language, children's spatial language was significantly higher in the experimental condition than in the control condition. Consequently, it appears that increased spatial guidance from mothers during LEGO construction play led children to use more spatial language in the same play task.

Mothers' and children's baseline spatial language confirmed the condition effect: although neither mothers nor children in both conditions differed in the amount of spatial language they produced during baseline play, findings showed that there was a significant difference by condition for mothers' spatial language as well as for children's spatial language in post-instruction (guided construction) play.

Concerning spatial language, one interesting point to make concerns descriptive statistics of parents' and children's spatial language (total spatial language and spatial language broken down by categories) and total words in LEGO construction play. These findings are exciting because they replicate past findings of Ferrara and colleagues (2011). Ferrara and colleagues (2011) conducted a similar study in which they assigned parent-child dyads to three different play conditions with blocks (phase 1): free play, guided construction play, and preassembled play. Children played in this phase for 10 minutes, the same amount of time that dyads in the current study played during the LEGO construction play task. In phase 2, all dyads were assigned to the guided construction play condition for another 10 minutes. Their guided construction play was almost identical to the LEGO construction play task described in the present study: dyads were given building blocks and five accompanying photographs of one construction built with the blocks. The five pictures provided steps for the dyads to follow in order to make the construction. Dyads were encouraged to use the pictures to build the structure.

Comparing Ferrara and colleagues' descriptive statistics for both parents' and children's spatial language and total words during guided construction play, particularly in phase 1, to the same descriptive statistics found in the present study during LEGO construction play, the findings are striking. In both studies' play tasks, mean spatial language and mean total words (spatial and non-spatial words) for parents and children total words are extremely similar (see Figure **5-1**, to view their descriptive statistics and see Tables 4-1 to view the present study's descriptive statistics). Furthermore, when broken down by spatial language categories, parents' and children's mean spatial language in Ferrara and colleagues' (2011) study (see Figure **5-2** and Figure **5-3**, respectively) are again extremely similar to parents' and children's mean spatial language in the present study (see Table 4-2 and Table 4-4, respectively). The similarities in dyads' spatial language production during these tasks suggest that both studies descriptive statistics are relatively accurate in measuring the amount of spatial language parents and children produce during guided construction play. Moreover, both studies provide relatively new, converging evidence that construction play with pictures of models is a good context for both parents and children to produce spatial language.

Table 1
Mean, Standard Deviation, and Range of Total Word and Spatial Word Counts for Parents and Children in Phases 1 and 2, Shown for the Guided, Free Play, and Preassembled Conditions of Study 1

		M (SD)	*Range*
Condition: Guided			
	Parent		
Phase 1	Total words	724(197)	415–1220
	Spatial words	71(32)	27–145
Phase 2	Total words	638(188)	318–1025
	Spatial words	58(22)	24–112
	Child		
Phase 1	Total words	197(91)	32–428
	Spatial words	14(9)	2–38
Phase 2	Total words	234(118)	84–441
	Spatial words	15	2–34
Condition: Free play			
	Parent		
Phase 1	Total words	496(165)	191–899
	Spatial words	29(15)	11–69
Phase 2	Total words	578(188)	180–947
	Spatial words	45(22)	12–95
	Child		
Phase 1	Total words	252(81)	115–403
	Spatial words	12(7)	4–29
Phase 2	Total words	231(81)	88–367
	Spatial words	12(6)	1–26
Condition: Preassembled			
	Parent		
Phase 1	Total words	567(272)	128–1164
	Spatial words	32(16)	7–66
Phase 2	Total words	582(248)	207–1120
	Spatial words	15(7)	3–28
	Child		
Phase 1	Total words	253(95)	68–428
	Spatial words	51(28)	8–102
Phase 2	Total words	240(78)	42–401
	Spatial words	17(8)	2–29

Figure 5-1. Descriptive statistics for mothers' and children's spatial language during guided construction play in a study conducted by Ferrara and colleagues (2011). This figure was taken from Ferrara and colleagues (2011).

Table 2
Means for Spatial Word Categories Demonstrated by Parents in Phases 1 and 2

Spatial word category	*Free play*	*Guided*	*Preassembled*
Phase 1			
Location	13.58	22.88	18.25
Deictic	6.67	17.5	9.58
Dimension	5.33	10.67	1.88
Feature/property	4.17	15.67	5.2
Shape	0.33	4.83	0.75
Orientation/transformation	5.5	9.3	6.17
Phase 2			
Location	17.75	24.17	19.71
Deictic	11.38	14.92	13.13
Dimension	4.71	7.25	5.29
Feature/property	12.58	13.42	13
Shape	1.04	1.79	1.04
Orientation/transformation	4.5	5.5	4.96

Figure 5-2. Parents' mean spatial language during guided construction play in a study conducted by Ferrara and colleagues (2011). This figure was taken from Ferrara and colleagues (2011).

Table 3
Means for Spatial Word Categories Demonstrated by Children in Phases 1 and 2

Spatial word category	*Free play*	*Guided*	*Preassembled*
Phase 1			
Location	5.29	3.21	9.58
Deictic	3.08	5.63	6.04
Dimension	2.13	3.67	0.46
Feature/property	1.58	1.83	1.33
Shape	0.13	1.33	0.04
Orientation/transformation	1.75	0.75	2.25
Phase 2			
Location	4.52	5.292	6.25
Deictic	3.75	5.3	6.67
Dimension	2.17	2.63	2.42
Feature/property	2.54	2.33	2.88
Shape	0.17	0.38	1.08
Orientation/transformation	1.58	1.08	1.38

Figure 5-3. Figure 5-3. Children's mean spatial language during guided construction play in a study conducted by Ferrara and colleagues (2011). This figure was taken from Ferrara and colleagues (2011).

The current study allowed the researchers to conclude that mothers' spatial guidance behaviors during spatial play with children are indeed malleable. Significant increases in spatial language and spatial behaviors by mothers suggest that mothers are capable of providing more spatial supports to their children during play with spatial toys. Moreover, increased spatial language from mothers appears to impact the amount of spatial language children produce during spatial play with parents. Together, these findings provide support for Vygotsky's sociocultural theory, which suggests that a more competent adult is able to scaffold children's learning via the *zone of proximal development* (1978). Once mothers in the experimental condition were informed about spatial thinking and its importance, and about some ways to make spatial information more salient to children during play, mothers were able to provide children with increased amounts of spatial guidance as compared to mothers in the control condition, who were not told the same information about spatial thinking. Moreover, children in the experimental condition produced more spatial language during play (than children in the control condition) as a result of hearing increased spatial language from mothers following the spatial instructions. These findings consequently support the idea that parenting is potentially a useful pathway for facilitating children's spatial thinking.

This simple intervention has important educational implications for both parents and teachers. These findings suggest that parents, especially of young children, should understand what spatial thinking is, why it is important, and ways that children's spatial skills can be supported during play. The findings from the present study support past studies' (e.g., Ferrara et al., 2011) findings suggesting that play with spatially-relevant toys such as jigsaw puzzles and building blocks is a good context in which children can develop spatial skills. The play materials in this study were particularly useful for allowing parents to guide children's building and highlight spatial aspects of toys (via language or other behaviors) as dyads played. Moreover, the present study's findings provide evidence for the notion that parent-child interactions during spatial play can support children's spatial development: when prompted, parents are able to provide increased levels of spatial guidance to children during play with materials that offer a rich context for discussing spatial concepts and using spatial language.

While this study supports the notion that parents may be able to provide children with increased spatial guidance at home and in other informal educational settings (e.g., science museums), the study's findings can also extend to teachers, particularly of young children. First, these findings suggest teachers should provide children with spatial materials in the classroom, including spatial toys such as building blocks and jigsaw puzzles. Children should be given opportunities to engage in play with these toys given the rich context they provide for promoting spatial thinking. Moreover, similarly to parents, teachers who are well informed about what spatial thinking is and its importance would likely be capable of offering children increased levels of spatial guidance during informal (and possibly formal) activities at school. If children are offered more opportunities to engage in spatial activities with more knowledgeable adults such as teachers, they may have a more opportunities to promote their burgeoning spatial skills.

This study also lays a foundation for future interventions that want to focus on providing parents, teachers and other adults with strategies for scaffolding children's spatial thinking informally, at home or otherwise. Given the short duration of this intervention, the researchers did not expect children's spatial abilities to increase over the course of the study. However, given its promising findings, this study can act as a springboard for future, long-term interventions that may focus on parenting as a way to facilitate children's spatial development. The researchers consequently suggest the utility of creating long-term interventions in the future that focus on providing parents with strategies and skills to support their spatial guidance behaviors in informal settings with children.

Given that the present study was too underpowered to consider children's gender as an independent variable in the primary analyses, future studies should include a large enough sample size to include children's gender as a predictor in order to assess whether findings such as these would vary by child gender. One interesting question is whether mothers would provide differential levels of spatial guidance behaviors to boys and girls, given that past studies have reported differences in parents' spatial input to children by children's gender (Levine et al., 2012), and that boys typically outperform girls on spatial tasks (Levine et al., 1999; Masters & Sanders, 1993; Quinn & Liben; 2008; Vasta & Liben, 1996). A related question would be whether spatial guidance differs by parent gender. That is, whether fathers and mothers who receive spatial instructions such as the ones in this study would provide children with differential amounts of spatial guidance. Given that only mothers were included in the current study, future studies could examine this question. Finally, future studies could examine whether mothers and fathers might provide differential amounts of spatial guidance to children based on children's gender. Would fathers provide more or less guidance to girls than boys, or vice versa? Would mothers' spatial guidance reveal a similar or different pattern than fathers to boys and girls? These questions should be investigated in the future.

One interesting point to note is children's interest in playing with the spatial toys they were provided within the experimental group. Anecdotally speaking, mothers in the experimental group seemed preoccupied with following the instructions they were given and with making their children stay on task and engage with the play materials in a way that followed what the researchers suggested. Some children seemed somewhat uninterested in playing with the materials in the more regimented way that mothers were asking them to; instead they wanted to play with the toys as they saw fit. The researchers consequently suggest that future research consider how to make play materials that can emphasize spatial knowledge more fun and interactive for children to play with so that learning about spatial thinking via play is an exciting and engaging experience for youngsters.

In summary, mothers' spatial guidance behaviors during play do appear to be malleable. When provided information about spatial thinking and its importance, mothers in the present study were able to increase the amount of spatial guidance they offer children during play with spatial toys. Children who heard more spatial language from mothers following the spatial instructions (in the experimental condition only) were able to increase the amount of spatial language they used themselves. These findings suggest that parents' spatial guidance behaviors can be trained and that parents' spatial guidance may have some indirect influences on children's spatial behaviors play activities that are spatially oriented (e.g., building blocks). It seems possible that interactive spatial play with parents may help young children increase their spatial development, although the present study only focused on targeting parents' spatial behaviors during play, and was not designed to answer this question. Future studies should continue examining not only how to target parents' spatial guidance behaviors, but should also continue examining the relation between parents' spatial guidance and children's spatial understanding. This study is the first to show that parents, whose spatial input to children varies naturally (Pruden et al., 2011) are capable of increasing the amount of spatial guidance they offer children during informal learning experiences. Future research should further elucidate parents' ability to provide children with support for spatial thinking during play, and examine parents' ability to influence children's spatial development.

Appendix

Spatial Instructions

"Normally, when talking about children's educational achievement, most parents are aware that literacy and mathematical skills are important foundations for children to build on as they progress through school. However, something parents may not be aware that spatial thinking skills are also important to develop. Spatial skills are tools that underlie mathematical skills and scientific skills. The term "spatial skills" is hard to define, but it refers to a person's ability to visualize and manipulate patterns that occur in space. Spatial thinking concerns the location of objects, their shape, their relations to each other, and the paths they take as they move through space. For instance, you use spatial thinking skills when you try to imagine how a triangle would look if it were flipped upside down, with its pointy top on the bottom. Also, words such as over, under, above, around, corner and edge are linguistic ways to signify spatial relations. For example, when a preschool child visualizes a cow jumping over the moon instead of under it or through it, that child is using their spatial skills.

Spatial skills are also important in school. They especially help children do well in math and science classes. For example, in an algebra class children have to understand the meaning of points on a graph, and know how to find them; in a geometry class they have to understand different geometric figures such as triangles, hexagons, and quadrilaterals, and the different angles they create. In a chemistry class students must understand how to picture the bonds of chemical compounds; in an Earth Science class they have to understand cross-sections of Earth; and in social studies, history or geography class children have to understand how to read maps. Children will also draw on these spatial skills in art classes when they have to draw figures from certain perspectives.

People will also draw on spatial skills in everyday life, for example, when they are using maps to figure out how to get from place to place; when looking at different objects in a picture like a flower and a bird, and their relation to one another in space; when figuring out how to backtrack to a hotel after getting dinner in a strange city; when determining the shortest route to the grocery store or which grocery store in a person's neighborhood is nearest to his or her home; when a person searches for his or her car in a parking lot; when finding a store in a mall; when walking around one's home during the night with the lights turned off in search of the bathroom, and not knocking into furniture along the way; knowing that Florida is south of New York and that New York is east of California, etc. If a person had to rearrange the furniture in a room, put together a desk or a bunk bed using diagrams on an instruction sheet, or play a video game like Tetris, they would have to use spatial thinking skills.

Spatial skills will aid children later in life if they choose to major in fields such as architecture, engineering, computer programming, cartography and many more. In fact, spatial training has been found to improve educational outcomes. For example, spatial training has been shown to help college students complete engineering degrees. With this in mind, we are trying to see if it is possible to encourage parents to stimulate their children's spatial skills during play with toys such as jigsaw puzzles or building blocks. These are toys that children likely own, so it might be especially easy for parents to encourage spatial thinking using these toys. Moreover, play with these kinds of toys can help children think spatially.

There are many ways to promote your child's spatial thinking via toy play. Here are examples of how guided play with a jigsaw puzzle can facilitate children's spatial thinking. Discussing the shape of the puzzle pieces and how they are different, such as the outside puzzle pieces versus the inside puzzle pieces, discussing pieces that have corners and edges verses pieces that are curved; talking about how if you turn or flip the puzzle pieces in a certain direction, the puzzle pieces will fit together, but if the pieces are turned in a different direction, they will not fit together. Thinking about the kind of angles that certain pieces might make with another piece, or about how a single piece, like a corner puzzle piece has a 90 degree angle in itself, talking about all of the puzzle pieces in relation to each other and how the pieces are all different from each other and making your child understand that if the singular pieces are fitted together in the right way they are able to create a bigger picture. Parents can also discuss perspective taking skills by showing the different ways that a person can view the puzzle. For example, a person can view the puzzle from an aerial view or a side view, and the way that he or she views it changes the way that the puzzle looks. These are just a few ways that a jigsaw puzzle can be used to encourage a child's spatial thinking".

Note: The instructions were not read verbatim.

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