Does SES Affect the Development of Children's Spatial Language Abilities?

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Abstract

Children's exposure to and knowledge of specific language has been shown to promote cognition and abilities in those related domains (e.g., Pruden, Levine, & Huttenlocher, 2011; Taumoepeau & Ruffman, 2006). The present study studied the influence of spatial language exposure on preschoolers' spatial language abilities. Children's spatial abilities have been related to later math achievement scores and entry into the Science, Technology, Engineering and Mathematics fields. The study also looked at SES differences in baseline spatial language abilities and differences in improvement. Over a one-month period, twenty-eight 4½-year-old children were exposed to spatial language in five, 15-minute play sessions. All children showed significant improvement after the training sessions, with the greatest increase in shape comprehension scores. There were no significant differences at baseline or post-test between the two SES groups (low-SES vs. middle-SES).

BIOGRAPHICAL SKETCH

Daniel Daewon Suh received a Bachelor of Science from Cornell University in May 2014. He majored in Human Biology, Heath, and Society. He began working at the Cornell Infant Studies Lab with Professor Marianella Casasola his sophomore year and continued to work there upon graduating. He worked as a Research Assistant for one year prior to enrolling in Cornell University in August 2015 for his Master of Arts in Human Development. After graduating, he will pursue his Doctorate in Developmental Psychology at New York University.

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Introduction

Research has shown that early language input can affect children's later cognitive and language abilities. Therefore, researchers have begun to investigate whether exposure to particular sets of words promotes cognition and abilities in those related domains (e.g., Pruden, Levine, & Huttenlocher, 2011). Levine et al. (2011) found that children exposed to more number words had better understanding of cardinal numbers at a later age. Taumoepeau and Ruffman (2006) found that mothers' use of desire language predicted children's later mental state language. A review by Harris et al. (2005) also found that there is a link between the language a child is exposed to and the child's ability to conceptualize mental states. Children exposed to more conversations about people's thoughts were better at conceptualizing mental states. Furthermore, Harris et al. found that a child's own language ability is also linked to the child's ability to conceptualize mental states. If children's language exposure and language ability are good predictors of improvement in cognitive abilities, the development of spatial language in children is a research area of much interest. Such studies could provide insight on how to improve spatial language and spatial abilities, which have been linked to higher performance in the math and sciences (e.g., Wai, Lubinski, & Benbow, 2009) and entry into the Science, Technology, Engineering, and Mathematics (STEM) fields (e.g., Shea, Lubinski, & Benbow, 2001). Research on spatial language development could also provide information on the possibility of language interventions to decrease the math achievement gap found in children from differing SES backgrounds (Galindo & Sonnenschein, 2015). Therefore, in the current study, I began to investigate the effect of spatial language exposure on children's acquisition of spatial language to fill the gap in the literature, as well as to shed light on a potentially fruitful area of research for future interventions.

In the past two decades, an increasing number of studies have looked at spatial language, but most have compared spatial vocabulary across different languages and how the variations relate to differences in spatial thinking (Bowerman, 1996; Bowerman & Choi, 2003). Few studies have looked at the effects of spatial language exposure on children's development of spatial vocabulary in a single language. One study by Pruden et al. (2011) began looking at the effect of naturalistic parent spatial language use on children's spatial language production. In this longitudinal study, researchers visited parent-child dyads nine times, about every four months, when the child was between 14 and 46 months of age. The parent-child interactions were recorded, via video camera, and then transcribed to investigate whether the amount of parent's spatial language input predicted children's spatial language production. Researchers found that increased parental spatial language input for children predicted an increased production of spatial language by children during these interactions. However, more research is needed on children's spatial language development to fill in the gaps on the effects of non-parental input and how input affects both children's production and comprehension.

Filling in the gap in the literature on spatial language development is especially important in light of research showing that children from lower SES backgrounds are at a higher risk for lower language scores (e.g., Peers, Lloyd, & Foster, 2000; Locke, Ginsborg, & Peers, 2002; Wiig, Secord, & Semel, 1992) and that children from low-SES backgrounds benefit more from caregiver language input than children from higher SES backgrounds (e.g., McCartney, 1984; Vernon-Feagans, Bratsch-Hines, & The Family Life Project Key Investigators, 2013). Vernon-Feagens et al. (2013) drew a sample of 3- and 4-year olds from the Family Life Project and looked at the effect of maternal language and caregiver verbal input on children's language development. The Preschool Language Scale, 4th Edition (PLS-4; Zimmerman, Steiner, & Pond,

2002) and the Peabody Picture Vocabulary Test (PPVT-IV; Dunn & Dunn, 2007) were used to measure children's general vocabulary abilities. Researchers found that high quality childcare caregiver language input acted as a buffer against low language measure scores when children were from low-SES households where mothers provided low language input at home. Children with low maternal language input scored similarly on the language outcome measures as children whose mothers provided high language input *only* if the children with low maternal language input had high levels of caregiver language input. Childcare caregiver language showed minimal influence on children's language development when from middle-SES households. These findings could have far-reaching policy relevance on incorporating language-based interventions in childcare settings, particularly those for children from low-SES households. However, it cannot be assumed that the buffering effects shown on low-SES children's general vocabulary abilities will hold true across different subsets of language and vocabulary. There may be an average improvement in general vocabulary, but variations in degrees of improvement across different domains of vocabulary. Therefore, it is important to investigate whether this buffering effect holds true for spatial language to better understand the effect of spatial language input on children's spatial language ability. The findings may then be used to develop interventions at the childcare level to improve low-SES children's spatial, math, and science abilities.

Recent research on language skill differences between children from different SES backgrounds has also begun to show that children from low-SES backgrounds have higher language production scores than language comprehension scores (Ryan, Gibbon, & O'Shea, 2015). In children from middle-SES backgrounds, research has shown that receptive language skills, or language comprehension, precedes expressive language skills, or language production, resulting in a lexical gap between children's comprehension and production of words (e.g., Benedict, 1979; Gershkoff-Stowe & Hahn, 2013). However, Ryan et al. (2015) found that in a low-SES sample of 3- and 4-year olds, the majority of children had higher language production scores than language comprehension scores. These findings held true for both a language delayed group and a typical language group. Ryan et al. state that these results may be due to socioeconomic variables, such as parent-child interaction style, having a greater influence on receptive than expressive language. However, the researchers do note that the effects of the socioeconomic variables may decrease for children older than their 3- and 4- year old sample (Letts et al., 2013). To my knowledge, there are no other studies that have done follow-ups on this finding and no studies that have investigated whether the findings hold true for spatial language. Therefore, an ancillary objective of this study was to investigate whether the findings by Ryan et al. (2015) could be replicated when looking at spatial language.

Due to the dearth of research on spatial language and the effect of spatial language input on children's spatial language abilities, this study had several objectives. Firstly, it investigated whether increased spatial language exposure increased children's spatial language abilities. Existing experimental studies tested linguistic influences on learning in a single session, with only a few minutes between language exposure and test. These studies showed that the effects of the influences can fade within minutes (e.g., Dessalegn & Landau, 2008; Dessalegn & Landau 2013). Therefore, in this study, children were given intensive spatial language input over five 15-minute sessions, two to three times a week, following the finding by Smith et al. (2002) that training children weekly was effective in advancing object names. To facilitate the experimenter's use of spatial language input, the experimenter and child participated in play activities together (e.g., Legos, origami).

Simultaneously, the present study examined possible differences in spatial language abilities between children from low-SES households and middle-SES households. The first objective was to observe whether differences existed between low- and middle-SES groups in their baseline spatial language skills. The subsequent goal was to investigate whether there were differences between low- and middle-SES groups in their improvement of spatial language abilities when exposed to equal amounts of spatial language input. The last objective was to see if there were differences in spatial language production and comprehension scores when comparing children from low- and middle-SES backgrounds, as seen by Ryan et al. (2015) when looking at general vocabulary scores.

Methods

Participants. This study was a part of larger study where children were visited at daycares and tested on various other skills. Participants were twenty-eight 4½-year-old children (*M* = 4.74 years, *SD* = 0.43), with 15 females and 13 males. One additional participant did not complete the study due to fussiness and a loss of interest in the play activities. This participant's data was omitted from final analysis. Children were recruited from private daycares in Ithaca, New York (*n* = 15) as well as from Head Start programs in Dryden, New York (*n* = 6) and East Harlem, New York (*n* = 7). All children were fluent in English and from either middle-SES or low-SES households. Participants' SES was determined by the type of child care center the participants were recruited from. Children from private daycares were recognized as middle-SES and those from Head Start programs were recognized as low-SES. Participants varied in their ethnic/racial backgrounds: Caucasian (*n* = 17), African-American (*n* = 4), Hispanic (*n* = 5), and Asian (*n* = 2) (see Table 1). Parents gave informed consent for their children's participation.

Materials. Children's spatial vocabulary was assessed through a naming and pointing task (see Figure 1). Their general vocabulary was assessed with the Peabody Picture Vocabulary Test (PPVT-IV) (Dunn & Dunn, 2007).

Spatial Vocabulary. Children's receptive and expressive spatial vocabulary for geometric shape names and spatial relation terms was assessed in a task developed in our laboratory. To evaluate expressive spatial vocabulary, children were shown thirteen separate images of geometric shapes and asked to name the shape (e.g., heart, diamond, parallelogram, trapezoid, star, rectangle, square, circle, octagon, oval, hexagon, triangle, pentagon). They were also shown a picture of a stuffed bear in relation to a red cup and asked to state where the bear was ("Can you use words to tell me where the bear is in relation to the cup?"). Children were asked to express seven spatial relations (e.g., behind, in, under, next to, far from, middle, above). In order to get the children to express the spatial relations, children initially required prompting. However, participants only required prompting for the first and, sometimes, second item, before they showed regular understanding as to what was being asked of them.

To evaluate receptive spatial language, children were asked to point to a geometric shape or a spatial relation portrayed through images of the same bear and cup used to assess expressive knowledge of spatial relations. Children were tested on their comprehension of five shapes (e.g., diamond, semi-circle, hexagon, diagonal, pentagon) and seven spatial relations (e.g., below, far away, under, behind, diagonal, upside-down, left). Children's percent correct was calculated on each section.

General Vocabulary. The Peabody Picture Vocabulary Test, Version IV (Dunn & Dunn, 2007) was used to assess children's general receptive vocabulary. Percentile scores were normed according to participants' age in months for analysis.

Apparatus. Children were tested in a quiet room or a quiet corner of the preschool's library. Children sat a table next to the experimenter and all sessions were filmed with a Canon FS200 camera.

Procedure. On the first day, all children were tested on their expressive and receptive vocabulary for shape terms and then for spatial relations. For each of the tasks, children's responses were recorded on a scoring sheet, which was then checked via video. Children's percent correct was calculated for each task (e.g., expressive shapes, receptive shapes, expressive spatial relations, receptive spatial relations).

Then, children began the first of five training sessions, where children participated in constructive play activities with an experimenter who provided spatial language during these activities. The trainings were typically given two to three times a week. Each session was about 15-20 minutes and included several constructive play activities. The activities differed slightly between the children at the private daycares and the Head Start programs (see Table 2), depending on what activities were available. Experimenters permeated the activities with generous amounts of spatial language (e.g., "Can you bring this left corner to this right corner? Let's press down on the middle. Now what shape did we make? A triangle!") All training sessions were transcribed and reviewed to ensure similar amounts and types of spatial language were given to all children throughout the training sessions. Children were given posttest measures between 1 and 14 days after their last training day ($M = 5.0$, $SD = 3.74$). All participants were also administered the PPVT-IV (Dunn & Dunn, 2007).

Shape Matching. Red, glittery foam was cut into a four geometrical shapes (e.g., triangle, pentagon, hexagon, and octagon). An identical set of glittery black foam shapes were cut along the vertical axis to create halves of each shape. The red shapes were set before the child in a two-by-two array. The experimenter would ask the children to name each shape. Children were corrected if they provided the incorrect shape name, or taught the shape name if they did not know it. Then, the experimenter would present the child with the black foam halves, one shape at a time. The black halves would be set apart from each other in odd angles. Children were then asked to point to the red shape the two black pieces would make when brought together. Children were then allowed to put the two black pieces together to see if the initial red shape they chose matched the shape formed by the two black halves. Children were then asked to name the shape again. This procedure was repeated with the remaining three shapes.

Magna-Tiles®. Children were given sets of Magna-Tiles® and larger, single shapes cut out of foam sheets (eg., triangle, square, trapezoid, rectangle, hexagon). Children were only given the number and type of Magna-Tiles® required to make the larger foam shape. Experimenters aided the children if they had difficulty producing the larger shapes.

Origami. Children created either an origami pig or an origami whale. The experimenter guided the child in creating an origami animal, using an instruction booklet with step-by-step color photographs.

Magnetic Shapes. Children chose one of four laminated images from the Mindware Imaginets® set to reproduce on a magnetic white board. The set included magnets of various shapes, sizes, and colors that could be used to form the image the children chose. The experimenter guided children in creating the different scenes.

Lego structures. At the private daycares, children and the experimenter chose a Lego® structure to build (e.g., Creator Mini-Fire truck, Olivia’s Speedboat, or Stephanie’s Pet Patrol). The Creator set could be used to make three distinct figures: a fire-truck, a jeep, or a helicopter.

The Olivia's Speedboat set could be used to build a speedboat and a sandcastle. The Stephanie's Pet Patrol set could be used to build a vehicle with a bike trailer or a rabbit hutch.

At the Head Start Program, children were given different Lego® structure options to choose from. The options were from the Lego® Classic Large Creative Brick Box: an Alligator, Flower, Ghost, or Tiger. The options were for the same age range and judged to be of similar difficulty as those used at the private daycares. All children were guided by the experimenter in creating the Lego® structures using a step-by step manual. Children were given 15 minutes to complete the Legos.

Block Building. Children were given a set of two Verdes Toys Foam Building Blocks and were asked to reproduce a block structure in a color photograph. Children reproduced 10 block structures.

Results

General Vocabulary. Children's percentile on the PPVT-IV (Dunn & Dunn, 2007) was normed for age so that the percentiles reflected their performance relative to their age in months. The PPVT-IV percentiles were examined in a 2 (Sex) x 2 (SES) ANOVA. The analysis yielded significant effects of SES, $F\ (1, 27) = 10.81$, $p = .003$. The low-SES group had lower scores than those the middle-SES group (see Table 3). The analysis failed to yield any significant effect of child sex.

Spatial Vocabulary. Preliminary analyses failed to yield any significant effects of child age and sex so these factors were collapsed in subsequent analyses.

Children's spatial vocabulary was examined in a 2 (SES) x 2 (Time: baseline vs. posttest) x 2 (Spatial Vocabulary Type: shapes vs. spatial relations) vs. 2 (Language Skill: expressive vs. receptive) ANOVA. The analysis yielded no significant effects of SES, $F\ (1, 27) = 1.061$, $p >$

0.5, $\eta_p^2 = .039$. However, analysis revealed significant main effects of Spatial Vocabulary Type, $F\ (1, 27) = 24.789$, $p < .001$, $\eta_p^2 = .488$, and Language Skill, $F\ (1, 27) = 88.964$, $p < .001$, $\eta_p^2 = .774$ (see Table 4). Children were more accurate in comprehending and producing spatial relations ($M = .762$, $SD = .027$, 95%CI [.707, 816]). Children were also more accurate in comprehending spatial vocabulary ($M = .804$, $SD = .022$, 95%CI [.759, .849]) than producing spatial vocabulary ($M = .590$, $SD = .031$, 95%CI [.526, .655]). These main effects were qualified by a Spatial Vocabulary Type x Language Skill interaction, $F\ (1, 27) = 9.318$, $p = .005$, $\eta_p^2 = .264$ (see Figure 3). The difference between children's spatial relation comprehension and shape name comprehension, $F\ (1, 27) = 40.230$, $p < .001$, $\eta_p^2 = .607$, was significantly greater than the difference between children's spatial relation productions and shape name production, $F\ (1, 27) = 1.780$, $p = .194$, $\eta_p^2 = .064$.

The analysis also yielded a significant main effect of Time, $F\ (1, 27) = 29.319$, $p < .001$, $\eta_p^2 = .530$ (see Figure 2). Children improved in all measures of spatial vocabulary from baseline ($M = .660$, $SD = .027$, 95%CI [.604, 716]) to posttest ($M = .734$, $SD = .024$, 95%CI [.685, .784]). Analysis also revealed a Time x Spatial Vocabulary Type x Language Skill interaction, $F\ (1, 27) = 5.723$, $p = .024$, $\eta_p^2 = .180$. In order to further investigate this interaction, analysis was done at each time point separately.

At baseline, a 2 (SES) x 2 (Spatial Vocabulary Type: shapes vs. spatial relations) x 2 (Language Skill: expressive vs receptive) ANOVA revealed no significant effect of SES, $F\ (1, 27) = .513$, $p = .480$, $\eta_p^2=.019$. Analysis yielded a significant main effect of Spatial Vocabulary Type, $F\ (1, 27) = 25.025$, $p < .001$, $\eta_p^2= .490$. Children were more accurate in their comprehension and production of spatial relations ($M = .737$, $SD = .029$, 95%CI [.677, .797]) than their comprehension and production of shape names ($M = .583$, $SD = .033$, 95%CI

[.515, .651]). There was also a significant main effect of Language Skill, *F* (1, 27) = 40.741, $p < .001$, η_p^2= .610. Children were more accurate at comprehending spatial relations and shapes (*M* = .754, *SD* = .028, 95%CI [.697, .812]) than producing spatial relations and shapes (*M* = .566, *SD* = .033, 95%CI [.497, .634]). These main effects were qualified by a Spatial Vocabulary Type x Language Skill interaction, *F* (1, 27) = 15.898, $p < .001$, η_p^2= .379 (see Figure 4). The difference between children's spatial relation comprehension and shape name comprehension, *F* (1, 27) = 46.808, $p < .001$, η_p^2= .643, was significantly greater than the difference between children's spatial relation production and shape name production, *F* (1, 27), = 1.123, $p = .299$, η_p^2=041.

At posttest, a 2 (SES) x 2 (Spatial Vocabulary Type: shapes vs. spatial relations) x 2 (Language Skill: expressive vs receptive) ANOVA revealed no significant effect of SES, *F* (1, 27) = 1.714, $p = .202$, η_p^2= 062. Analysis yielded a significant main effect of Spatial Vocabulary Type, *F* (1, 27) = 13.671, $p = .001$, η_p^2= .345. Children were more accurate in their comprehension and production of spatial relations (*M* = .786, *SD* = .026, 95%CI [.732, .840]) than their comprehension and production of shape names (*M* = .682, *SD* = .029, 95%CI [.623, .742]). There was also a significant main effect of Language Skill, *F* (1, 27) = 81.915, $p < .001$, η_p^2= .759. Children were more accurate at comprehending spatial relations and shapes (*M* = .854, *SD* = .022, 95%CI [.808, .900]) than producing spatial relations and shapes (*M* = .615, *SD* = .031, 95%CI [.550, .680]). In contrast to the baseline ANOVA, the Spatial Vocabulary Type x Language Skill interaction was no longer significant, *F* (1,27) = 2.352, $p = .137$, η_p^2= .083 (see Figure 5). This absence of the interaction was explained by significant increases in shape comprehension scores, *F* (1, 27) = 11.6, $p = .002$, η_p^2=.309. This increase in shape comprehension scores minimized the difference between children's posttest shape comprehension and relations comprehension, causing the interaction at baseline to disappear.

Discussion

Understanding the development of spatial language in early childhood can provide insight into improving children' spatial cognition and skills (Pruden, Levine, & Huttenlocher, 2011), which have been linked to children's math and science achievement (e.g., Wai, Lubinski, & Benbow, 2009). Therefore, this study aimed to investigate the development of spatial language by observing whether increased periodic exposure to spatial language would increase children's spatial language abilities, particularly their comprehension and production of shape terms and spatial relational terms. The question was investigated in children from two different SES backgrounds by observing and comparing their baseline spatial language abilities as well as the amount of improvement after training.

Results revealed that, as a group, children performed better on tests of spatial relations than shape terms. Participants were also better at comprehending, than producing, all types of spatial vocabulary at both baseline and posttest, which differs from findings by Ryan et al. (2015) that suggest SES-related differences in comprehension and production. At baseline, children also showed a greater disparity between their comprehension scores (spatial relations vs. shape terms) than between their production scores (spatial relations vs. shape terms). However, at posttest, this disparity disappeared as the difference in comprehension scores decreased, making the difference between the difference in comprehension scores and the difference in production scores insignificant. This was due to a greater increase in shape comprehension scores than in other spatial language ability scores.

The results of the present study also extended findings by researchers on children's vocabulary development (e.g., Smith et al., 2012), showing that periodic exposure to spatial vocabulary increases children's spatial vocabulary abilities. As a group, children improved on all measures of spatial vocabulary, but improved significantly more in their ability to comprehend shape terms than in any other category. This is most likely due to the fact that shape name comprehension was the area with the greatest potential for improvement (Pruden, Levine, & Huttenlocher, 2011).

One key finding of the current study was that there were no significant differences in spatial vocabulary abilities at baseline between children from differing SES backgrounds. This finding differs from prior postulations and research on general vocabulary abilities (e.g., Vernon-Feagans, Bratsch-Hines, & The Family Life Project Key Investigators, 2013), as well as the current study's findings on general vocabulary abilities measured through the PPVT-IV (Dunn & Dunn, 2007). In previous studies, as well as the present study, the middle-SES group significantly outperformed the low-SES group in general vocabulary abilities.

One possible explanation for the differences found between children's general vocabulary abilities and their baseline spatial language abilities is that that all parents, regardless of SES, expose their children to similar amounts of spatial language in their homes, whereas there may be SES differences in the amount and types of overall general vocabulary used at homes. This could result in insignificant differences on spatial language skills at baseline. Another possibility is that there were significant SES differences in spatial language ability prior to children's admittance to childcare centers. However, caregivers at the Head Start Program provided sufficient spatial language input leading to insignificant differences between the two SES groups at baseline. If this is the case, the current findings extend the findings by Vernon-Feagans et al.

(2013) showing that the language input by childcare caregivers can play a significant role in buffering children who are at risk because of poverty. Further studies need to be conducted to investigate whether there are SES group differences in the general vocabulary scores and spatial language scores of children who do not attend childcare centers. The findings from such a study could begin to shed light on whether the findings of the present study are caused by the type of language input provided by childcare caregivers or the findings are caused by differences in household parental language input.

Another key finding of the current study was that there were no significant differences between the SES groups in their improvement from baseline to posttest, suggesting that there is no difference in spatial language learning abilities between children from differing SES backgrounds. This finding in conjunction with the observation that there were no baseline differences in spatial language abilities between SES groups is especially significant. Previous studies have consistently shown that children, ranging from kindergarteners to middle-schoolers, from middle SES backgrounds outperform children from lower SES backgrounds on tests of mathematic skills (e.g., Magnuson & Duncan, 2005; Galindo & Sonnenschein, 2015). The present study suggests that these differences in mathematic skills may not be due to differences in spatial language abilities or spatial cognitive abilities in early childhood, differing from prior research (e.g., Shea, Lubinski, & Benbow, 2011; Wai, Lubinski, & Benbow, 2011). However, before making such a conclusion, it is important to note that the data used by Shea et al. (2011) and Wai et al. (2011), were from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (National Center for Education Statistics, 2001) and Project Talent (Wise, McLaughlin, & Steel, 1979), respectively. It may be that in recent years, due to increased quality of child care and increased quality of parental care, the math achievement gap has decreased. Then, our results would be in line with what would be predicted when looking at children's math achievement scores. The difference in this study's results from expectations could also be because the small sample size was unable to capture existing SES differences in spatial language abilities. Further studies are needed to look into other possible variables that may explain the observed math achievement gap between SES groups, despite the nonexistence of a gap in spatial language skills.

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Table 1

Ethnicity of participants organized by location, SES and gender

	Low-SES		Middle-SES	Totals
Location	Dryden, NY	East Harlem, NY	Ithaca, NY	
Ethnicity				
Caucasian	6	-	7	13
African-American	-	3	1	4
Hispanic	-	3	2	5
Asian	-	-	2	2
Gender				
Male	4	2	7	13
Female	2	4	9	15

Table 2

Activities children participated in during the five training sessions separated by daycare.

Private Daycares	Head Start Program
1. Shape Matching, Origami Pig, Lego	1. Origami Pig, Magnetic Shapes
2. Shape Matching, Origami Whale, Magnetic Shapes	2. Block Building, Origami Whale
3. Shape Matching, Origami Pig, Lego	3. Magnatiles, Lego
4. Shape Matching, Origami Whale, Magnetic Shapes	4. Jigsaw Puzzle
5. Origami Pig	5. Lego

Table 3

Means and Standard Deviations for PPVT % by SES

	Mean PPVT % (SD)
Low-SES	56.333 (29.379)
Middle-SES	87.225 (18.996)

Table 4

Descriptive statistics (% correct) for spatial vocabulary measures of all participants

	Baseline		**Posttest**	
Measures	*M (SD)*	*95% CI*	*M (SD)*	*95% CI*
1. Spatial Relation Comprehension	.886 (.100)	[.848, .925]	.933 (.087)	[.899, .967]
2. Shape Comprehension	.629 (.229)	[.540, .718]	.786 (.210)	[.704, .867]
3. Spatial Relation Production	.594 (.247)	[.498, .689]	.652 (.239)	[.559, ,744]
4. Shape Production	.541 (.157)	[.480, .602]	.585 (.139)	[.531, .639]

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Figure 1
Spatial vocabulary test measures: expressive spatial language items (left), and receptive language items (right).

Figure 2
Bar graph of difference (posttest minus baseline) scores of spatial vocabulary abilities by SES

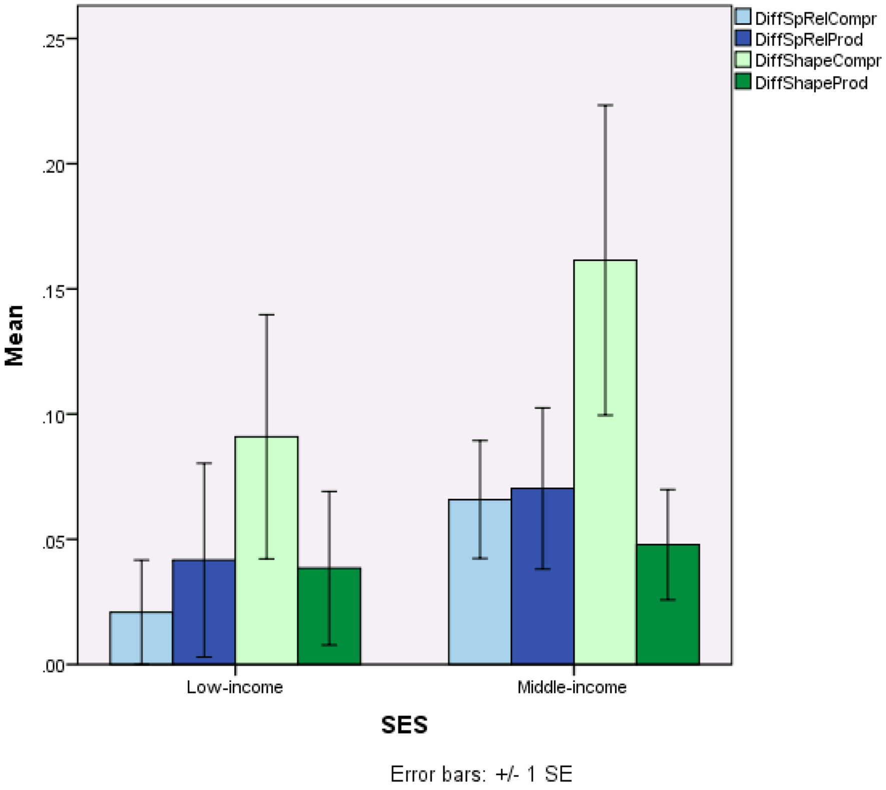

Figure 3

Total estimated marginal means of spatial vocabulary type by language

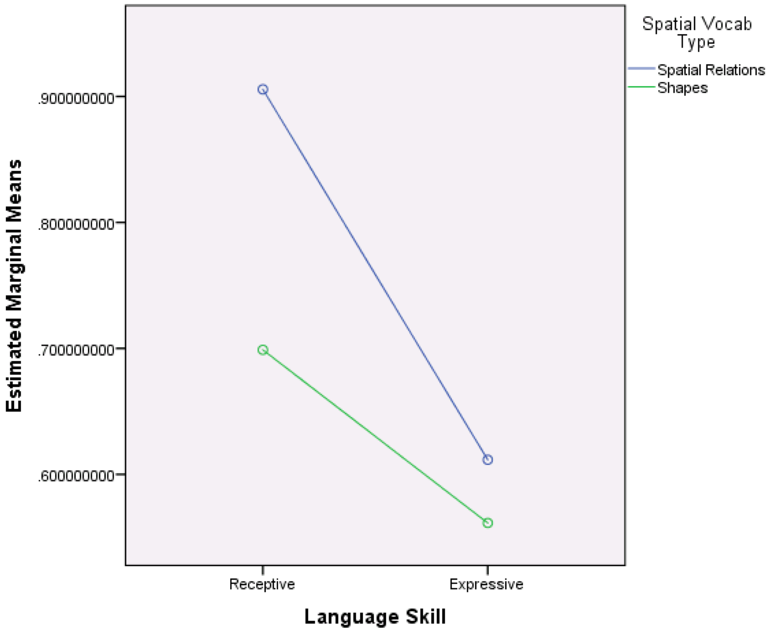

Figure 4

Baseline estimated marginal means of spatial vocabulary type by language skill

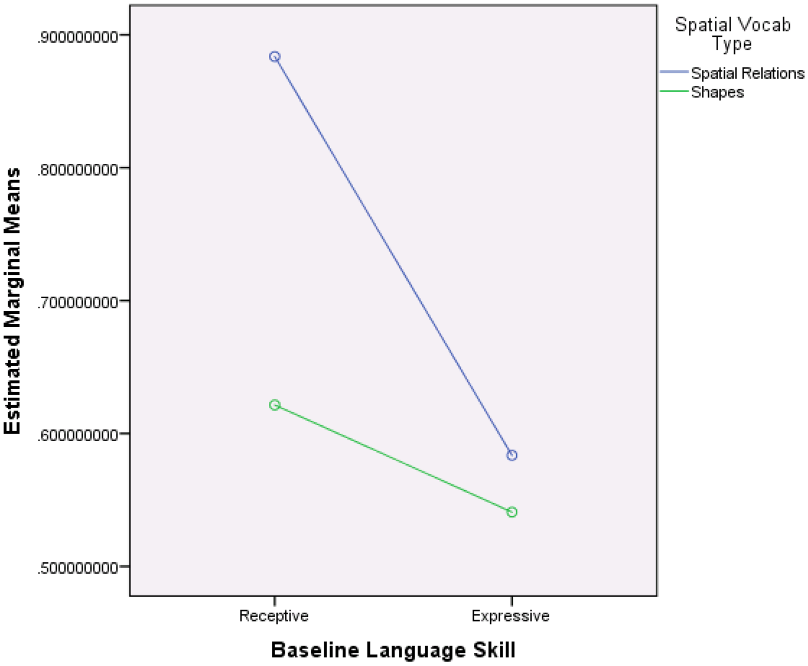

Figure 5

Posttest estimated marginal means of spatial vocabulary type by language skill