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Exploring Parent-Child Interactions During Natural Spatial Play

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Exploring Parent-Child Interactions During Natural Spatial Play
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Abstract

Spatial skills develop continuously throughout life. One way for young children to improve spatial skills is by working together with a more knowledgeable person such as a parent. When parents use spatial language during play, they bring attention to the spatial information on and around the target object, which subsequently promotes spatial skills in children (Cartmill et al., 2010; Pruden et al., 2011; Pruden & Levine, 2017). In the past, most research on the development of spatial skills was conducted in highly structured laboratory settings. While laboratory studies are useful because they allow researchers to control circumstances that can introduce noise into data, laboratory studies may not accurately capture the way children play and interact with others in a natural environment. Real life is 'noisy:' It is unstructured and variable, and it operates under a different set of constraints than the laboratory environment. Therefore, this study sought to explore how parents and children interact to solve spatial tasks together in a more natural environment. Previously collected videos from an online digital library were coded to explore the different ways parents and children solve spatial problems together in a more naturalistic, less controlled setting. A secondary goal of the study was to create a coding manual that would capture language and adult-child interactions as they work together through spatial tasks in the more natural environment.

Keywords: spatial development, natural environment, working together, spatial language

Introduction

Most of our daily activities require spatial cognition: thinking about the shape, location, and movement of objects in relation to one another or to other objects in the environment (Newcombe & Shipley, 2014). We drive cars, carefully changing lanes and anticipating where other cars and pedestrians will appear. We fit plates and bowls into the dishwater, placing each object like a piece in a complicated puzzle to cram as much as possible for each wash. We take walks around the neighborhood, using the landmarks in the environment to guide us back home.

Spatial cognition develops through experience and benefits from instruction. Driving skillfully, maximizing dishwasher space, and navigating home are skills that improve with practice and feedback. According to Vygotsky (1978), working together is particularly important for acquiring a skill that is just beyond reach. The goal of this study was to explore how parents and children work together to solve spatial problems in natural settings during early development.

Categories, Types, and Tests of Spatial Cognition

Spatial cognition refers to a set of complex skills related to cognition, perception, and action. Driving a car requires different skill sets than loading a dishwasher or navigating home. The three most widely studied spatial skills are spatial perception, mental rotation, and spatial visualization. Spatial perception requires an individual to determine the spatial relationship of an object with respect to their body or another object and is measured with tasks such as the Rod and Frame test in which participants must decide the correct orientation of a vertically tilted rod (Linn & Petersen, 1985). In contrast, mental rotation requires individuals to mentally rotate two- and three-dimensional objects in their minds (Linn & Petersen, 1985; Newcombe & Shipley, 2014). It is often measured with tasks such as Shepard's and Metzler's (1971) mental rotation task which asks participants to determine whether two 3-dimensional objects that differ in angle are the same object. Finally, spatial visualization requires multistep spatial manipulations that may combine the use of other spatial skills (such as spatial perception and mental rotation) to solve one task. Spatial visualization can be measured with a task such as the Block Design task in which participants rearrange patterned blocks to recreate a target picture (Linn & Petersen, 1985; Newcombe & Shipley, 2014; Uttal et al., 2013).

Development and Flexibility of Spatial Skills

Spatial skills appear early in infancy and develop steadily through early childhood. Newborn babies can visually recognize an object that they touched, suggesting that early in life, infants are able to transfer tactile information to a 3-dimensional visual stimulus (Sann & Streri, 2007). Infants at 3 months prefer to look at a familiar stimulus rotating at an unseen angle than its mirror image, suggesting the ability to mentally rotate a dynamic 3-dimensional stimulus (Moore & Johnson, 2011). By 9 months, infants who spend more time crawling and exploring objects show better mental rotation skills than those with no crawling experience and who did not explore the objects (Schwarzer, Freitag, & Schum, 2013). Around the same age, infants begin to locate objects in space, using salient landmarks to locate a previously seen stimulus (Lew, Bremner, & Lefkovitch, 2000). Young infants also experience a shift in the way they monitor their spatial orientation from 6 months to 16 months (Acredolo, 1978). Infants between 6 and 11 months consistently fail at keeping track of their location in space if placed in a different position. By 16 months infants are able to keep track of their spatial orientation even when moved to a different position (Acredolo, 1978). Other skills, such as spatial navigation, require more experience and practice to develop. For example, it is not until kindergarten that children begin to demonstrate evidence of constructing and navigating complex routes on maps (Sandberg & Huttenlocher, 2001).

Spatial skills can be boosted through practice or training with everyday toys such as building blocks, puzzles, and shape sorters (Newcombe & Shipley, 2014; Uttal et al., 2013; Verdine et al., 2017). Consider the way a child holds a spoon at 10 months versus 24 months or the way they walk at 13 months versus 18 months. In the beginning, they will often grip the spoon incorrectly or frequently fall, but, with time, are able to feed themselves and walk. In addition, practicing with a spoon or practicing how to walk also aid a child with these tasks. Spatial cognition abides by the same developmental principles. Playing, or practicing, with building blocks, puzzles, and shape sorters help improve a child's spatial skills. Building blocks are commonly used for training because they require spatial skills such as mental rotation and spatial visualization as the child attempts to fit, manipulate, and move blocks together (Verdine et al., 2014). Thus, playing with these toys provides a simple training session whose effects are later shown in formal spatial measures. For example, kindergartners who participated in a building block intervention showed better performance on a spatial visualization test, but not on a mental rotation test, suggesting that practice can lead to improved performance but with some limitations (Casey et al., 2008a). Similarly, preschoolers who played with more puzzles during practice sessions performed better on mental transformation tasks than those who did not (Levine et al., 2011). These results held even after controlling for parent education, income, and overall amount of parent speech to child (Levine et al., 2011). Another laboratory study paired puzzle building with a storytelling paradigm to improve geometry skills in lower-middle-class-community kindergartners (Casey et al., 2008b). Girls showed improvement with the intervention whereas boys showed improvement regardless of intervention (Casey et al., 2008b).

Finally, when children use shape sorters and categorize shapes, they appear to build on geometric-spatial skills. For example, with practice, the external information of shapes (e.g., its size, how many corners it has, etc.) helps children become better at determining whether a particular shape fits into a space (Verdine et al., 2014). Furthermore, training spatial skills is durable and these improvements can last up to a month after training (Uttal et al., 2013). With the appropriate interventions and training sessions, there is evidence that spatial skills can improve in children as young as kindergarteners (Uttal et al., 2013)

Although the training in one spatial skill did not generalize to a different skill in Casey et al.'s (2008a) study with block intervention, other studies are more promising, suggesting that practice and training can lead to transfer of learning. That is, training can enhance the performance on spatial tasks similar to the original task as well as tasks that require a different set of skills than the original task (Uttal et al., 2013). In a large-scale meta-analysis, results from 217 studies showed that compared to participants without any training, undergraduate students with training showed better performance on both original (familiar) and novel (unfamiliar) tasks (Stericker & LeVesconte, 1982). In another study, students were trained on a mental rotation or mental paper-folding task (Wright et al., 2008). Training on one task (e.g., mental rotation) transferred to novel stimuli of the original training task (e.g., mental rotation) and to other non-practiced spatial tasks (e.g., mental paper-folding) (Wright et al., 2008). A similar pattern of generalization was observed in laboratory studies with younger children. Training grade 2 and grade 4 children for 7 months on Logo Microworlds (a program used to train mathematics and programing) showed generalized performance on a map-reading task (Geva & Cohen, 1987).

Working Together

Working together can be particularly beneficial for the development of spatial skills. According to Vygotsky (1978), for learners of all ages, much of learning takes place in the zone of proximal development (ZPD) resulting from the interaction and communication between the learner and teacher. That is, a skill or knowledge that is just beyond the child's (learner's) reach is attained more efficiently with support from another individual (teacher). Knowledge can be transmitted from the expert to the novice, or transfer may be bidirectional (from teacher to learner or from learner to teacher). Working together creates an environment conducive to transferring spatial knowledge from one individual who knows more to another who knows less. Working together is what happens in everyday life.

Findings regarding the effectiveness of working together in experimental or highly controlled settings are mixed. While some experiments show benefits (Fawcett & Garton, 2005; Phelps & Damon, 1989), others show no effects of working together on spatial tasks (Bearison et al., 1986; Golbeck & Sinagra, 2000). Children who are encouraged to talk to a partner during a sorting task produce a higher proportion of correct responses than those who do not talk to their partner (Fawcett & Garton, 2005; Garton & Pratt, 2001). In another laboratory study, fourth graders who were randomly assigned into a math or spatial peer collaboration group later performed better on math and spatial problems relative to those in a control group (Phelps & Damon, 1989). Furthermore, working together was most effective on mathematical ratio, proportion, and spatial perspective problems, yet least effective on modeling or rote learning problems (Phelps & Damon, 1989). In contrast, young children (5- to 7-year-old) randomly assigned to work together did not perform better on spatial-perspective problems than children who worked alone (Bearison et al., 1986). Nor does working together impact performance on a horizontal water test (Golbeck & Sinagra, 2000).

In contrast to the mixed results about children working together, there is clearer and stronger evidence that parents' use of spatial language is beneficial for children, demonstrating the importance of parent and children working together during spatial development. Spatial language includes words that describe the dimension (big, little), shape (circle, triangle), and properties (curvy, pointy) of an object. Spatial language also includes words or phrases that describe the relationship of objects and locations (on, above, near, behind). Spatial language can point to the external features of objects that helps children categorize items such as shapes, and other information that allows children to differentiate among different objects. Imagine a parent describing the external information of a triangular block to their child. The parent is likely to describe features such as the triangle's pointy corners or its characteristic shape, or discuss its location or distinction from other objects, using spatial language to direct the child's attention to spatially relevant parts of their environment. Exposure to spatial language encourages later spatial reasoning in children and can guide future behavior on spatial skill tasks. For example, parents' spatial language use predicts their child's spatial language use (Pruden et al., 2011; Pruden & Levine, 2017). Parents who talk more about the size and shape of objects when playing with their children have children who are likely to use more spatial language (Pruden et al., 2011; Pruden & Levine, 2017). As a result, this relationship predicts a child's later spatial skills. When children hear more spatial language early (14- to 46- months of age), they perform better on non-verbal spatial tasks later (54 months of age) (Pruden et al., 2011).

Parental spatial language is influenced by other variables related to working together such as awareness of spatial thinking. Awareness of the importance of spatial cognition can increase spatial language use. In one study, mothers were presented with the definition of spatial thinking; its importance for daily life, school, and careers; and instructions on how to encourage spatial thinking during play (Borriello & Liben, 2018). This brief and simple introduction increased the amount of spatial language and guidance mothers used during dyadic play regardless of their child's age. Mothers in the experimental group used a higher percentage of spatial language than mothers in the control group. In response, children in the experimental group showed an increase in the amount of spatial language used during dyadic play compared to those in the control group (Borriello & Liben, 2018). However, similar to findings on gestures, parents in lower SES families tend to use fewer spatial words than parents in higher SES families (Verdine et al., 2014).

Other variables like type of play, difficulty of task, type of toy, and child's age also affect the amount of parental spatial language produced (Ferrara et al., 2011; Kısa et al., 2019; Levine et al., 2011; Zosh et al., 2015). In a laboratory study, Ferrara et al. (2011) examined how the context in which a child and their parent play with blocks (free, guided, or preassembled structure) affects the quantity of spatial language produced. Guided play provides more structure that ultimately encourages the use of spatial language (Weisberg et al., 2016), but also allows the adult to act as a collaborative instructor who scaffolds the child through comments, co-play, and games. The combination of child autonomy and adult guidance creates a rich learning environment in which spatial skills can develop and improve. Guided play with blocks promoted more spatial talk from parents than free play or with a preassembled structure (Ferrara et al., 2011). Moreover, children demonstrated more spatial language in guided play than the other conditions (Ferrara et al., 2011). Another study found that children randomly assigned to guided play demonstrate improved definitional learning of shapes, accept more real shapes, and reject most fake shapes relative to those in two different conditions: free play or didactic instruction (Fisher et al., 2013). On visuospatial tasks, all children showed improvements in their visuospatial abilities after exposure to guided play however, those who benefit the most were children with little to no guided play experience prior to the intervention (Jemutai et al., 2019). In naturally occurring parent-child puzzle interactions, parents engage and provide their children with more spatial language when the children worked on more difficult puzzles (Levine et al., 2011). Puzzles that were harder provided greater opportunity for parental input as well as more opportunity for child spatial learning (Levine et al., 2011). Parents also tend to use more spatial language with their children when randomly assigned to play with traditional toys compared to electronic versions of the same toys (Zosh et al., 2015). Finally, age is another predictor of the amount of spatial language parents use (Kısa et al., 2019). In children 16- to 21- months old parents tend to use more spatial language as their children aged (Kısa et al., 2019).

Current Study

The primary goal of this study was to explore how parents and children work together to solve spatial tasks in the natural environment. A plethora of studies have documented that working with a parent can promote spatial cognition in a structured laboratory setting (e.g., Ehrlich et al., 2006; Pruden et al., 2011; Pruden & Levine, 2017). However, such laboratory studies do not capture the real-world ‘noise’ that occurs in the natural environment. Working together in a more naturalistic setting is different than working together in a controlled laboratory task. When parents and children work together informally, they are not given specific instructions, nor are they randomly assigned to specific experimental conditions. Children are not asked to work on a particular task for a specific amount of time in a specific way. Instead, children might leave in the middle of a task to work on another one or become distracted by other activities or people. Parents may help a child with a familiar task, and help may begin in the middle of the activity and occur sporadically. Children might show interest in multiple games and toys, and parents might help children structure how they can interact with the games and toys simultaneously. Thus, to expand on previous findings from laboratory studies, the current study examined how parents and children work together in a more naturalistic setting that is informal and unstructured. Data came from existing videos in Databrary (databrary.org) in which parents and children spent time in a room with several toys. In all videos, none of the parents or children were instructed how to play or what to do. To examine how working together in a naturalistic setting differs (or mimics) working together in a highly controlled laboratory setting, I explored variables that have been studied in laboratory studies: language use and object type.

A second goal of this study was to develop a reliable coding scheme to accurately capture the nature of working together in a more naturalistic environment. In previous research, testing participants in a laboratory setting allowed researchers to avoid the interruptions and surprises that can occur in the natural environment. Experimental tasks were developed to allow efficient data coding; coding schemes were not developed to work around the challenges of an informal and unstructured setting. I began with *A System for Analyzing Children and Caregivers' Language about Space in Structured and Unstructured Contexts* (Cannon, Levine, & Huttenlocher, 2007), a lab-based coding scheme that is detailed and reliable and has been used in multiple studies (Borriello & Liben, 2018; Cartmill et al., 2010; Ferrara et al., 2011; Kısa et al., 2019; Pruden et al., 2011; Pruden & Levine, 2017; Zosh et al., 2015). In this study, I simplified this coding scheme to capture the kind of spatial language that occurs in a natural environment.

Although the previous literature comes from laboratory settings, I predicted that findings from a more naturalistic setting will share the general patterns of results on language and behaviors as experimental studies. For example, I predict that working together will result in more spatial language from both parent and child than when a child is working alone. However, not all communication may be on-task or helpful; some communication may be affected by the distractions of a naturalistic environment. Additionally, because this study explores the role of working together in a naturalistic environment, there may be several components that differ from the findings of experimental studies. For example, we may see less spatial language from parents and children because they are not given explicit instruction to use it. This study is critical for exploring and determining in what ways, if any, a naturalistic environment diverges from the laboratory.

Method

Data Selection Process

Videos from Databrary (databrary.org) were selected to explore how children and parents work together on spatial tasks in the natural environment. Databrary is a web-based data library that allows developmental research scientists to store and share videos, audio files, experimental procedures, and metadata. Databrary is open to registered members from the scientific community. Databrary is composed of volumes (individual studies) that can each contain multiple video files, audio files, photos, and datasets. At the start of this study, Databrary housed 758 volumes. While most were public, about 100 were private and required direct permission from the primary investigator to access the files. The videos used in this study were open to the public or accessed with permission and selected after four rounds of careful scrutiny.

Initial Round

I began by looking at volume titles, focusing on relevant phrases such as “spatial skills,” “spatial toys,” and “spatial cognition.” Although the volumes on Databrary are tagged with key words, the search function does not allow filtering. Therefore, I looked through all video files in the 758 volumes and manually selected videos that included titles with the keywords. Excluding the private videos, this approach yielded just one volume with three videos. The initial round of data selection showed that this approach was too narrow and excluded many potential videos.

Second Round

To cast a wider net, I searched each volume for the age of the child and the nature of the task regardless of the video title. Again, I looked through all 758 volumes and manually selected videos that contained children in a predetermined age range performing a specific set of tasks (see criteria in Third Round below). In addition, I contacted three PIs to request permission to access their private volumes and received access from one PI. The second round yielded a significantly larger pool of videos compared to the initial round ($N = 166$) because the goal was to go broader than necessary to further refine the selection process.

Third Round

In the third round, I developed a strict set of exclusion criteria to further narrow the videos from the second round. Based on findings from previous research, the selection criteria included restrictions on task, age of children, number of children in the video, length of video, presence of parents or researcher, and location of task.

Task. Videos were selected if they included children playing with blocks, puzzles, shapes, fruit, buckets, dolls, and shape sorters. This selection criteria is based on previous research suggesting that parents tend to use more spatial language when playing with traditional toys compared to electronic toys (Zosh et al., 2015) and toys such as blocks, puzzles, shapes, and shape sorters encourage spatial thinking (Levine et al., 2011; Verdine et al., 2014).

Age. I looked for volumes with children who were at least 9 months old. Communication commences far before children speak in formal sentences; by 9-months infants can already respond to sound with sounds, understand words like "no," copy sounds, point, and gesture (Bates, 1976). At this age, infants begin to play a more active role in communicative interactions. However, the volumes on Databrary with 9-month-old participants did not fit the other criteria and were not selected. The youngest participant was 11 months old. I also included videos of older children as long as they were engaging in spatial tasks. This wide age range would look at the way children solve spatial tasks at different developmental points. Thus, the oldest participant was 12 years old.

Number of children. The previous studies typically examined the interactions between one child and one parent. Therefore, I selected videos that included one child working with an adult so that findings from the current study could be compared with findings from previous research. I also selected videos that included one child working alone to serve as a comparison group.

Length of Video. Videos were included if they were at least two minutes long because they were likely to produce several codable interactions between a parent and child or child alone while working on spatial tasks in a naturalistic setting. Shorter videos were excluded in case they did not contain enough observable interactions to code.

Presence of parents or researcher. Videos of a child working with one parent, or one researcher were selected to examine how children and adults work together to solve spatial tasks.

Location. Videos that met the above criteria and were recorded at home were selected for coding. In addition, videos recorded in a laboratory setting were also included if the experimenter did not provide any directions to the parents or children on how to engage with the tasks around them. Doing so mimics the unstructured and informal environment found at home, though to a lesser degree in terms of distraction and comfort level.

Using these criteria, I selected 70 videos from 10 volumes during the third round. They included 50 videos of children working with a parent or researcher (31 at home and 19 in a lab) and 20 videos of children working alone (20 in a lab setting). The videos of children working with a parent or researcher had a wider range in children's age (11 months to 12 years) and length of video (2 minutes to 1 hour and 4 minutes) compared to the videos of children working alone (11 months to 4 years and 2 to 13 minutes). Additionally, there were almost three times the number of videos of children working together compared to children working alone. These issues were addressed in the final round.

Final Round

Because there were more videos of children working together than working alone, I matched the working together and working alone videos for child's age and video length. This process eliminated videos of children older than 24 months and videos longer than 13 minutes. In addition, I eliminated 6 videos where the parent spoke a different language (e.g., Spanish), and only used videos where the parent spoke English. This decision was made because not enough members of our team spoke Spanish fluently and thus, I could not attest to proper translation for primary and reliability coding. Finally, given that the primary goal of the study is to explore how *parents* and children work together to solve spatial tasks in the natural environment, I eliminated videos in which the child was working with a researcher. The final data set for coding and analyses included 25 videos from three volumes (Table 1) with ages ranging between 11 months and 24 months. A subset of 21 videos (included in the total count) came from the Strange Situation Task in which the child first worked with a parent and then worked alone. The section of the video where the child worked with their parent was included in the working together set and the section of the video where the child worked alone was included in the working alone set. Only seven videos from the Strange Situation Task were used in both the working together condition and working alone condition.

Table 1

Data Classification Sheet

Age	Working Together		Working Alone	
	N	Tasks	*N*	Tasks
11-12 months			1M, 2F	Blocks, rock-a-stack, toy bus, bucket
12-13 months	1M, 2F	Blocks, rock-a-stack, toy bus, bucket, shapes, shape sorter	3M, 3F	Blocks, rock-a-stack, toy bus, bucket
13-14 months	2M	Blocks, rock-a-stack, toy bus, bucket, shapes, shape sorter	1M	Blocks, rock-a-stack, toy bus, bucket
14-15 months	1F	Blocks, rock-a-stack, toy bus, bucket	1F	
15-16 months	2M, 1F	Blocks, rock-a-stack, toy bus, bucket	2M, 1F	Blocks, rock-a-stack, toy bus, bucket
18-19 months	1M	Shape sorter		
23-24 months	1M	Shape sorter		
Total	7M, 4F		7M, 7F	

Note. Ages not included indicate that there were no children of that age in this study.

Participants

Using the criteria from the data selection process, the final data sample consisted of 11 parent/child dyads in the working together condition: 7 boys and 4 girls ($M = 15.24$, $SD = 3.35$), and 14 children in the working alone condition: 7 boys and 7 girls ($M = 13.10$, $SD = 1.42$). Demographic information available in Databrary indicated that children were White (61.1%), Black or African American (22.2%), Asian (5.6%), and more than one race (11.1%). Of this population 38.9% of children identified as Hispanic. Further demographic information such as parental income, education, or employment were not available in Databrary.

Data Coding

Given that the secondary goal of the study was to develop a simplified coding scheme to capture language and adult-child interactions as they work together through spatial tasks in a natural environment, I simplified *A System for Analyzing Children and Caregivers' Language about Space in Structured and Unstructured Contexts* (Cannon, Levine, & Huttenlocher, 2007). This coding manual distinguishes spatial terms into several detailed categories (e.g., spatial dimensions, shapes, location and direction, orientation and transformation) and examines parents' use of spatial language as they engage with their children.

The codes from Cannon, Levine, and Huttenlocher's (2007) manual were simplified in order to capture the language and interactions that may occur in a natural environment rather than in an experimental setting. All videos were coded with Datavyu (datavyu.org), an open-source Java-based software package used for coding behavioral observations. Datavyu allows users to view videos, record observations, and export data for statistical analysis. In Datavyu, the user can record behavioral observations through columns which contain cells that have different "fill-in-the-blank" codes. To be able to do so, the user writes scripts in Ruby that are customized for their project. In this study, because the videos varied in length, I created columns with cells occurring every 10 seconds in order to capture language exchanges and parent/child interactions (refer to Appendix A for an example). Within every 10 second cell, the coder has the opportunity to record whether a behavior or use of language is present (indicated by "y" for yes, and "n" for no). The creation of different columns in Datavyu permits codes to link and nest across time.

Doing so allows us to focus on individual pieces of data or capture a broader view across all codes. To see this study's completed coding manual, refer to Appendix B.

Speech

Previous literature demonstrates the benefits of spatial language for children's spatial development. To capture different types of spatial language, the first step was to record the presence of speech. Within each 10-second trial the primary coder recorded any instance in which the parent or child produced a fully voiced sound that could be part of a word. I considered a fully voiced sound as clear words, phrases, and non-word vocalizations that could be an attempt at communication.

Spatial speech

On each 10-second trial coded "yes" for speech, the coding team next coded the type of spatial speech. The goal of this category was to determine whether and how parents and/or children use spatial speech when working together and when working alone. I selected four codes from *A System for Analyzing Children and Caregivers' Language about Space in Structured and Unstructured Contexts* (Cannon, Levine, & Huttenlocher, 2007) that best fit the children in the videos we used. These codes were selected based on their simplicity and whether children 13-15 months of age were capable of using them. In spatial speech, I included words relating to spatial dimensions, shapes, orientation and transformation, and location and direction. The category of spatial dimensions was defined as any word that describes the size of objects, people, and spaces. Shapes were defined as the standard or universally recognized form of enclosed two- and three-dimensional objects and spaces. Location and direction were described as the relative position of objects, people, and points in space. Finally, orientation and transformation were characterized as words that describe the relative orientation or transformation of objects and people in space. Other codes from the Cannon, Levine, and Huttenlocher (2007) coding manual (e.g., spatial features, patterns, and continuous amounts) were excluded, since dyads with children aged 13-15 months are unlikely to have these as part of their vocabulary. Each category had a list of words that corresponded to its definition. For example, the list of words under shapes was circle, ring, ball, triangle, square, rectangle, diamond, cube, and cone (see Appendix B for entire lists). If the parent or child used any words on the list, in both together and alone conditions, the primary coder recorded those instances. Additionally, I found that these four linguistic categories represented some of the more widely studied spatial skills: spatial perception, mental rotation, and spatial visualization. For example, words related to orientation and transformation often invoke skills such as spatial perception or mental rotation as they describe the relative position of objects in relationship to themselves or other objects.

Other uses of language

Given that human vocabulary surpasses spatial categories, I also explored how language is used by parent and child regardless of whether it includes spatial content. I developed several categories to capture the other ways in which children and parents speak, particularly those that could be related to spatial speech. The categories included questions, encouragement or praise, suggestion and directive, expressive interjection, laugh, naming and stating, and miscellaneous (refer to Appendix B to see full list of words included in each category). Therefore, the primary coder recorded any moment when the parent or child asked a question, expressed recognition, approval, hope, or confidence, advised, presented an idea, or provided an explicit command or directive, used an utterance to express a reaction, laughed, named or stated something, or vocalized something unintelligible (such as a child's babble).

Objects

It was imperative to examine the objects and tasks the children explored given the goal of this study because the type of object a child plays with matters to their spatial development. I created four categories based on the toys present in the videos that would allow us to report what spatial tasks the children interacted with: fit, real, sound, and stack (refer to Appendix B for full list of words in each category). The primary coder reported when children interacted with toys that required fitting or manipulating pieces together (e.g., puzzles, shape sorter), toys that represented real life objects (e.g., school bus, ball), toys that made sounds (e.g., pianos), and toys that get stacked or nested together (e.g., ring towers). My coding team also coded the order in which the child played with the toys. For example, if the child first played with a stacking object and then an object that makes a sound, we recorded the stack first and sound second. As with spatial speech, these objects encapsulated spatial perception, mental rotation, and spatial visualization. Any object that requires fitting such as a shape sorter requires the child to successfully perceive where the shape should go in relation to the holes in the sorter. Or a child may want to first mentally rotate a shape before putting it into the sorter. A ring tower also requires spatial visualization and multistep spatial manipulations as the child picks up a ring and puts it through the tower. Therefore, all the objects in the video had the potential to use a spatial skill.

Reliability

The coding team coded each major category for reliability to assure that the codes could be used consistently across different coders. For each video, a primary scorer coded 100% of all 10-second trials for all codes described above. Additionally, a second scorer coded 25% of all 10-second trials for all the codes described above. If there were disagreements among the codes of the primary and reliability coder, the two coders met with another researcher to discuss each of the discrepancies and resolve the disagreement. We used a benchmark of 85-90% agreement as it was the first time using these codes. Updates and clarifications were made to the manual following these discrepancies as necessary. The final reliability ranged between 89.23% and 99.99% agreement between primary and second scorers across all codes.

Results

The main goal of this study was to explore how parents and children interact with one another during natural spatial play. To do so, I looked at speech presence, types of spatial speech, other uses of language, and object use by children. Given that children's age may influence how well they speak and the kind of spatial interactions they may have, prior to any in-depth analyses I first examined children's ages in each condition. As a group, the children in the working together condition were significantly older ($M = 15.42$, $SD = 3.35$) than the children working alone condition ($M = 13.1$, $SD = 1.42$), $t(23) = 2.17$, $p = 0.04$, $d = 0.83$. This condition-related difference in age is due to the two oldest children in the working together condition (18.3 and 24 months). Without these two children, as a group, the children in the working together condition were the same age ($M = 13.93$, $SD = 1.18$) as those in the working alone condition ($M = 13.1$, $SD = 1.42$), $t(21) = 1.46$, $p = 0.16$, $d = 0.64$. Therefore, in the following sections, I accounted for this difference wherever possible by analyzing the data twice with and without the oldest children when necessary. The number of boys and girls was roughly the same in the working together condition (7 boys, 4 girls) and the working alone condition (7 boys, 7 girls). When the two oldest children are removed from the working together condition, the number of boys and girls becomes more even (5 boys, 4 girls).

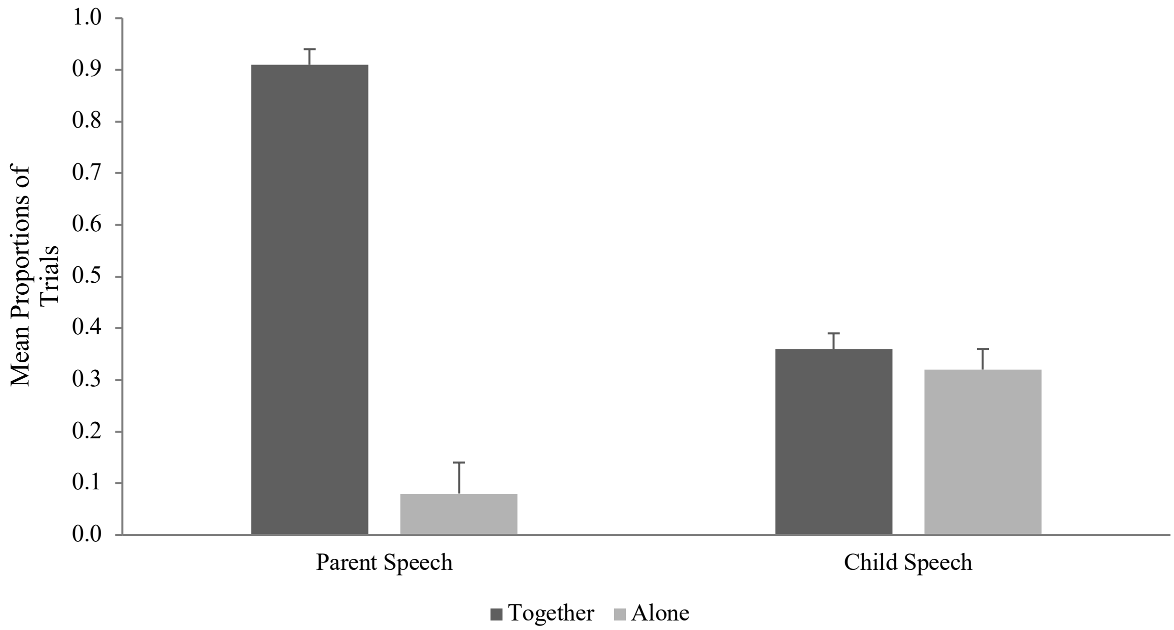
Presence of Speech

I began by examining whether parents and children speak at all in a naturalistic environment (i.e., when they are not required to speak or interact) and whether there are any commonalities in their interactions. Figure 1 shows the proportion of 10-second trials (simply called trials from here on) in which there was any vocalization. Parents in the together condition ($M = 0.91$, $SD = 0.09$) speak more compared to the parents alone condition ($M = 0.08$, $SD = 0.10$), $t(22) = 22.1$, $p < 0.001$, $d = 8.96$. Indeed, parents in the together condition spoke on nearly all trials. In contrast, children speak equally when working with a parent ($M = 0.36$, $SD = 0.21$) and when working alone ($M = 0.32$, $SD = 0.14$, $t(22) = 0.61$, $p = 0.55$, $d = 0.28$). There was no relationship between the amount parents spoke and the amount children spoke when working together ($r = -0.06$, $p = 0.86$), or when working alone ($r = 0.30$, $p = 0.23$).

Pearson's correlation revealed a positive relationship between children's age and the quantity of speech in the working together condition whether the two oldest children were included ($r = 0.81$, $p = 0.003$) or removed ($r = 0.72$, $p = 0.03$). There was no relationship between children's age and the quantity of speech in the working alone condition ($r = -0.13$, $p = 0.66$), suggesting that older children tend to speak more only when working together with their parent.

Figure 1

Mean Proportion of Trials in which Parents and Children Vocalize



Note. Error bars represent mean standard errors.

Spatial Speech

Given how much parents were talking, particularly in the working together condition, I next examined whether parents use spatial speech and if they do, the type of spatial speech they use. As shown in Table 2, parents do use spatial language when working with their child during natural spatial play—even when they are not instructed to do so. In the working together condition, parents used words related to location and direction on about 1/3 of trials and words related to shapes on about 1/5 of trials. In contrast, children almost never used spatial words.

Table 2

Means and Standard Deviations of Spatial Language

Condition	Parent				Child			
	Together		Alone		Together		Alone	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Category								
Spatial Dimensions	0.02	0.05	-	-	-	-	-	-
Shapes	0.12	0.19	-	-	0.01	0.03	-	-
Location and Directions	0.26	0.19	-	-	-	-	-	-
Orientation and Transformation	0.08	0.16	-	-	0.03	0.11	-	-

Considering that parents are using spatial language when working with their children, I further explored whether certain categories are frequently used together. Specifically, I looked at more frequently occurring categories (e.g., location and direction) to see whether there were connections among categories. When working with their child, parents used more words related to location and direction when also using words about shapes ($M = 0.25$, $SD = 0.44$) than when only using words related to location and direction ($M = 0.05$, $SD = 0.22$, $t(232) = -4.70$, $p < 0.001$, $d = 0.57$). For example, they were likely to say “That’s not a circle, the circle is over here” instead of just “That’s not it, it’s over here.” We found no significant findings among the other categories. Furthermore, we found no significant relationships among spatial categories in the working alone condition (ps > 0.08).

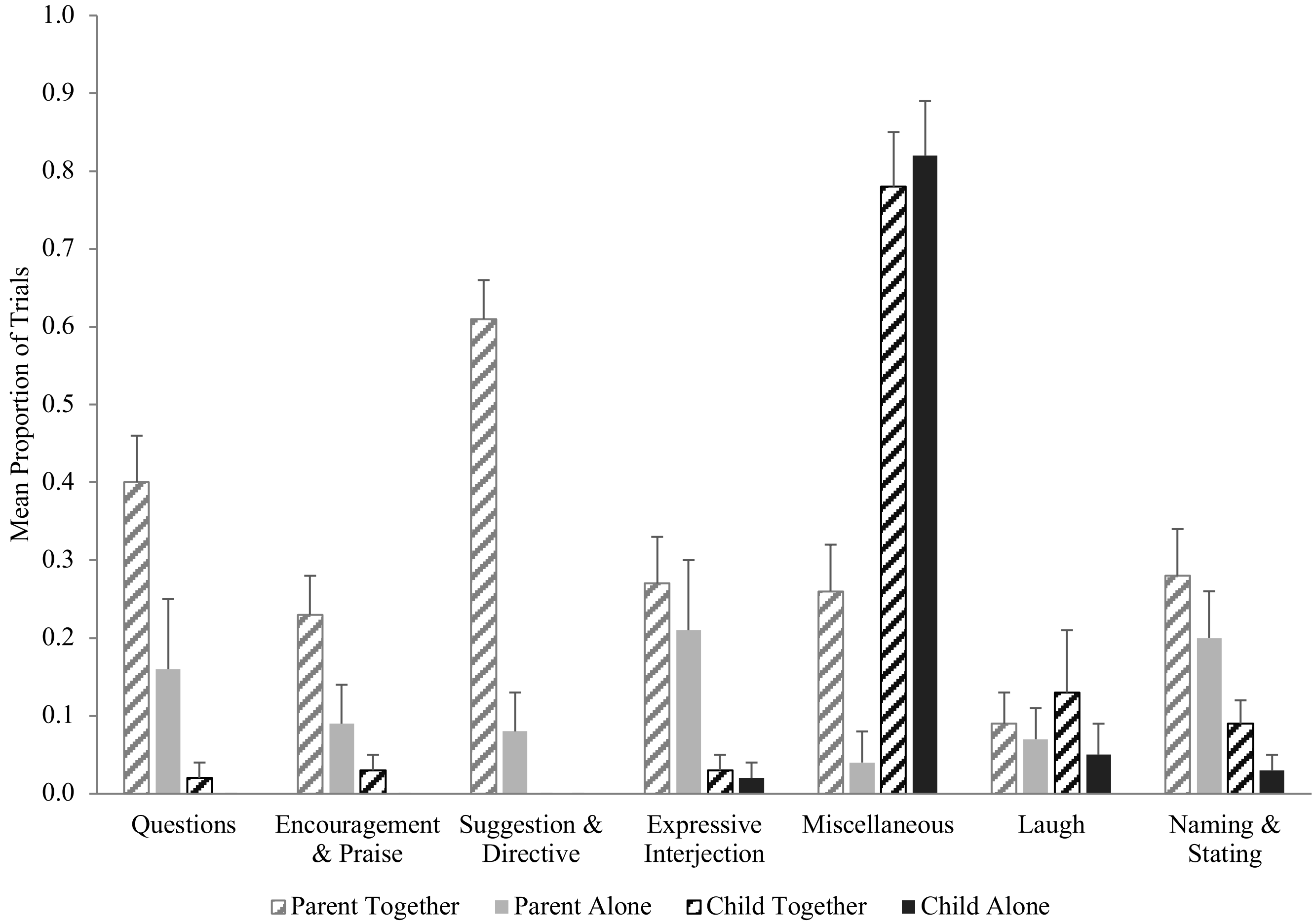
Other Uses of Language

To provide additional context in which spatial language occurs, I also examined the manner in which language was used regardless of whether it was spatial or not (refer to Appendix B). Figure 2 shows that in the working together condition, parents use suggestions and directives (*M* proportion of trials = 0.61, *SD* = 0.18) most frequently, followed by questions (*M* = 0.40, *SD* = 0.20). Parents use encouragement and praise (*M* = 0.23, *SD* = 0.18), expressive interjections (*M* = 0.27, *SD* = 0.19), and naming and stating approximately equally (*M* = 0.28, *SD* = 0.19). They also laugh (*M* = 0.09, *SD* = 0.12) and use a variety of other miscellaneous manners of speech (*M* = 0.26, *SD* = 0.21) (e.g., parent imitating a car sound, "vroom vroom"). Because parents in the alone condition do not talk much, their use of various manners of language are equally rare. Parents would often use expressive interjections (*M* = 0.21, *SD* = 0.36) or ask questions (*M* = 0.16, *SD* = 0.33). Children dominated the use of the miscellaneous category both when working with a parent and when working alone. This likely occurred because of the frequent babbles and unintelligible vocalizations children make at that age.

As with spatial speech, I also wanted to explore whether the most frequently used categories in other language co-occur with other categories within this section. To do so, I examined the categories that frequently co-occur with suggestion and directive and questions. Interestingly, when parents work with their children they used more words related to suggestion and directive when also asking questions (*M* = 0.44, *SD* = 0.5) than when only using words related to suggestion and directive (*M* = 0.25, *SD* = 0.44, $t(232) = -2.92$, $p = 0.004$, $d = 0.40$). For example, a parent might say "Do you want to build some blocks with me?" I did not see any similar patterns emerge within any of the other categories (*p*s > .06) or when the child is working together (*p*s > 0.08).

Figure 2

Mean Proportion of Trials in which Parents and Children use Other Language



Note. Error bars represent mean standard errors.

Based on the nature of this study which was to explore how parents and children interact in the natural environment to solve spatial tasks, it was very possible we see an overlap between the way parents use spatial language *and* other uses of language. Therefore, I decided to investigate whether categories among spatial language and the other uses of language occur together. I found that words related to suggestion and directive are commonly used alongside location and direction (M = 0.40, SD = 0.49) than when only using words related to suggestion and directive ($M = 0.04$, $SD = 0.49$, $t(232) = -6.55$, $p < 0.001$, $d = 0.99$). For example, parents might say "Put it on top. Make a tower." Similarly, when parents use words related to orientation and transformation, they also use words related to suggestion and directive ($M = 0.17$, $SD = 0.37$, $t(232) = -4.04$, $p < 0.001$, $d = 0.65$). For example, parents might say "you have to turn it over, silly." I found no significant effects in the working alone condition (ps > 0.08).

Objects

Finally, because object play can influence children's spatial experiences and development, I examined the kind of objects children explored during the study. Children spent a majority of their time playing with objects whether working together (92% of the trials) or working alone (82% of the trials). Across the two conditions, children manipulated at least one object in 530 out of 637 total trials (83.2% of all trials). Of those 530 trials, children played with objects that required stacking such as blocks in 44.3% of trials, objects that fit together such as shape sorter in 33.2% of trials, objects that made sounds such as a mini piano in only 9.4% of trials, and objects that represented real life objects such as school buses and teddy bears in 8.7% of trials.

I also recorded the order in which the children used the objects (see Table 3). Objects that require stacking were most frequently used as the first item children manipulated. Following were objects that require fitting. On the other hand, objects that make sounds and represent real objects were least frequently used first. This pattern maintained itself in the objects children manipulated second and third. However, these findings were the frequencies in both conditions combined.

Table 3

Frequency of Objects by Occurrence Order

Order	First						Second						Third					
	All		Together		Alone		All		Together		Alone		All		Together		Alone	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Category																		
Stack	235	44.3	84	38.7	151	51.1	50	9.4	19	8.4	31	10.2	2	.38	2	.9	-	-
Fit	176	33.2	84	38.2	92	32.5	33	6.2	16	7.1	17	5.6	-	-	-	-	-	-
Sound	50	9.4	29	12.9	21	6.9	15	2.8	3	1.3	12	3.9	-	-	-	-	-	-
Real	46	8.7	23	10.2	26	9.5	21	3.96	10	4.4	11	3.6	-	-	-	-	-	-

It should be noted that in the working together condition there were four videos (four parent-child dyads) in which only one toy was present throughout the entire video: a shape sorter. Based on our coding manual, the shape sorter was coded as a “fit” object because the different shapes must fit within their corresponding holes. To determine whether those four videos skewed the frequency of the “fit” category, I examined the frequency of all the object categories without those data. Without the four videos, children manipulated an object in 450 trials out of 556. That is, in approximately 80.9% of trials children manipulated at least one object. Furthermore, as shown in Table 4, the four data previously accounted for almost 100 more trials in which a fit object was manipulated. Additionally, the percentage in which fit was used as the first object a child manipulated dropped by more than 10%, going from being used 33.2% of the time as the first object to 21.8% of the time without the 4 data. Thus, these data did impact the importance of the fit category. However, removing these four children did not affect the general pattern of data in which stacking toys were used most frequently, followed by a drop off for fit toy, which was followed by another drop off for sound and real toys

Table 4

Frequency of Objects by Occurrence Order without 4 Dyads

Order	First						Second						Third					
	All		Together		Alone		All		Together		Alone		All		Together		Alone	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Category																		
Stack	235	52	84	.60	151	.52	50	11.1	19	11.1	31	8.1	2	.44	2	1.2	-	-
Fit	98	21.8	6	.04	92	.32	33	6.9	14	8.2	17	4.4	-	-	-	-	-	-
Sound	50	11.1	29	.21	21	.07	15	3.3	3	1.8	12	3.1	-	-	-	-	-	-
Real	52	10.2	20	.14	26	.1	21	4.7	10	5.8	11	2.9	-	-	-	-	-	-

Finally, to gain a comprehensive understanding of the way children and parents work together in the natural environment, I explored the ways in which their language and behavior interact. When working with their parent, children manipulated more stacking objects when their parent also used words related to naming and stating ($M = 0.43$, $SD = 0.50$), than when their parent did not use naming and stating words ($M = 0.27$, $SD = 0.45$, $t(232) = -2.38$, $p < 0.001$, $d = 0.32$). Interestingly, children also manipulated more stacking objects when their parent used location and direction words ($M = 0.36$, $SD = 0.48$), than when their parent did not use words related to location and direction ($M = 0.23$, $SD = 0.42$, $t(232) = -2.22$, $p < 0.001$, $d = 0.45$). I did not find any significant effects among the other categories nor in the working alone condition (ps > 0.06).

Discussion

The main goal of the present study was to explore and describe how parents and children interact in the natural environment when solving spatial tasks. Based on previous literature, the development of spatial cognition during early childhood is critical in order to navigate the world as adolescents and adults which requires the successful use of spatial skills. Working together fosters an environment in which important skills, including spatial skills, can improve and prosper in children. Moreover, the development of spatial cognition in children thrives when parents are more likely to use spatial language and engage with spatial toys. Given that spatial skills play such an important role in development, and the majority of prior studies take place in an experimental setting, I found it important to explore how much of what we already know occurs without the prompting or direction found in experimental studies. To do so, a secondary goal of the study became to develop a coding manual that would capture spatial activity related to language and behaviors among parents and children. To successfully accomplish the primary goal, I needed to achieve the secondary goal first. I was able to capture how parents and children interact in a non-structured environment through a series of explicit and objective codes. Reliability for these codes was high, which suggests several conclusions. For one, the codes created were sufficiently thorough. Almost all language or behavior that occurred in the videos could be scored using our codes, suggesting that I was able to capture a representative account of what happens when children and parents work together in the natural environment. Second, given the high agreement among coders, the codes appear to be clear and explicit so that other researchers would be capable of using them in similar settings. Indeed, these codes, modified from *A System for Analyzing Children and Caregivers' Language about Space in Structured and Unstructured Contexts* (Cannon, Levine, & Huttenlocher, 2007), could be used to provide a more complete guide for capturing real world spatial behaviors and interactions.

The results from this study were striking particularly because the setting was naturalistic and parents and children were never instructed to behave or interact in certain ways—akin to the unstructured nature of the home environment. Nevertheless, parents speak frequently when working with their children, even though children talk equally frequently whether a parent is working with them or not. I suspected, based on prior research, that having an adult present would encourage children to speak more when collaborating, yet found it intriguing that in this case they did not. I expected children to speak more when working with a parent than when working alone, but most of the content that made up the children's speech was categorized as miscellaneous. A likely explanation for the children's frequent use of the miscellaneous category is because of their age. The children were relatively young in this study and were more likely to communicate through babbling rather than with clear words or phrases. Such findings exemplify the uniqueness of naturalistic studies as it allows a direct view of what occurs naturally (in this case, frequent babbles), even if not directly on-task.

Another surprising finding was related to the amount of spatial language parents used. Without prompts or directions, parents *are* naturally using spatial language when working with their child. On almost 30% of the trials, parents used words related to location and direction, and in approximately 12% they used words related to shapes. It is interesting that parents frequently used location and direction words which describe the position of objects relative to other objects. When parents use words related to location and direction, the child must rely on spatial perception and visualization skills. Parents' general use of spatial language without explicit instructions to do so further confirms the indispensable value and importance spatial cognition has on solving everyday spatial tasks. Although it is difficult to quantitatively compare the findings from this study to those from Pruden et al. (2011), because of important differences in children’s age and study design (the previous study included older children and used a longitudinal design), the current findings reinforce the notion that parents naturally and consistently use spatial language in the natural environment. Parents used more spatial language in the current study than the parents in the Borriello and Liben (2018) study who were informed about the benefits of using spatial language during play. On the other hand, the children in this study hardly used spatial language—a finding which diverges from several previous studies (Pruden et al., 2011; Ferrara et al., 2011; Borriello & Liben, 2018). Children in previous studies were 46 months and older, while the average child in the current study was approximately 14 months. Thus, this difference can certainly be attributed to age and their still developing language skills during the second year of life.

Unlike prior work which only focused on spatial language, I also recorded the ways in which parents and children use language aside from spatial content. For example, parents used words related to suggestion and directive in about 60% of trials and asked questions in almost 40% of trials. When parents used words related to suggestion and directive they advised, commanded, or presented an idea to their child. Asking questions and using words related to suggestion and directive ultimately reflect guided play. Guided play provides structure for the child and allows the adult to be an instructor. In this study, when a parent asked a question such as “what about this [toy]?” or presented an idea like “maybe use two hands,” we can see how they act as an instructor by scaffolding the child’s experience while also giving the child autonomy to decide what they want. Even more striking, parents frequently used words related to suggestion and directive alongside location and direction and orientation and transformation. This combination of spatial and other uses of language maximizes the opportunity to create a space reflective of guided play—a rich learning environment for spatial skills to develop (Ferrara et al., 2011).

Perhaps unknowingly, parents frequently and naturally create ZPDs for their children. That parents and caregivers are the people children most consistently see and interact with makes them the best people to create ZPDs. The scaffolding they provide when working with their children as they ask questions or use suggestions and directives creates a zone of proximal development. There were plenty of instances when a parent provided scaffolding for a child’s learning experience by asking questions or suggesting the child manipulate an object a certain way. For example, in one video a parent suggested the child use two hands to stack a block on top of another. Stacking may have been a skill that was too difficult for the child, but with the guidance and encouragement from their parent through language, they may now attain that skill.

This training of one skill—stacking blocks—in the ZPD may assist tasks that require different spatial skills such as using a shape sorter or building a puzzle. The opportunities created in the natural environment are plentiful for the development of spatial skills in other areas.

Considering that language was quite limited in the children of this study, the findings on the type of objects children most frequently manipulated allowed the chance to explore another way in which spatial cognition may develop. Children most often interacted with "stacking" toys like ring towers and blocks that get stacked or nested together. As a child builds a block tower or plays with a ring tower, the child must be aware of the ring's relationship to the tower or the block's relationship to another block as they stack each object on top of the other. These toys require the successful use of spatial perception and visualization skills. To our surprise, not only were children frequently manipulating an object when working with their parent, they manipulated an object almost the same amount when working alone. One could draw several conclusions from these findings. The frequency with which children manipulated an object suggests that although they did not use spatial language, they were exposed to and engaged with spatial tasks, which may ultimately contribute to the development of their spatial cognition (Verdine et al., 2014; Levine et al., 2011; Uttal et al., 2013). Furthermore, despite the children in the working together condition having both object and language exposure from their parents, the children in the working alone condition still had the opportunity for spatial cognition to develop through their own manipulation of objects. Thus, it is possible that children in both conditions had a surprising amount of exposure to spatial objects and language that may boost their own spatial skills.

The current study is one of the first steps in which we expand out of the experimental environment to further explore how spatial cognition develops in the naturalistic environment.

However, it should be noted that this study was not perfectly naturalistic. While parents and children were never given instructions on how to interact with one another or with the objects around them, they were still in a laboratory setting. At home with their own toys, for example, children may rely less on stacking and fitting toys during their typical play sessions, resulting in different spatial experiences. Additionally, because we did code archived data from different researchers, we were at times limited to the quality of audio and video from their footage. This made it challenging to record language and behavior at times. Moreover, although it is known that socioeconomic status influences parents' use of spatial language (Verdine et al., 2014), I was unable to address any possible effects on our own data as that information was not available.

Nevertheless, the results of this study add to the literature on spatial cognition in children and parents. Parents naturally use spatial language when working with their children. While children are not speaking as often as their parents when working together or when working by themselves, they compensate for that lack of language by frequently manipulating and exploring the spatial objects around them. These findings have important implications to the way spatial cognition naturally develops. Parents unknowingly provide a sort of spatial skills training session when working with their children just by the language they use. Furthermore, children create their own training session through manipulating and exploring objects when they are alone. Future studies should consider measuring spatial skills after a natural "training session" with well-known tests such as mental rotation tasks or visuospatial tasks. This would allow researchers to draw more conclusive evidence about how the way parents naturally interact with their children influences their spatial development. Researchers could also make clearer distinctions about the ways working together may offer a different learning environment compared to when a child is working alone. Additionally, future studies looking at the effects of natural interactions on a child's spatial experience should venture out to the home environment, the primary environment in which spatial skills develop through informal and unstructured play experiences.

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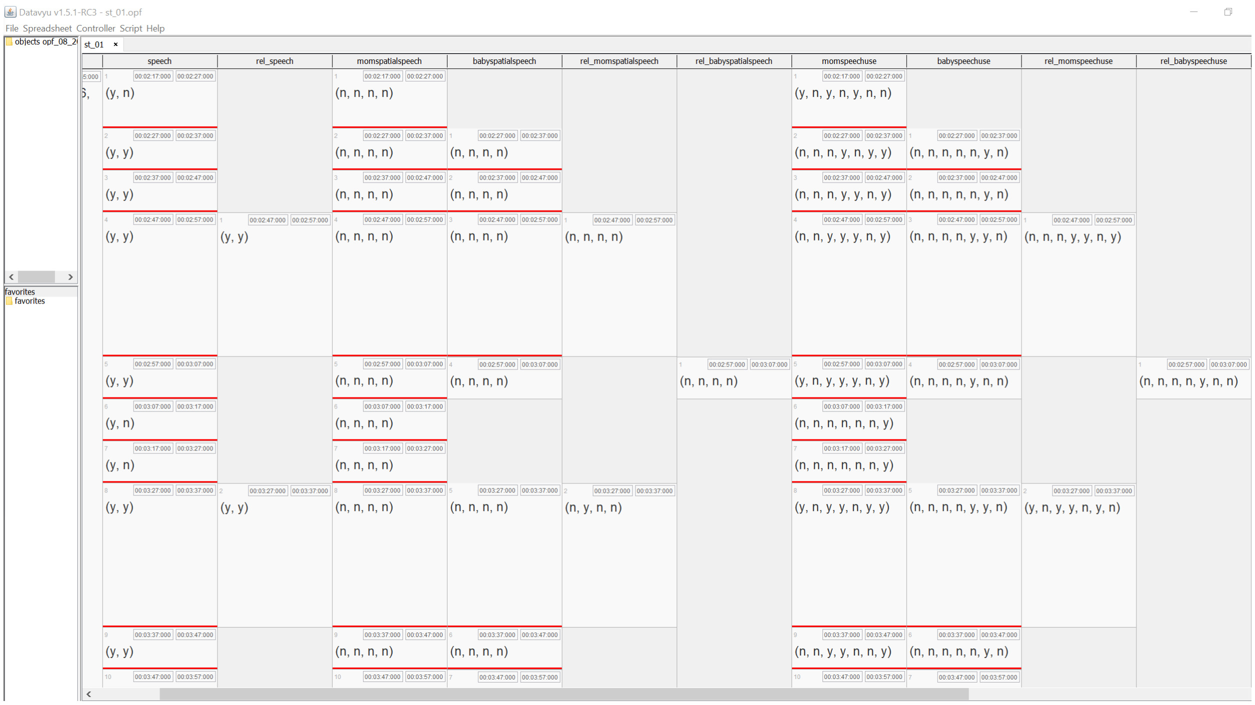
Appendix A

Example of Datavyu Coding File



Appendix B

Datavyu & Databrary Coding Manual

Step 1: Download video from Databrary.

- Go to the "Child Learning Lab" Teams.
- Click on "Nicole Thesis" Channel.
- Under "Files" find the "SpatialThinking_CodingSheet" excel sheet.
- On the first sheet labeled "coders" review the id of the video you will code.
- On the second sheet labeled "databrary info" review the page, volume name, and file of the video you will code.
- Go to https://nyu.databrary.org/
- Log in.
- Click on "Find Clips"
- Go to corresponding page.
- Look for corresponding volume.
- Click on corresponding file.
- Click on download button (see example below).
- Click "Download" (see example below).
- Save video on your computer in a folder named "Coding videos".

Step 2: Open datavyu file.

- Go to the "Child Learning Lab" Teams.
- Click on "Nicole Thesis" Channel.
- Under "Files" find the "Blank Datavyu Files" folder.
- Find the file of your corresponding ID.

- Download the file and save it on your computer in a folder named “Datavyu Files”.
- Once saved, open the file.
- Make sure your number pad is plugged in.
- The ID column will already be loaded.
- The onset time and offset time will already be filled out.
- Refer to coding sheet and input data for “id,” condition,” “sex,” “bday,” tday,” and “agem”.
    - bday and tday should be in this form: mm/dd/yy

Step 3: Add video data.

- Look at your Data View Controller and click on “Add Data” (see below).

- Open the video file that you downloaded and saved in Step 1.

Step 4: Run speech script.

- Go to the “Child Learning Lab” Teams.
- Click on “Nicole Thesis” Channel.
- Under “Files” find the “Scripts” folder.

- Download the script titled "create speech column" and save it in a newly created folder called "Datavyu Scripts".
- Go back to your Datavyu file, click on "Script" and click on "Run Script" (see example below).

- Run "create speech column" script.

Step 5: Begin coding speech column.

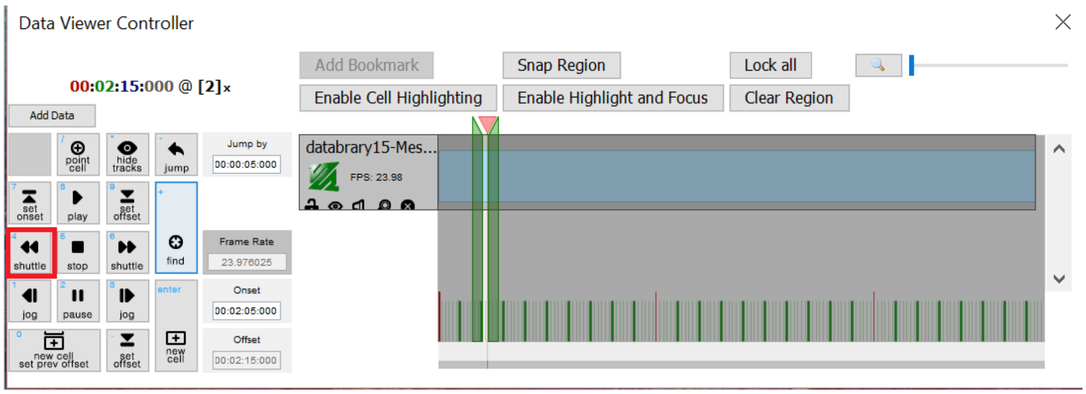
- The goal of the speech column is to explore whether parent and/or children are speaking throughout the duration of the video
- I would suggest wearing headphones so that it is easier to hear the audio from the video.
- I would suggest setting up your screen like this (see below).
- This view allows you to see all three main windows at once.
- Click on first speech cell, then click "Find", then click "Snap Region" (see below).
- Doing this allows Datavyu to only show you the video from those 10 seconds.
- Coding videos from the Working Together Condition:
    - You will see that there are two codes: "momspeech" and "babyspeech".

- If you hear the mom use any sound that is an attempt at communication, put a “y” in “momspeech”.
  - Definition: A fully voiced sound that could be a part of a word.
    - This includes clear words, phrases, and any non-word sounds or vocalizations that could be an attempt at communication.
    - Exclude sounds that are not used for communication like sneezing, coughing, or sighing.
- If you do NOT hear the mom use any sound that is an attempt at communication, put a “n” in “momspeech”.
- If you hear the baby use any sound that is an attempt at communication, put a “y” in “babyspeech”.
  - Definition: A fully voiced sound that could be a part of a word.
    - This includes clear words, phrases, and any non-word sounds or vocalizations that could be an attempt at communication.
    - Exclude sounds that are not used for communication like sneezing, coughing, or sighing.
- If you do NOT hear the baby use any speech, put a “n” in “babyspeech”.

- Coding videos from the Working Alone Condition:
  - You will see that there are two codes: “momspeech” and “babyspeech”.
  - In this condition typically the child is alone. However, there are some clips where the child is playing alone, and the mother is in the room.

- In the case of that the mother is in the room, code “momspeech” using the following rules:
    - If you hear the mom use any sound that is an attempt at communication *to her child*, put a “y” in “momspeech”.
        - Definition: A fully voiced sound that could be a part of a word.
            - This includes clear words, phrases, and any non-word sounds or vocalizations that could be an attempt at communication.
            - Exclude sounds that are not used for communication like sneezing, coughing, or sighing.
    - If you do NOT hear the mom use any sound that is an attempt at communication OR if the mom speaks to anyone that is not her child, put a “n” in “momspeech”.
- If you hear the baby use any sound that is an attempt at communication, put a “y” in “babyspeech”.
    - Definition: A fully voiced sound that could be a part of a word.
        - This includes clear words, phrases, and any non-word sounds or vocalizations that could be an attempt at communication.
        - Exclude sounds that are not used for communication like sneezing, coughing, or sighing.
- If you do NOT hear the baby use any speech, put a “n” in “babyspeech”.

- Code each cell following this procedure.
- Watch each cell as many times as you want or as many times that is necessary in order to code accurately.
- You can also use the shuttle on the Data View Controller to slow down the video (see below).



Step 6: Run spatial speech script.

- Now that you have coded the entire video for speech, you will run the spatial speech script.
- Go to the "Child Learning Lab" Teams.
- Click on "Nicole Thesis" Channel.
- Under "Files" find the "Scripts" folder.
- Download the script titled "create spatial speech column" and save it in your "Datavyu Scripts" folder.
- Go back to your Datavyu file, click on "Script", and click on "Run Script".
- Run "create spatial speech column" script.

Step 7: Begin coding spatial speech column.

- The goal of this pass is to examine whether parent and/or child use spatial language when working together and when working alone

- You will see that running this script creates a new column called

"spatialspeech" which creates new cells whenever you coded "momspeech" as "y".

- You will see that there

are four codes: "spadim", "shapes", "locdir" and "oritrans".

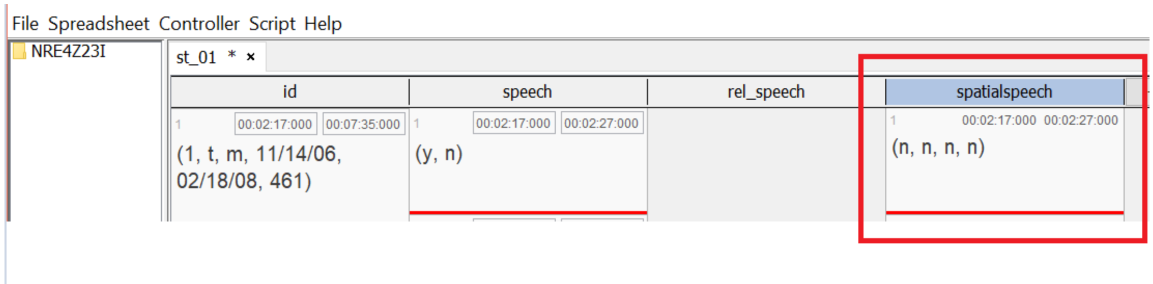
- Listen carefully to each cell before coding.
- The code "spadim" is short for spatial dimensions.
    - Definition: words that describe the size of objects, people, and spaces.
    - Words include:
        - Big
        - Little
        - Small
        - Tiny
        - Huge
        - Long
        - Short
        - Empty
        - Tall
        - Fit
    - If mom uses any of those words, code "spadim" as "y".
    - If mom does NOT use any of those words, code "spadim" as "n".
- The next code is "shapes".
    - Definition: words that describe the standard or universally recognized

    form of enclosed two- and three-dimensional objects and spaces.

- Words include:
    - Circle
    - Ring
    - Ball
    - Triangle
    - Square
    - Rectangle
    - Diamond
    - Cube
    - Cone
- If mom uses any of those words, code “shape” as “y”.
- If mom does NOT use any of those words, code “shape” as “n”.

- The code “locdir” is short for location and directions.
    - Definition: words that describe the relative position of objects, people, and points in space.
    - Words include:
        - At
        - In
        - Out (of)
        - (On) top
        - Bottom
        - Behind
        - By

        - With
        - Together
        - Middle
        - Here
        - There
    - If mom uses any of those words, code "locdir" as "y".
    - If mom does NOT use any of those words, code "locdir" as "n".
    - If any of the words above are used in non 'locdir' manner, code as "n" (e.g., "Look at that.")
- The code "oritrans" is short for orientation and transformation.
    - Definition: Words that describe the relative orientation or transformation of objects and people in space.
    - Words include:
        - Upside down
        - Turn
        - Flip
        - Open
        - Close
    - If mom uses any of those words, code "oritrans" as "y".
        - Note: Some words can be ambiguous (e.g., push, pull), but code as "y" if doing so changes the orientation or transformation of the object.
    - If mom does NOT use any of those words, code "oritrans" as "n".
- Note: If there is no spatial language in any particular cell, it should look like this:



Step 8: Run script on other language column.

- Now that you have coded the entire video for spatial speech, you will run the other language script.
- Go to the “Child Learning Lab” Teams.
- Click on “Nicole Thesis” Channel.
- Under “Files” find the “Scripts” folder.
- Download the script titled “create other language column” and save it in your “Datavyu Scripts” folder.
- Go back to your Datavyu file, click on “Script”, and click on “Run Script”.
- Run “create other language column” script.

Step 9: Begin coding other language column.

- You will see that running this script creates two new columns.
- One is called “momspeechuse” which creates new cells whenever you coded “momspeech” as “y”.
- The other column called “babyspeechuse” which creates new cells whenever you coded “babyspeech” as “y”.
- The goal of other language is to determine how language is being used by mom or baby, regardless of whether it includes spatial content.

- You will see that there are seven codes: “ques”, “encopra”, “sugdir”, “expin”, “misc”, “laugh”, and “nastate”.
- Listen carefully to each cell before coding.
- The code “ques” is short for questions.
    - Definition: any instance where the mother (or child) proposes a question.
    - Examples:
        - “What about this one?”
        - “Where’s the ball?”
        - “Who’s that?”
    - If the mom (or child) proposes a question, code “ques” as “y”.
    - If the mom (or child) does not propose a question, code “ques” as “n”.
    - **Note**: some questions are not always structured in the correct grammatical format but are still questions because of their tone. These instances should be coded as “y”.
        - Example: “You like that?”
    - This phrase does not begin with a “question” word (e.g., what, who, where, etc.) but, based on the tone, still proposes a question and should be coded as “y”.
- The code “encopra” is short for encouragement and praise.
    - Definition: any instance where the mother (or child) expresses recognition, or approval, or expresses hope or provides confidence.
    - Examples:
        - “Good job”

        - "Yay"
        - "You did it"
        - "You can do it"
        - "Very good"
        - "Yeah"
        - **Note**: only code "yeah" as "y" if the mother uses it in an instance that recognizes, approves, or expresses hope, or provides confidence to her child.
            - For example: The child correctly puts one block on top of the other and the mother responds "yeah!"
    - If the mom (or child) expresses recognition, approval, or expresses hope or provides confidence, code "encopra" as "y".
    - If the mom (or child) does not express recognition, approval, or expresses hope or provides confidence, code "encopra" as "n".
- The code "sugdir" is short for suggestion and directive.
    - Definition: any instance where the mother (or child) advises her child or presents an idea to her child or gives an explicit command or direction to her child.
    - Examples:
        - "Maybe use two hands"
        - "What about this one?"
        - "I'll do it"
        - "Look"

        - "Do this"
        - "Go ahead"
        - "Go get the ball"
    - If the mom (or child) advises her child or presents an idea to her child or gives an explicit command or direction to her child, code "sugdir" as "y".
    - If the mom (or child) does not advise her child or present an idea to her child or give an explicit command or direction to her child, code "sugdir" as "n".
    - Note: this category may also be expressed as a question (e.g., "what about this one?") and you would therefore code both "ques" and "sugdir" as "y".
- The code "expin" is short for expressive interjection.
    - Definition: any instance where the mother (or child) uses an utterance to express a reaction.
    - Examples:
        - "Uh oh"
        - "Woah"
        - "Whoops"
        - "Mhm"
        - "Wow"
    - If the mom (or child) uses an utterance to express a reaction, code "expin" as "y".
    - If the mom (or child) does not use an utterance to express a reaction, code "expin" as "n".

- The code “misc” is short for miscellaneous.
    - Definition: any instance where the mother (or child) makes a fully voiced sound that could be a part of a word, but it is unintelligible, or any instance where the mother (or child) makes imitation sounds (e.g., animal or car sounds)
    - Examples:
        - Baby babbles
        - “Vroom vroom”
    - If the mom (or child) follows any of the above definition, code “misc” as “y”.
    - If the mom (or child) does not follow any of the above definition, code “misc” as “n”.
- The next code in this category is “laugh”.
    - Definition: any instance where the mother (or child) laughs.
    - If mom (or child) laughs, code “laugh” as “y”.
    - If mom (or child) do not laugh, code “laugh” as “n”.
- The code “nastate” is short for naming and stating.
    - Definition: any instance where the mother names or states something without any expectation that the baby will respond or take action. These are statements that are different from providing direction or encouragement.
    - Examples:
        - “I like this.”

      - "School bus."
      - "One, two, three."
    - If the mom (or child) names or states something without any expectation that the baby will respond or take action, code "nastate" as "y".
    - If the mom (or child) does not name or state something without any expectation that the baby will respond or take action, code "nastate" as "n".
- **<u>Note 1:</u>** You may come across single instances where certain vocalizations may not fit into any of the categories. For example, out of the 7 videos you must code, only 1 video shows the child crying. Crying does not fit into any of the categories and because it would seem like an isolated instance, do not code it as any of the categories. Rather, leave a comment with the time stamp so we know what was going on when we look at the data.
- **<u>Note 2:</u>** There are a few videos in the working alone condition where the mother is speaking in Spanish. If the instances are few where the mother speaks Spanish, code those instances as "n".

Step 10: Run script on objects column.

- Now that you have coded the entire video for other language, you will run the objects script.
- Go to the "Child Learning Lab" Teams.
- Click on "Nicole Thesis" Channel.
- Under "Files" find the "Scripts" folder.
- Download the script titled "create objects column" and save it in your "Datavyu Scripts" folder.

- Go back to your Datavyu file, click on "Script", and click on "Run Script".
- Run "create other language column" script.

Step 11: Begin coding objects column.

- You will see that running this script creates one new column.
- The goal of this objects column is to determine how the children are manipulating the objects around them and how this may influence their spatial experience.
- This column consists of four codes: "manob", "obj1", "obj2", and "obj3".
- The code "manob" is short for manipulating object.
    - Definition: any instance where the baby is holding or manipulating an object.
    - If the baby holds or manipulates any object, code "manob" as "y".
    - If the baby does not hold or manipulate any object, code "manob" as "n".
    - **Note:**
        - The baby must be holding or manipulating the object for a minimum of 2 continuous seconds *OR* two cumulative seconds throughout each 10 second trial (as long as it is separated by less than 2 seconds) for you to code it as "y".
- The codes "obj1", "obj2", and "obj3" are short for type of object.
    - This code will allow us to examine what type of object the baby was holding or manipulating.
    - If you coded "manob" as "y", then you will code *at least one* of the "obj" codes as one of the following:

        - fit
            - toys that require manipulating and fitting pieces together such as: puzzles or shape sorters
        - real
            - toys that do not make sound or require a battery, but represent real objects in the world such as: stuffed bear, plastic dinosaur, ball, school bus, bucket
            - **Note:** if the child is holding a magazine, although not a toy, count this instance as y
        - sound
            - toys that make sound or require a battery such as a mini piano, rattle like toy, or pop-up toys
        - stack
            - toys that are stacked or nested together such as: rings, ring tower, nesting cups, or blocks
    - If the child only uses 1 object within a 10 second cell, then you will code "obj1" as one of the above codes and you will code "obj2" and "obj3" as "n". (See examples below).
    - **Note:**
        - Please make sure to spell the object exactly as it is written above.
        - If the baby is holding two of the *same* objects in each hand (e.g., two stacking rings- one in each hand) you should only code that as 1 object

      - Example: (y, stack, n, n)
    - If the baby is holding two *different* objects in each hand (e.g., doll in one hand, stacking ring in the other) you should code that as 2 objects
      - Example: (y, real, stack, n)
      - Code as two objects even if the baby is only paying attention (primarily looking at) to one of those two objects
    - If the baby is holding two *different* objects of the *same* category (e.g., ring in one hand, nesting cup in another) you should code that as 2 objects
      - Example: (y, stack, stack, n)
    - If the baby is holding on to a chair or a doorknob, code this instance as “n” as this will likely not influence their spatial experience
  - If you coded “manob” as “n”, simply code all of the “obj” codes with “n”.
  - Examples: