Young Children's Ability to Use Ordinal Labels in a Spatial Search Task

Stephanie E. Miller *University of Mississippi*
Stuart Marcovitch and Janet J. Boseovski *University of North Carolina at Greensboro*
David J. Lewkowicz *Northeastern University*

The use and understanding of ordinal terms (e.g., "first" and "second") is a developmental milestone that has been relatively unexplored in the preschool age range. In the present study, 4- and 5-year-olds watched as a reward was placed in one of three train cars labeled by the experimenter with an ordinal (e.g., *first* car), color (e.g., *brown* car), or generic label (e.g., *that* car). Results revealed that 4-year-olds actually had more difficulty retrieving the reward once occluded under identical tunnels when they were provided with ordinal labels compared to color and generic labels. Search performance improved with age and showed dramatic growth in the ordinal-label condition from 4 to 5 years of age. Results are discussed with regard to children's ability to use verbal labels of developing conceptual knowledge (i.e., linked to ordinality) to guide behavior.

Our behavior and interpretations of events rely on our ability to perceive and understand temporal and spatial order. For example, ordinal organization is necessary to coordinate complex movements from typing to dancing; to engage in everyday routines such as planning one's day to cooking a meal; and to understand a sequence of sounds as words, sentences, or music. Given

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Stephanie E. Miller, Stuart Marcovitch, and Janet J. Boseovski, Department of Psychology; David J. Lewkowicz, Department of Communication Sciences and Disorders.

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Address correspondence to Stephanie Miller, Department of Psychology, University of Mississippi, 207 Peabody, Lyceum Circle, University, MS 38677. Phone: (662) 915-6541. Fax: (662) 915-5398. E-mail: semille5@olemiss.edu.

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the importance of serial-order perception in behavior and interpretation of stimuli, it comes as no surprise that the ability to perceive and learn serial-order information emerges early in life (Kirkham, Slemmer, & Johnson, 2002; Lewkowicz, 2004, 2013; Mandel, Nelson, & Jusczyk, 1996; Saffran, Aslin, & Newport, 1996). However, competence with serial-order information clearly becomes more sophisticated with age. For example, even though 4-month-olds encode adjacent relations between specific elements in a sequence (e.g., the relationship between A and B in the sequence ABCD), they do so on the basis of statistical relations rather than on the basis of the ordinal position of these elements (e.g., that B is the second element in ABCD; see Lewkowicz & Berent, 2009). The latter ability emerges at 6 months of age and the more sophisticated ability to perceive the adjacent relations between two adjacent sequence elements emerges only at 10 months of age and, when it does, depends on statistical relations (Lewkowicz, 2013).

A sophisticated understanding of serial order involves the appreciation of the relational structure between all elements in a sequence (see Lashley, 1951). Gulya and Colombo (2004) demonstrated that, by preschool, after learning a linear sequence (e.g., ABCD), 3- and 4-year-olds were typically unable to order a subset of the sequence correctly (e.g., order BD instead of DB), and it was not until 7–10 years of age that children correctly identified all relationships between individual elements (e.g., AB, AC, AD, BC, BD, CD). Further, these children used logical shortcuts to reason about elements in a sequence. For example, when presented with a subset of the memorized list (e.g., ABD), children did not have to refer to their linear representation to order each element. Rather, they reasoned that, once only one element remained (e.g., D), it must fall in the last possible ordinal position. These results suggest that a sophisticated understanding of serial order that involves an appreciation of the relational structure between all elements in a sequence develops into school age.

One possible contribution to advanced serial-order knowledge is the acquisition of ordinal labels (e.g., "first" and "second"). A linguistic ordinal system provides an explicit systematic method for identifying and remembering order information and relationships in a sequence. For instance, knowing that a particular student is the *third* tallest child in the class enables one to represent the relationship between all children represented in the sequence and automatically implies that only two other children in the class are taller and that this student is necessarily taller than the *fourth* tallest child. Furthermore, if all the children were together in the classroom, it would be simple to identify this particular student, especially if the children were lined up in descending height. Therefore, ordinal labels rank elements in a sequential order resulting in number assignments that represent the relationship between elements (Wiese, 2003).

Empirical evidence suggests that children begin to demonstrate competence with ordinal numbers during school age. For instance, Piaget (1952/1997) presented 4- to 6-year-olds with ten cards of differing heights placed in order from shortest to tallest, where the cards were multiples of the smallest card (e.g., A, 2A, 3A, 4A). Children were then trained on size relations until they understood "that the second card can be cut up into 2A, the third into 3A cards, and so on" (p. 135) and could answer basic ordinal questions following training by at least 5 years of age (e.g., "Which one is the first one?" [p. 136]). However, when children were presented with a situation where employing ordinal knowledge would be helpful (i.e., they were asked how many units of the smallest card made up a card selected at random), it was not until 6 years of age that children employed an ordinal strategy and could reason that if card F is in the sixth/6 position, it is made up of 6 units. A study by K. Miller, Major, Shu, and Zhang (2000) also identified school age as a period of developing ordinal-label competence, as kindergarteners from the United States (*M* age = 6.37 years) began to use ordinal labels when asked to identify various items (e.g., first, second, fourth, last) in a series of 7 items (averaging 65.6% correct) and second and fourth graders performed perfectly. The few studies that have examined preschoolers' use of ordinal labels suggest they may struggle with these labels. Siegel (1971) demonstrated that 3- and 4-year-olds had difficulty when asked to press the "second" picture in an array. When presented with up to 80 trials, the youngest children never achieved a criterion of 9 out of 10 consecutive correct responses, and even the oldest children needed 50 trials on average to reach the criterion. As part of a larger study, Kingma and Zumbo (1987) administered the Number Facility Test to 4- to 7-year-olds, which "includes 45 items consisting of instructions such as, cross the third object in the row, cross the first five objects in the row, cross the last object of the row and the like" (p. 563). The 4- and 5-year-olds performed poorly on the task (4.14 and 11.22 out of 45, respectively). Although 6- and 7-year-olds did better (21.76 and 29.20 out of 45, respectively), their performance was far from perfect.

Although school-age children begin to master formal assessments of ordinal-label knowledge (e.g., point to the second item), research on preschooler's use of ordinal labels remains limited. One possibility for examining preschoolers' proficiency with ordinal numbers is through their ability to make decisions based on labels. The addition of relevant, well-learned labels has been shown to influence children's problem solving (e.g., Jacques & Zelazo, 2005; Kirkham, Cruess, & Diamond, 2003) and even 2½-year-old language novices benefit from relevant labels in problem solving tasks (S. Miller & Marcovitch, 2011). Thus, children's understanding of ordinal labels could be evaluated by presenting children with a situation in which ordinal knowledge would be useful. Better performance with ordinal labels compared to irrelevant labels would be indicative of early ordinal-label understanding. For example, Loewenstein and Gentner (2005) employed a similar strategy to demonstrate that well-learned spatial relational labels (e.g., top, middle, and bottom) improved performance in a spatial mapping task. In this task, preschoolers watched as the experimenter placed a card in each section of a vertically partitioned hiding box and designated one of three locations the "winner" by placing a card marked with a star on the back at that location. Children were then presented with a similar finding box (e.g., a similarly partitioned box of a different color with three cards) and had to close their eyes while the winner was designated in the very same section of the finding box. Loewenstein and Gentner demonstrated that children who were presented with spatial relational labels during the hiding phase (e.g., the winner is at the bottom of the box) were better able to find the winning card in the finding box compared to children who received no spatial relational language (e.g., the winner is right here). Further, integrated relational language describing relationships between all locations in a larger structure (i.e., top, middle, bottom) was more beneficial than nonintegrated relational language that described separate spatial relations (i.e., on, in, under). If children appreciate this ordinal linguistic system as representing relationships between elements in a series (Wiese, 2003), they should demonstrate competence with ordinal labels in a spatial search task (Loewenstein & Gentner, 2005) relative to nonrelational labels.

In the present study, we evaluated preschoolers' competence with ordinal labels by comparing their use of ordinal labels to their use of nonrelational labels. The 4- and 5-year-olds' use of ordinal labels was evaluated within a spatial search task in which a reward was placed in one of three differently colored train cars. The experimenter then labeled the train cars with either an ordinal (i.e., first, second, or third), color (i.e., brown, green, or gray), or generic (i.e., "that") label. Children then watched the train car travel around the track and become hidden under a set of identical tunnels. Last, the experimenter asked children to find the sticker by lifting up a tunnel. Color and generic labels were included as nonrelational controls (i.e., labels that do not focus on relationship between cars). The preschool age range was selected because children typically begin to master ordinal labels by school age, and we hypothesized growth in ordinal-label competence relative to nonrelational labels during the seldom-studied preschool years. If ordinal labels (e.g., first, second, and third) form an integrated relational system (Wiese, 2003) akin to the relational labels that improved performance in a spatial mapping task (Loewenstein & Gentner, 2005), 4- and 5-year-olds should demonstrate competence with ordinal labels relative to nonrelational control labels that should be of no use once the train cars are hidden under identical tunnels.

Method

Participants and Design

A total of 216 preschool-aged children participated in this study. Thirteen were excluded because they did not complete the experiment (*n* = 2) or because of experimenter error (*n* = 11). The remaining 203 had a mean age of 4.92 years (*SD* = .51, range 4.04–5.99, 103 boys). Children were recruited from day-care centers, preschools, and a database of children whose parents expressed interest in research participation. Written informed consent was obtained from a parent or guardian before children participated.

The spatial search task required children to observe a reward placed in one of three train cars and search for that reward once the train traveled around the track and was occluded by three identical tunnels. The experiment was split into the familiarization phase and the testing phase. The purpose of the familiarization phase was to acquaint children with the goal of the task (i.e., retrieve a reward from under a tunnel), introduce the labels for the cars, and map the correspondence between the tunnels and the labeled cars. During familiarization for the ordinal and color conditions, children were acquainted with the labels they would eventually use during the testing phase. Because the generic-label condition would technically not have required training, as all cars were identically labeled (i.e., *that* car), children in the generic conditions were familiarized with color or ordinal training to equate training experience. This resulted in an ordinal condition, a color condition, and three generic conditions, which varied on the type of training they received, summarized in Table 1. Specifically, in the ordinal condition, children were familiarized with ordinal cues and presented with ordinal cues during the test phase. In the color condition, children were familiarized with

Table 1. Description of conditions

	Ordinal-cue training	Color-cue training	Verbal-cue present during test	Distinct visual color cue
Ordinal (*n* = 75)	×		×	×
Color (*n* = 72)		×	×	×
Generic A (*n* = 22)		×		×
Generic B (*n* = 16)	×			×
Generic C (*n* = 18)	×			

color cues and presented with color cues during the test phase. In the generic A condition, children were familiarized with color cues but presented with generic cues (i.e., the sticker is in *that* car) during the testing phase. In the generic B condition, children were familiarized with ordinal cues, but presented with generic cues during the testing phase. Finally, we also manipulated the color of the train cars within the generic conditions to eliminate the possibility that the color of the car influenced search performance. Thus, in the generic C condition, children were presented with identical train cars (see Figure 1A) and ordinal labels during familiarization but received generic cues during the test phase. Including these three generic conditions enabled us to determine whether training (i.e., color or ordinal training) influenced search performance and whether children may have implicitly encoded color to differentiate items to aid search performance.

Materials

A Fisher-Price GeoTrax train set, which was assembled to form a roughly circular track, consisted of five cars arranged in the following order (all measurements are front to back × side to side × height and do not include the 1- to 2-cm length of the hitches that connect one car to the other): engine (9 × 6 × 6 cm), brown car (6 × 4 × 4.5 cm), green car (6 × 4 × 5 cm), gray car (6 × 5 × 4.5 cm), and caboose (6 × 4.5 × 6 cm) (see Figure 1). An experimenter operated the train by using a remote device. In addition, three identical silver tunnels (9 × 10 × 11.5 cm) were used to cover the internal three train cars. Finally, a 38 × 51-cm poster board was used to obscure the view of the tunnels during the delay.

Procedure

Familiarization phase. Children were seated in front of the train set, while the experimenter sat to the left of the children. The familiarization phase began with the three tunnels covering the track. After children demonstrated that they could retrieve the reward (i.e., a small adhesive sticker or label) from under each tunnel, the experimenter moved the three tunnels behind the track and introduced the train one car at a time (see Figure 1A). The first and last cars were given the same label (i.e., engine and caboose, respectively) in all conditions and were not used as hiding locations, so as to avoid search bias of starting the search at the outside positions and searching through the tunnels in order (see Spetch & Parent, 2006). Children either heard ordinal labels (i.e., first, second, or third) for the inner cars or color labels (i.e., brown, green, or gray), depending on their condition. For example, when introducing the first/brown car, the experimenter stated,

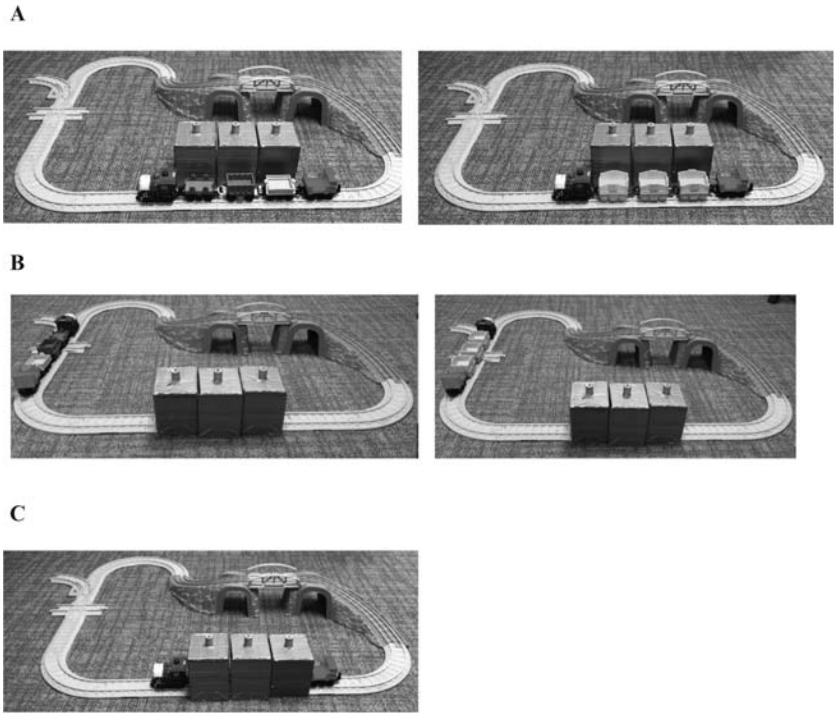

Figure 1. Train setup for **A**. familiarization with distinct and identical hiding cars, **B**. starting position with distinct and identical cars, and **C**. testing phase.

"Now, here we have the first [or brown, depending on condition] car. Can you say the first [or brown] car? [Wait for response.]" After all the cars were introduced, the children were prompted to name all the cars from left to right (e.g., "What car is this?"). The train was then driven around the track and stopped in front of the tunnels, which were still behind the tracks. The experimenter again had children identify each car and gave them feedback on their responses.

The experimenter then pointed out the one-to-one correspondence between each tunnel and the car that it would eventually cover:[1] For example, when introducing the tunnel for the first/brown car, the experimenter stated, "See this tunnel. This is the tunnel for the first [or brown] car." After the children correctly identified each tunnel, the experimenter placed the

1. Pilot data indicated that explicit instruction on the one-to-one correspondence between the tunnels and train cars was necessary for children to comprehend the relationship between the tunnel and the car.

tunnels over the train cars and drove the train out so that it was no longer occluded by any tunnels. This was used as the starting position for the test phase so that children could not rely solely on memory because they did not actually see the reward hidden under the tunnel (see Figure 1B).

Test phase. Before every test trial, children were prompted to identify the tunnel for each car by the label they learned during training. All children received six test trials such that the sticker was hidden randomly in each car once before being hidden in any car for the second time. In both the color and ordinal conditions, the experimenter continued to use the labels that the children were trained on. In the generic conditions, the experimenter provided a generic label for the car (i.e., *that* car).

The experimenter began the first trial at the starting position (see Figure 1B) and said, "I am going to put the sticker in the second [or green or *that*] car, and it is your job to find the sticker so you have to remember that it is in the second [or green or *that*] car." Children watched as the experimenter placed the sticker in the train car and the train traveled around the track and were reminded of the sticker's location twice during the train's journey. The train stopped when the three internal cars were hidden by the three identical tunnels (see Figure 1C). A delay was imposed during which the experimenter placed the poster board in front of the tunnels to obscure the view and counted aloud to five. This is a common practice in search tasks that eliminates children's ability to stare at the correct location continuously (e.g., Marcovitch & Zelazo, 2006; Spencer, Smith, & Thelen, 2001). After the delay, children were allowed to search for the sticker by lifting up the tunnel. If children searched incorrectly, the tunnel was placed back on the track and they were allowed to search until they were correct. All subsequent trials were identical to the first trial, except that children were given abbreviated instructions at the start of each trial: "This time I am putting the sticker in the third [gray or *that*] car."

Results

For each child, we calculated the proportion of correct responses.[2]

As there were no effects of sex, nor any interactions between sex and other variables in the analyses, we do not report on it further. Analyses

2. For several children, experimenter error invalidated one of the six hiding trials. For 10 children, the train cars were not stopped directly under the tunnels, and children observed one of the target train cars emerge from under the tunnels on one trial. In addition, 10 children were not afforded a 5-second delay before search on one trial. In all cases, the questionable trial was not considered and the proportion correct was calculated based on the five remaining trials. This did not change the general pattern of findings.

on children within the generic conditions revealed that there were no differences between children trained with ordinal labels, children trained with color labels, and children trained with identically colored cars and ordinal labels, $F(2, 50) = .38$, $p = .69$, $\eta^2 = .02$, nor did the different types of training interact with age, $F(2, 50) = .48$, $p = .62$, $\eta^2 = .02$ (see Table 2). Since car color and training did not influence performance, we analyzed the performance of all children in the generic conditions together to provide a baseline in which no informative labels were presented during testing.

Using a general linear model, we analyzed the impact of age (continuous and centered) and condition (categorical: ordinal, color, or generic) on the proportion correct and found a significant effect of age, $F(1, 197) = 35.54$, $p < .01$, $\eta^2 = .15$, and an age by condition interaction, $F(2, 197) = 3.03$, $p = .051$, $\eta^2 = .03$. Planned comparison on the unstandardized slopes examining age effects revealed that age-related improvement in the spatial search task was significantly larger in the ordinal condition, $B = .296$, compared to the color condition, $B = .121$, $t = 2.28$, $p = 0.02$, $\eta^2 = .03$, and the generic condition, $B = .147$, $t = 1.93$, $p = 0.055$, $\eta^2 = .02$ (see Figure 2). To calculate effect sizes and standardized regression coefficients, we conducted separate regression analyses for each condition with age as a continuous predictor. These analyses revealed that, in addition to larger slopes related to age in the ordinal condition, more variance was accounted for in the ordinal condition, with a large effect size, $\beta = .55$, $t(74) = 5.60$, $p < .01$, $R^2 = .30$, compared to a small effect size in the color condition, $\beta = .24$, $t(71) = 2.09$, $p = .04$, $R^2 = .06$, and a medium effect size in the generic condition, $\beta = .36$, $t(55) = 2.81$, $p = .01$, $R^2 = .13$. Planned comparisons revealed that 4-year-olds' performance was worse when presented with order labels in the ordinal condition compared to the color condition, $F(1, 197) = 8.25$, $p = .01$, $\eta^2 = .04$, and generic condition, $F(1, 197) = 7.77$, $p = .01$, $\eta^2 = .04$. The 5-year-olds' performance did not significantly differ between the ordinal, color, and generic conditions. Both 4- and 5-year-olds performed significantly better than chance (i.e., 33% correct) regardless of condition, all ts > 5.63, ps $< .01$.

Table 2. Proportion correct by generic condition

	4-year-olds	5-year-olds
Generic A (distinct cars trained with color labels)	.76 (.07)	.88 (.07)
Generic B (distinct cars trained with order labels)	.75 (.09)	.87 (.08)
Generic C (identical cars trained with order labels)	.68 (.08)	.85 (.08)

Note. Standard errors are in parentheses.

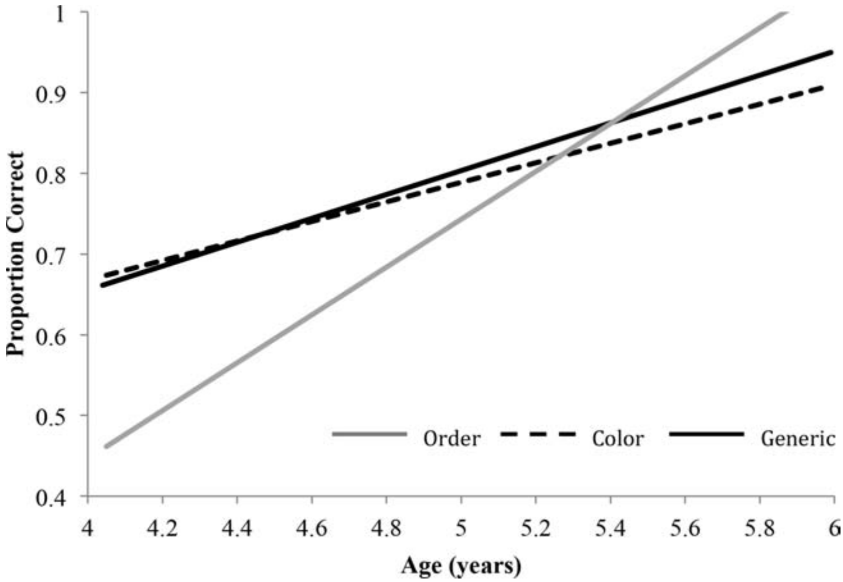

Figure 2. Proportion correct by age and label type. The *solid gray line* is the best linear fit for the ordinal-label condition, the *solid black line* is the best linear fit for the generic-label condition, and the *black dashed line* is the best linear fit for the color-label condition. Age in years (rather than centered age) is depicted for ease of interpretation.

Discussion

We examined 4- and 5-year-olds' use of ordinal labels in a spatial search task to determine whether they might show early competence with ordinal labels compared to labels designed to be less helpful in this spatial search task (i.e., color or generic labels). Although we thought it likely that children would initially be unable to benefit from ordinal labels, the 4-year-olds performed worse, surprisingly, with ordinal labels than with color and generic labels. Children's use of ordinal labels also clearly improved from 4 to 5 years of age. The difficulty with ordinal-label use in young preschoolers is consistent with research demonstrating preschoolers' struggle with explicit ordinal-label knowledge and implicit use of ordinal labels (Kingma & Zumbo, 1987; K. Miller et al., 2000; Piaget, 1952/1997; Siegel, 1971). In the present study, 4-year-olds' difficulty benefiting from ordinal labels relative to color and generic labels extends our understanding of preschoolers' ordinal-label competence by demonstrating that enforcing an ordinal strategy can negatively impact young preschoolers' spatial search performance relative to control conditions.

It is doubtful that 4-year-olds' superior performance with the color cues was due to color enhancing young children's spatial search performance (see Park & James, 1983; Plumert & Nichols-Whitehead, 2007). This is because children performed similarly in the generic conditions when the internal cars were distinct or identical in color, indicating that they did not implicitly encode car color as a unique identifier to guide search performance. The similar performance with and without visually distinct hiding locations also suggests that children did not spontaneously create a color label to guide search, and the combined generic conditions could serve as a measure of baseline spatial search performance in which no informative labels were present during testing. Further, children's performance with color labels was statistically indistinguishable from our generic-label condition, suggesting that the presence of a color label did not further improve baseline spatial search performance. Despite this, the fact that children performed above chance across all conditions is consistent with findings that infants and young children possess basic spatial memory abilities (e.g., Baker-Ward & Ornstein, 1988; Ellis, Katz, & Williams, 1987; Marcovitch & Zelazo, 1999; Piaget, 1954; Schumann-Hengsteler, 1992). Further, selecting an appropriate task difficulty level is important because Loewenstein and Gentner (2005) demonstrated that children might fail to benefit from some relational language (e.g., on, in, under) in a spatial search task if the task is too difficult (e.g., if baseline groups are at chance performance). Thus, the color-label and generic-label conditions are presented as the baseline spatial search performance to which spatial search performance with ordinal labels can be compared, and we can be assured that children did not fail to apply ordinal labels because the task was too difficult or overwhelming.

One explanation for the ordinal-label disruption relative to color and generic cues in 4-year-olds' spatial search is that children presented with generic or color labels may encode spatial location information automatically (see Park & James, 1983) but inefficiently, whereas young children presented with ordinal labels implement an ordinal strategy they are not yet equipped to employ effectively. In the current experiment, children were provided with all the information they needed to use an ordinal strategy—the locations were given an ordinal label and the relationship between the locations and tunnels was acknowledged. However, we believe that very young children were probably less familiar with ordinal labels prior to the task, as suggested by their poor performance with ordinal labels during the preschool years (Kingma & Zumbo, 1987; K. Miller et al., 2000; Piaget, 1952/1997; Siegel, 1971) and the emphasis on cardinal labels early in life (Anderson, 1997). Thus, our results also speak to how less familiar labels can influence preschoolers' problem-solving behavior.

Theories of language, thought, and behavior suggest that labels should serve as a tool for thought (e.g., Vygotsky, 1934/1986), and an effective label should encourage children to form a representation of relevant information (e.g., the sticker is in the third position) that they can reflect on to guide their behavior during problem solving (e.g., Marcovitch & Zelazo, 2009; Zelazo, 2004; Zelazo, Müller, Frye, & Marcovitch, 2003). The fact that ordinal labels did not facilitate 4-year-olds' performance suggests that ordinal labels were not used in a relational way (see Loewenstein & Gentner, 2005). That is, it may be that 4-year-olds create ill-formed representations without a direct link to ordinality and that reflection on these difficult concepts (i.e., deliberately thinking about ordinal representations to solve the problem; see Marcovitch & Zelazo, 2009) may hinder basic spatial search performance if children are not cognitively prepared to employ an ordinal strategy (e.g., Bjorklund, 1997; Bjorklund & Harnishfeger, 1987). Specifically, reflection on this less familiar ordinal label may place additional demands on executive function (e.g., used to process the link between the label and the ordinal concept consciously), which is also necessary for the spatial search task (e.g., holding the reward location in mind, inhibiting the tendency to search at the last correct location; Marcovitch & Zelazo, 2006). The fact that the ability to use ordinal labels improves markedly with age suggests that the link between ordinal labels and ordinal knowledge becomes better learned and more automatic, and thus no longer interferes with the executive function necessary to complete the task.

This improvement may be related to the growth underlying two associated linguistic developments: the acquisition of relational labels (e.g., Göksun, Hirsh-Pasek, & Golinkoff, 2010) and the acquisition of cardinal number labels (e.g., Wynn, 1990, 1992). Göksun et al. proposed that to learn *relational terms* (i.e., terms describing relationships between items such as prepositions and verbs), infants must have a preverbal means for perceiving the action or event to map on to their language. The aspects of an event that children will attend and refer to will be influenced by the language children learn. For example, although young infants from English-speaking backgrounds can detect difference between degree of fit (e.g., tight versus loose), language by the third year becomes a factor and children with languages that describe degree of fit when describing the relational terms "in" and "on" (e.g., Korean languages) will be more sensitive to this relation (see Göksun et al., 2010). A similar developmental pattern has been described in children's acquisition and understanding of cardinal number labels (e.g., one, two, and three), which represent quantity rather than the relationship between elements in a sequence (Wiese, 2003).

Similar to relational language, it has been proposed that a more sophisticated linguistic and symbolic representation of numerosity builds on nonverbal understanding (e.g., Hubbard et al., 2008), in which children first use number words without a direct link to numerosity (e.g., Fuson, 1988; Gelman & Gallistel, 1978) and then incorporate their preverbal understanding of number with newfound number labels (e.g., one, two, and three). By the fourth year, children begin to understand the mapping of number words to cardinality (Wynn, 1990, 1992) and the *cardinality principle* (i.e., the idea the last number counted represents the quantity; Fuson, Pergament, Lyons, & Hall, 1985).

Ordinal-relation terms may be acquired in a manner similar to relational and cardinal number labels. It has already been established that infants have a nonverbal means for perceiving serial-order relationships (e.g., Kirkham et al., 2002; Lewkowicz, 2004, 2008, 2013; Lewkowicz & Berent, 2009; Marcovitch & Lewkowicz, 2009; Saffran et al., 1996). Children's early difficulty with ordinal labels in the present study may capture a period in which children typically rely on their preverbal perceptions and do not use an abstract linguistic system to represent order and sequences. Next, as children integrate serial-order knowledge with ordinal labels, the deficit may disappear and eventually transform into a benefit once children acquire a relational ordinal-label system. Competence with ordinal labels may lag behind cardinal number label competence because children encounter more of an emphasis on quantity and cardinal labels early in life (Anderson, 1997). Further, cultural differences in ordinal-label competence (K. Miller et al., 2000) may lend support to the hypothesis that cultural differences in relational language shape the representation of ordinal concepts (Göksun et al., 2010). For instance, in Chinese cultures, ordinal-number labels are very similar to cardinal numbers and thus encountered more frequently, resulting in more advanced competence with ordinal labels in kindergarteners (e.g., identify the fourth object) compared to U.S. children (K. Miller et al., 2000).

Serial-order perception and understanding is a foundational ability that emerges early in life and likely transforms into a more sophisticated symbolic relational system in early childhood. The present study demonstrates that although preschoolers initially appear overwhelmed and unable to apply ordinal labels to improve spatial search performance, they become more competent with these labels with age. These results may have educational implications, as school-age children are frequently instructed to assign labels and symbols to concepts for which they show an early sensitivity (e.g., labeling basic rules of grammar and learning symbols for addition and subtraction). Although these symbols likely enhance cognition by enabling children to eventually reflect on and think about concepts at a higher level (e.g., in number cognition, adults with formal education can perform more sophisticated operations such as adding specific or large quantities), the present results suggest development in performance when linking these concepts to language. Children may initially demonstrate recognition of basic concepts like order or number without language (e.g., Lewkowicz & Berent, 2009; Wynn, 1990), followed by a disruption in performance once labels are introduced for these concepts, finally resulting in a more sophisticated symbolic system. These results suggest that this early struggle applying new symbols and labels to existing knowledge is common, and enforcing strategies and concepts before children are ready could initially impair performance. Further research examining children's competence with ordinal labels by using more supportive contexts will inform the development of children's serial-order representation and corresponding linguistic system.

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