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Perseverators are "Stuck" on a Concrete Dimension: Individual Differences in Achieving Dual Representation

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Although numerous researchers have found that young children have difficulty perceiving both a concrete and an abstract dimension of a symbol (i.e., achieving dual representation), few researchers have examined the reasoning behind this difficulty. In this study, individual differences in cognitive flexibility as they relate to achieving dual representation are examined. Participants (children at 30, 36 and 42 months) completed a standard scale model task (to assess dual representation) and a Dimensional Change Card Sort (DCCS) task (to assess cognitive flexibility). It was expected that children with good cognitive flexibility would perform better on a task of dual representation than would children with poor cognitive flexibility. Although hypotheses were not supported, findings from this data warrant future investigations on this topic. Limitations and future directions are discussed.

Keywords: cognitive development, dual representation, cognitive flexibility, development

Adults understand that a building on a map represents an actual building in space. Young children, on the other hand, may not understand this representational relation between objects. Previous researchers have found that children's ability to use symbols as representations for other things develops quickly between 30 and 36 months of age (DeLoache, 1987; Marzolf & DeLoache, 1994). This paper addresses potential individual differences in children's abilities to understand and use symbols during this developmental period.

Symbols

A symbol, broadly defined, is anything that is intended to represent some other thing (DeLoache, 2004). This understanding of a dual-purpose for a single object is linked to cognitive development (Uttal et al., 1998). To succeed in using symbols, individuals must understand that there is a representational relationship between a symbol and an analogous object (i.e., representational insight), match similarities between a symbol and an analogous object (i.e., mapping), and be able to make judgments about an analogous object based on a symbol. In addition, to achieve representational insight, one must understand and perceive a concrete and an abstract dimension of that symbol (i.e., dual representation).

DeLoache and colleagues have conducted several studies on representational insight during the preschool period using a scale model task (DeLoache, 1987; Uttal, Liu, & DeLoache, 2006). These researchers have established that a rapid change in symbolic understanding occurs between 30 and 36 months such that children at 30 months have great difficulty achieving representational insight whereas children at 36 months have little difficulty In this task, children are presented with a scale model of a referent room and are required to use that scale model as a symbol to find a hidden toy in that referent room. Success in this task is defined by the percentage of trials in which the child retrieves the hidden toy on his/her first attempt. To use a scale model successfully as a symbol for a referent room, children must understand that a model can serve as both a concrete and symbolic object, understand a representational relationship between that model and referent room, perceive similarities between that model and referent room, and make judgments about each based on the other. Because children are able to achieve dual representation and representational insight with some symbols and not others, researchers believe the nature of a symbol is important (DeLoache, 1991).

Interestingly, when using a photograph as a symbol, children at 30 months of age have little difficulty achieving representational insight. Scale models and photographs as symbols differ in the ease with which dual representation can be achieved. Furthermore, in studies where dual representation was either easy to achieve (e.g., by placing the model behind a clear wall) or not required (e.g., when a referent room appeared to shrink), children had little difficulty achieving representational insight (DeLoache, 2000; DeLoache, Miller, & Rosengren, 1997) whereas in studies where dual representation was difficult to achieve (e.g., by allowing children to play with the model, increasing the physical salience of a symbol), children had great difficulty achieving representational insight (DeLoache, 2000). Based on these findings it appears that young children find it harder to understand and use symbols that have a dominant concrete dimension as opposed to a dominant abstract dimension.

Young children may have difficulty achieving dual representation with representational objects that have dominant concrete dimensions because they either cannot perceive both a concrete and abstract dimension of that object or cannot switch their attention from a concrete to an abstract dimension of that object. For example, children may have difficulty achieving dual representation with a photograph of an apple because they cannot perceive the photograph as both a representation for that apple and a piece of two-dimensional paper. Or, children may have difficulty achieving dual representation with a photograph of an apple because they are unable to switch their attention from the representational and concrete features. If the former is true, then children should not be able to use representational objects in any situation. From previous work, however, researchers have found that children can use a variety of types of representations that have both abstract and concrete dimensions including video (e.g., Troseth, 2003), photographs (e.g., Preissler & Carey, 2004) and gestures (e.g., Tomasello, Striano, & Rochat, 1999). Examining the latter possibility (i.e., that dual representation is difficult to achieve because of difficulties with attention switching), it is expected that children who have difficulty switching or inhibiting attention may also have difficulty achieving dual representation. This hypothesis requires an examination of the cognitive flexibility literature.

Cognitive Flexibility

Cognitive flexibility is the ability to switch attention and/or behavior between or within tasks (Diamond, 2002). This flexibility is believed to involved in switching attention, inhibitory control, and working memory (Garon, Bryson, & Smith, 2008). Perseveration, or cognitive inflexibility, is the act of repeating a previously relevant behavior when a new behavior is appropriate (Garon et al., 2008; Hanania, 2010). In the scale model literature, children tend to perseverate by searching for a hidden toy based on where that toy was hidden in a previous trial. When children's opportunity to make perseverative errors was decreased or eliminated—for example by removing a previous hiding location—children still performed poorly (DeLoache & Burns, 1994; Sharon & DeLoache, 2003). Because children were no longer able to make perseverative errors and yet they were still unable to achieve dual representation, DeLoache (2002) concluded that perseverative search errors are a mere consequence rather than cause of children's inability to achieve dual representation. Although perseverative searches may not be a preventing factor in achieving dual representation, perseverative thinking may be a preventing factor in achieving dual representation.

In the cognitive flexibility literature, researchers have found that compared to children who are unable to switch between sorting dimensions (i.e., perseveration) in the Dimensional Change Cart Sort task, children who are able to switch sorting dimensions (i.e., switching) are better able to think abstractly by making categorizations (Kharitonova, Chien, Colunga, & Munakata, 2009). In the Dimensional Change Card Sort task, children are presented with two model cards (e.g., blue truck, red bird) (DCCS; Frye, Zelazo, & Pelfai, 1995). Children are then given multiple cards (e.g., red truck, blue bird) to sort based on one dimension (e.g., color) and then asked to sort those same cards based on a second dimension (e.g., shape). When the perceptual salience of the first sorting dimension is increased, such as when sorted cards are placed face up in trays instead of face down, making it harder for children to focus on the current relevant dimension, children perform poorly. Thus, in this task children often struggle to perceive multiple dimensions of a single object or to switch their attention between these dimensions, similar to in the scale model task.

There are three prominent explanations for perseverative behavior in the DCCS: Selective Attention Theory (e.g., Kirkham & Diamond, 2003), the Working Memory Theory (e.g., Morton & Munakata, 2002), and the Cognitive Complexity and Control theory (e.g., Zelazo, Frye, & Rapus, 1996). In the Selective Attention Theory, perseveration is thought to occur because individuals become fixated and have difficulty switching their attention (Ruff & Cappozzoli, 2003). This pull to continue focusing on a single object or single dimension of an object is known as attentional inertia (Anderson, Heywon, & Lorch, 1987; Kirkham & Diamond, 2003). Interestingly, children at 36 months perform well when two dimensions of a sorting card are separated (e.g., a blue truck on a red background to be sorted with either trucks or the color red) rather than integrated (e.g., a blue truck on a white background to be sorted with either trucks or the color blue) (Diamond, Carlson, & Beck, 2005). Additionally, children at 36 months perform well when they do not have to switch sorting based on a second dimension (i.e., they switch based on a different rule with the same dimension) (Brooks, Hanauer, Padowska, & Rosman, 2003).

In the Working Memory Systems Theory, perseveration is thought to occur because of a competition between active and latent working memory systems during task switching (Morton & Munakata, 2002). A latent memory system codes stimulus-specific information (e.g., detecting shape) and becomes stronger based on repeated behaviors whereas an active memory system codes abstract information (e.g., detecting sameness) and focuses on current, task-relevant information (e.g., Brace, Morton, & Munakata, 2006; Kharitonova et al., 2009). A repeated active representation will lead to a latent representation. A weak active representation will lead to a weak latent representation whereas a strong active representation will lead to a strong latent representation (Yerys & Munakata, 2006). During task switching, competition occurs between these systems. In this competition, perseveration occurs when a latent memory system is strong and switching occurs when an active memory system is strong.

The Cognitive Complexity and Control theory (CCC) is based on the premise that children build increasingly complex rule systems. Increases in complexity of a rule system result in increases in response control (Zelazo et al., 1996). Complexity in this theory is described as the number of rules embedded in a rule system. In a standard DCCS task, for example, there are two rules for the pre-switch phase (e.g., blue cards go in tray one, green cards go in tray two). Because these two rules are non-contradictory and relatively non-complex, most young children succeed at this level. In the post-switch phase, however, rules change such that there are two new rules (e.g., square cards go in tray two, circle cards go in tray one). Because each sorting card matches on only one correct dimension per sorting dimension, children must be able to embed these new rules within previous rules and select the appropriate rule based on the card presented (e.g., blue squares cards go in tray one except in the shape game in which blue squares go in tray two). Perseveration occurs when children are unable to embed these complex rules and in turn they resort to using basic rules.

Each of these theories provides a framework for explaining perseverative behavior which may extend to explaining the difficulty young children experience in achieving dual representation. That is, to the extent that achieving dual representation requires switching perception between two dimensions of a single object, individual differences in children's cognitive flexibility may predict their ability to achieve dual representation.

Hypotheses

Based on the idea that cognitive flexibility is an important factor in children's ability to achieve dual representation, the following hypotheses were formed. First, compared to children with good cognitive flexibility, children with poor cognitive flexibility will have more difficulty achieving dual representation. That is, children who are able to switch sorting dimensions will have a higher percentage of errorless retrievals than will children who are unable to switch sorting dimensions in a scale model task. Second, compared to older children, younger children will have more difficulty achieving dual representation. That is, children at 30 months will have a lower percentage of errorless retrievals than children at 36 and 42 months. Differences between children at 36 and 42 months were not expected, because previous studies show children to achieve dual representation with a scale model by 36 months of age. Third, it was hypothesized that age and cognitive flexibility will interact such that young children with poor cognitive flexibility will have the most difficulty achieving dual representation. That is, children at 30 months who perseverate were expected to have the lowest percentage of errorless retrievals in a scale model task as compared to any other condition.

Method

Participants

A total of 65 children were recruited through public birth announcements. Participants included 23 (11 male, 12 female) 30-month-olds (29-32 months, *M*= 30.2), 21 (13 male, 8 female) 36-month-olds (35-37 months, *M* = 36.3), and 21 (7 male, 14 female) 42-month-olds (41-44 months, *M* = 42.3). Most of these children were Caucasian and only one of these children experienced corrected visual difficulties. Twelve (eight 30-month-olds, three 36-month-olds, one 42-month-old) of these children were excluded from analyses for failure to complete tasks (*n* = 6), lack of color knowledge (*n* = 1), experimenter error (*n* = 3), and interference from a parent (*n* = 2) (see Table 1 for sample size after exclusions). Parents gave written informed consent and children gave verbal or written assent.

Materials

DCCS (Frye et al., 1995): The DCCS was chosen because it is an established measure of cognitive flexibility in preschool-aged children. Although the DCCS has primarily been used with children 36 months and older, it is suggested for use with children as young as 30 months (Zelazo, 2006). Thus, for consistency in procedures across each age group, the DCCS was used for all ages. The stimulus cards consisted of two model cards, four training cards, and eight sorting cards (see Figure 1). The model cards were affixed on a tray such that children could see both cards at all times during the experiment. All cards depicted a colored shape on a white background; both trays were white. All cards were 12 cm x 10.5 cm; both trays were 20.5 cm x 13 cm with a base of 11.5 cm x 13cm.

The model cards in this study depicted a green truck and a blue star. The training cards depicted a yellow star, a red truck, a blue bird, and a green boat. Each training card matched only one model card on only one dimension (i.e., there was no ambiguity in a correct response). The sorting cards in this study depicted a blue truck and a green star. Each sorting card matched each model card on only one dimension (i.e., shape or color).

Scale model task (DeLoache, 1987): This phase of the study took place in two separate but adjacent rooms. The referent room was a laboratory workroom and included several items (e.g., a couch, two desks, a large cabinet, an artificial tree, a table with computers, four office chairs). In an adjacent room was a scale model (hidden from view until initiation of experiment) of the referent room as well as an area for children to play while the experimenter reviewed informed consent with parents. The referent room and scale model (including its contents) were at a ratio of approximately 9:1. The toys to be hidden included a large stuffed bear (30 cm high) and a highly similar, small stuffed bear (4 cm high). The toys were identified as "big Max" and "little Max," respectively.

Table 1

Distribution of sample after each exclusion criteria (N = 65)

Distribution after exclusion for failure to complete tasks, lack of color knowledge, experimenter error, and interference from a parent (*n* =53)

	2.5 year-olds	3.0 year-olds	3.5 year-olds
Pass pre-switch	8	13	16
Failed pre-switch	7	5	4

Distribution of after exclusion for failing pre-switch (n = 36)

	2.5 year-olds	3.0 year-olds	3.5 year-olds
Pass post-switch (switchers)	1	5	5
Failed post-switch (perseverators)	6	8	11

Distribution after random selection of equal participants (*n* = 22)

	2.5 year-olds	3.0 year-olds	3.5 year-olds
Pass post-switch (switchers)	1	5	5
Failed post-switch (perseverators)	1	5	5

Figure 1. Stimuli in DCCS

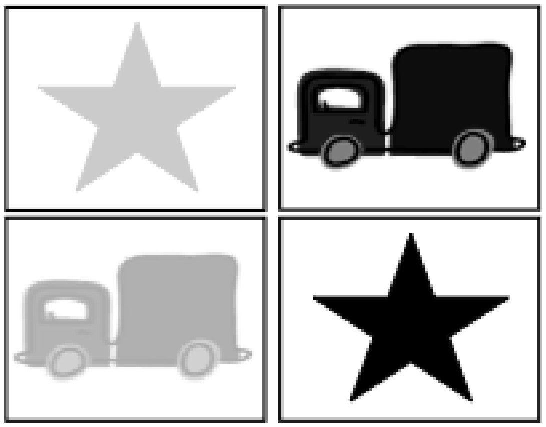

Figure 1. Stimuli used for sorting cards. Model cards (above) included a green truck and a blue star. Sorting cards (below) included a blue truck and a green star.

Procedure

Children completed two tasks: Dimensional Change Card Sort (DCCS; Frye et al., 1995) and standard procedure Scale Model task (DeLoache, 1987). To account for order effects, conditions were counterbalanced such that half of the participants completed the DCCS first and half of the participants completed the scale model task first. This counterbalance was maintained across age and sex. All children completed both tasks individually. The same experimenter conducted each session and one of the remaining researchers coded each session. Each of the two coding researchers went through a series of training exercises to ensure accuracy. Coding researchers sat behind the children as not to distract them during each task.

DCCS: This procedure closely follows that of Diamond and colleagues (2005). Each child sat at a preschool-sized table. The experimenter began by verifying the child's knowledge of color and shape. The experimenter pointed to each model card and reported on the same dimension of each card (e.g., "This is a truck. This is a star."). The experimenter then asked that child to identify each shape (e.g., "Can you point to the truck? Can you point to the star?") The experimenter then reported on the other dimension of each card (e.g., "This is green. This is blue."). The experimenter then asked that child to identify each color (e.g., "Can you point to the green one? Can you point to the blue one?"). The experimenter provided support and feedback to ensure that child understood both shapes and colors.

The experimenter then began training for the second dimension to be tested. She announced that she and the child would begin by playing a color game1. She gave explicit directions about both rules for this game (e.g., "In the color game, green ones go here and blue ones go here."). She then asked that child to identify where each card goes (e.g., "In the color game, where do the green ones go? In the color game, where do the blue ones go?"). Finally, she asked the child to place a training card in the appropriate tray (e.g., "Here's a green one, where does it go? Here's a blue one, where does it go?"). This procedure was repeated for two cards. The experimenter provided support and feedback. If the child was incorrect, the experimenter provided instructions again and the child sorted up to an additional two cards. With all sessions, if a child placed a card face up, the experimenter gently turned the card face down. This procedure element was used because previous researchers found that children had greater difficulty switching sorting dimensions when sorting cards remained face-up (Kirkham, Cruess, & Diamond, 2003). This difficulty likely stems from children's inability to focus on the current sorting card when other cards are in view.

The experimenter then announced that they would play the shape game. The same procedure as just described was carried out with two additional training cards (note, each training card matched only one model card on only one dimension; e.g., a red truck). Each training card could be presented twice for a maximum of eight training trials (two per card per dimension).

The first experimental phase began with the same dimension as the second training phase. For example, children that trained first with color and second with shape began the experimental phase with shape. Each sorting card was presented in the same pseudo-random order. Prior to each sorting trial, the experimenter reiterated the rules of the current game (e.g., "Remember in the color game, green ones go here and blue ones go here.") On alternating trials the experimenter asked the child to identify the rules of the current game (e.g., "In the color game, where do the green ones go? And where do the blue ones go?"). Children were only given feedback when they identified rules for the current game but not for their performance during each trial. Children sorted eight cards during both pre-and-post switch phases.

The experimenter then announced that they were finished with the color game and would now play a new game. The experimenter reiterated the rules of the new game (e.g., "In the shape game, all trucks go here and all stars go here."). The experimenter then asked the child to identify the rules of the current game (e.g., "In the shape game, where do the trucks go? And where do the stars go?"). The experimenter provided feedback when children identified each rule.

The experimenter then began the second experimental session. The experimenter followed the same procedure as in the first experimental session. No cards were removed from the trays between sessions. Children's responses were recorded after they released the card from their hands. While still holding a card, children could change their minds. Hesitations were noted through live behavioral coding and used in descriptive analyses. Hesitations were defined as a child placing a card and then replacing that card before the experimenter asked the next question. Hesitations were scored dichotomously for each card placed: hesitation or no hesitation. Researchers were trained in noting these hesitations but as each session was coded live, there was no calculation of interrater reliability. Participants were categorized as either passing or failing both dimensions. Passing required a correct sort in six of eight consecutive trials (similar criteria used in Diamond et al., 2005). Only data from participants who passed the first dimension were used. After completing the DCCS, children were rewarded with a stamp and took a brief break. The experimenter then explained that they would play a new hiding game.

Scale model task: This procedure closely follows that of DeLoache (1989). The scale model task took place in a different location of the same laboratory as the DCCS task. The experimenter first showed a child the previously described stuffed bears and expressed that the bears like to do the same things: "This is big Max and this is little Max. Little Max likes to do the same things as big Max." The experimenter then showed a child the referent room and the scale model: "This is big Max's room and this is little Max's room. They look exactly the same." She then labeled five major objects in each space. The objects labeled included a desk, couch, tree, cabinet, and chair. The experimenter then completed, based on the child's understanding, up to two imitation and practice trials to ensure the child understood directions. Children's understanding was determined by the experimenter and based on their performance in practice trials. For practice trials, the experimenter placed the small bear on a desk in the scale model and asked the child to put the large bear in the same place in the referent room. She then hid the small bear in a location within the scale model that would not be used for experimental trials and asked a child to find the large bear in the referent room. Support was given if a child had trouble in either the imitation or practice trials.

A child then completed four experimental trials2. Similar to previous studies (e.g., DeLoache, 2000), the experimental trials included three events: hiding event, retrieval one, retrieval two. In the hiding event, while the child was watching, the experimenter hid the small bear in the scale model (e.g., "Little Max is hiding here."). She then hid the large bear in the referent room (without the child watching) and announced the similar hiding places (e.g., "Big Max is hiding in the exact same place as little Max. Can you find big Max?"). The name of the hiding location was never explicitly told to a child. In retrieval one the child was then prompted to find the large bear. For each trial a second researcher, again placed behind and away from the child, recorded where a child initially searched (i.e., defined as attending to and touching a location) for the toy and whether he or she was successful. If the initial searches were unsuccessful, then the child was prompted by clues to find the toy. Only the first searched location was scored. In retrieval two the child was then asked to find the small bear in the scale model. Success in retrieval two indicated that the child's failure to find the bear in retrieval one was not due to memory error but instead inability to achieve dual representation. Again, if the initial searches were unsuccessful, then the child was prompted by clues to find the toy but only the first searched was scored. After completing both tasks the child was given a hand stamp and a certificate of appreciation.

Results

Preliminary Analyses

DCCS: Consistent with previous studies, there was a non-normal distribution in pre-and-post switch distribution. Fifty-three percent of children (eight 30-month-olds, nine 36-month-olds, fourteen 42-month-olds) sorted all eight cards correctly in pre-switch phase and 61% sorted either all cards correctly (three 30-month-olds, five 36-month-olds, eight 42-month-olds) or incorrectly (six 30-month-olds, seven 36-month-olds, six 42-month-olds) in post-switch phase (see Figure 2). Remaining participants sorted between one and seven cards correctly. Participants were then categorized as either passing or failing both phases. Passing required a correct sort in six of eight consecutive trials. Hesitations in both sorting dimensions were examined. On average, children did not hesitate for even a single card in sorting dimension one ($M = .51$, $SD = 1.24$) or sorting dimension two ($M = .75$, $SD = 1.18$). This provides evidence that children felt confident in their knowledge of the rules for each sorting dimension.

Sixteen additional participants (seven 30-month-olds, five 36-month-olds, four 42-month-olds) were excluded for failure to successfully sort six of eight cards in pre-switch (leaving an n of 36) (see Table 1). Children are excluded for failing the pre-switch phase because this initial failure may be an indicator that they are not attending to the first dimension of the card and thus cannot "switch" to a new dimension. Interestingly, 14 (six females, nine males) of these 16 children were assigned to sort by color in pre-switch, $\chi 2(1) = 14.96$, $p < .001$. A two (sex: male, female) x two (cognitive flexibility: switchers, perseverators) chi-square was performed to assess sex differences in switching ability. No sex differences were found, $\chi 2(1) = .419$, $p = .67$.

Scale model task: Consistent with previous studies, children found a hidden bear in 39% ($M = 1.55$) of trials in retrieval one (i.e., finding a bear in this large referent room) and 80% ($M = 3.19$) of trials for retrieval two (i.e., finding a bear in this scale model) (see Tables 2 and 3). These results suggest that children's difficulty finding the bear in retrieval one was not a result of poor memory of the hiding location but rather is a result of difficulty achieving dual representation. A t-test between sex of participant (male, female) and percent of errorless retrievals in the scale model retrieval one was performed to assess for sex differences. No sex differences were found, $t(34) = .90$, $p = .43$.

Main Analysis

Approximately twice as many participants perseverated in the DCCS than switched within each age group. Thus, analyses comparing perseverators to switchers would suffer from unequal sample sizes (Howell, 2009). Before excluding for performance in DCCS (e.g., failure to pass pre- or post-switch), however, there were approximately equal sample sizes within each age group (15, 18, and 20 for 30-, 36-, and 42-month-olds, respectively). A main effect of age on performance in the scale model task was examined again using a one-way ANOVA with age (30, 36, 42) as an independent variable and percent of errorless retrievals as a dependent variable. From this there was a significant main effect for age such that 42-month-olds had the highest percent of errorless retrievals ($M = .58$, $SD = .36$) and 30-month-olds had the lowest percentage of errorless retrievals (M = .17, SD = .22), F (2, 52) = 7.825, p = .001. These results are presented in Figure 4.

To account for unequal sample size, a random selection of an equal number of participants who perseverated was matched to those who switched (leaving a final n of 22). This was done within each age group (see Table 1). A 2 (cognitive flexibility: switchers, perseverators) x 3(age: 30, 36, 42 months) ANOVA with percent of errorless retrievals as a dependent variable was then conducted. It was expected that these factors would interact such that perseverative young children would have the lowest number of errorless retrievals. There were no significant main effects for either cognitive flexibility, F(1, 21) = .58, p > .10 or age, F(2, 21) = 4.617, p = .14. There was also no interaction between cognitive flexibility and age, F(2, 21) = .481, p = .63. These results are presented in Figure 3. Again, there were no significant main effects for either cognitive flexibility, F(1,18) = .111, p = .77 or age, F(2,18) = 2.78, p = .15. There was also no interaction between cognitive flexibility and age, F(2, 18) = .828, p = .38. Results were similar when using all age groups and unequal group sizes, F(2, 35) = .291, p = .83.

Exploratory Analyses

As previously mentioned, several researchers have found that children make perseverative errors in the scale model task. That is, these children often search for the hidden bear in a location where it was previously hidden. To examine the relation between cognitive flexibility and these perseverative searches, a t-test with cognitive flexibility (switchers, perseverators) as an independent variable and number of perseverative searches in the scale model task as a dependent variable was performed. Although perseverators (M = 1.42, SD = 1.23) had more perseverative searches than did switchers (M = .82, SD = .98), this comparison

Table 2

Percent of errorless retrievals in retrieval one of scale model task (n = 53)

Percent errorless retrievals			Sex		Total
			Male	Female	
0%	Age	2.5	5	4	9
		3.0	2	2	4
		3.5	0	3	3
	Total	7	9	16	
25%	Age	2.5	0	2	2
		3.0	4	2	6
		3.5	0	4	4
	Total	4	8	12	
50%	Age	2.5	1	3	4
		3.0	3	2	5
		3.5	0	2	2
	Total	4	7	11	
75%	Age	2.5	0	0	0
		3.0	1	1	2
		3.5	3	3	6
	Total	4	4	8	
100%	Age	2.5	0	0	0
		3.0	1	0	1
		3.5	3	2	5
	Total	4	2	6	

Table 3

Percent of errorless retrievals in retrieval two of scale model task (n = 53)

Percent of errorless retrievals			Sex		Total
			Male	Female	
0%	Age	2.5			-
		3.0			-
		3.5			-
	Total				-
25%	Age	2.5	2	0	2
		3.0	0	3	3
		3.5	0	0	0
	Total		2	3	5
50%	Age	2.5	1	3	4
		3.0	0	0	0
		3.5	0	2	2
	Total	1	5	6	
75%	Age	2.5	1	2	3
		3.0	4	1	5
		3.5	3	5	8
	Total	8	8	16	
100%	Age	2.5	2	4	6
		3.0	7	3	10
		3.5	3	7	10
	Total	12	14	26	

was not significant, $t(35) = 1.467$, $p = .70$. There were no differences when examining perseverative searches when defined as a search to any previous hiding location (i.e., not necessary the immediately previous location), $t(35) = .09$, $p = .10$. These results are displayed in Figure 5.

Discussion

Although there was a significant main effect for age when using a larger subset of this sample, this main effect was no longer significant using a smaller subset. In addition, there was no main effect of cognitive flexibility and no interaction between the two factors. One plausible explanation for these findings is the nature of the DCCS task. This task was chosen because it is an established measure that was age appropriate for a majority of this sample. Although the DCCS is typically used with children 36 months and older, it has been used with children as young as 30 months (Zelazo, 2006). In the current sample, participants were as young as 29 months. Of these younger children, 26% required additional training cards (recall that children are allowed up to 2 additional cards per dimension if they do not appear to understand the rules of the games) and only 53% passed pre-switch. This is evidence that these young children may have had difficulty understanding the experimenter's instructions of the game even prior to post-switch. This lack of an interaction between age and cognitive flexibility is potentially a reflection of the age of the current sample.

Another potential explanation for these findings is the difference in our referent room (i.e., large hiding space) compared to previous referent rooms. The referent room in this study was a working laboratory with many objects whereas other researchers have used smaller rooms with few objects (e.g., only those necessary for the task). With this difference one might expect percentage of errorless retrievals in this study to be lower than in other studies but this is not the case. In this study, the percentage of errorless retrievals for the referent room (retrieval one) and scale model (retr-ieval two) were similar to those of previous researchers (DeLoache, 2000, 1987). Future research should aim to explore these described plausible explanations.

Other limitations in this study provide opportunities for areas of future investigation. First, the cross-sectional nature of variables in this study precludes making causal statements about cognitive flexibility and dual representation. Although cognitive flexibility cannot be manipulated directly, indirect manipulation could be attempted through use of scaffolding to "teach" one group of children to switch dimensions (and provide no additional instruction to a control group) in a cognitive flexibility task and test if they apply this knowledge to the task of using a symbol.

Second, future studies should aim to resolve issues in this study pertaining to age. Because the DCCS is ideally used with children at least 36 months of age, researchers could use a symbol that is of similar difficulty for children of this age. Previous researchers have found that scale models with little relational similarity to their referent room and maps are more difficult for children at 36 months (Marzolf, DeLoache, & Kolstad, 1999). Alternatively, researchers could use a standard scale model and an easier task of cognitive flexibility. Previous researchers, for example, have used tasks of response shifting (e.g., A-not-B task) with children as young as 24 months (Smith, Thelen, Titzer, & McLin, 1999).

Finally, future research should explore explanations for the finding that most of the children in this study assigned to first sort by color began to sort by shape. This is most intriguing given the fact that these children were never previously asked to sort these cards by shape and that they were able to identify rules of the "color" game when queried. Although previous researchers also excluded participants who fail pre-switch from analyses, these researchers fail to report which sorting dimension they were first assigned and thus may have found similar patterns (Brace et al., 2006; Munakata & Yerys, 2001). A potential explanation for this behavior comes from the literature on "shape bias." A shape bias refers to children's preference for attending to shape rather than other properties (e.g., color, texture) of an object (e.g., Disendruck & Bloom, 2003). Shape is generally a reliable cue for category membership because shape varies more across objects than within objects (i.e., fish are shaped similar to other fish and different than other animals). Findings of a shape bias in the DCCS is particularly interesting because children were given explicit instructions on how to match the "target object" (i.e., sorting card) and even when told to sort by color, 14 of 16 children sorted by shape. Shape bias in a DCCS task is important in that it shows the potential strength of this bias. That is, the bias seems to direct attention even against direct instruction otherwise.

Overall, data from this study did not support hypotheses that individual differences in cognitive flexibility are related to achieving dual representation. Because sample size was lowered substantially after each exclusion criteria, complexity of and power in statistical analyses was limited. Future studies should investigate a potential shape bias in DCCS, age appropriate tasks, a pseudo manipulation of cognitive flexibility, and a less complex referent room.

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