PERSEVERATORS ARE "STUCK" ON A CONCRETE DIMENSION: INDIVIDUAL DIFFERENCES IN ACHIEVING DUAL REPRESENTATION

by

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(Under the Direction of Janet E. Frick)

ABSTRACT

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 we explore individual differences in cognitive flexibility as they relate to achieving dual representation. Participants (children at 2.5, 3.0 and 3.5 years) 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 (i.e., switchers) would perform better on a task of dual representation than would children with poor cognitive flexibility (i.e., perseverators). Although our predictions were not supported, findings from our data warrant future investigations on this topic. Limitations and future directions are discussed.

INDEX WORDS: Child development, Cognitive development, Dual representation, Cognitive Flexibility

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B.S., University of North Florida, 2007

A Thesis Submitted the Graduate Faculty at the University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

Athens, Georgia
2010

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May 2010

DEDICATION

This thesis is dedicated to my friends, family, and mentors – all of whom have provided me invaluable support through this difficult process. I am confident that I could never have done this without you.

ACKNOWLEDGEMENTS

I would like to acknowledge my major professor, Janet Frick, for her guidance, the UGA Infant Research Lab members for their support and hard work, and most of all the families that donated their time to participate in this study.

TABLE OF CONTENTS

Introduction

Adults understand that a building on a map represents an actual building in space. Young children, on the other hand, may not understand this relationship. Adults can use a map for directions because the map is perceived as a symbol for actual terrain. This representation is what defines a symbol's function. Symbols function as tools to help us give meaning to the world around us; adults understand and regularly use them with ease. Young children, however, don't always understand and use symbols with such ease. Children's ability to use different types of symbols develops quickly between 2.5 and 3 years of age. In this paper we will address individual differences in children's ability to understand and use symbols.

Symbols

A symbol can be defined, broadly, as anything that is intended to represent some other thing (DeLoache, 2004). Success in using symbols is dependent on both individual and social factors (see DeLoache, 2002a for a review). On a basic level, to succeed in using symbols individuals must a) understand that there is a symbolic relationship between a symbol and an analogous object (i.e., representational insight), b) match similarities between a symbol and an analogous object (i.e., mapping), and c) 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 using a scale model task (see Uttal, Liu, & DeLoache, 2006; DeLoache, 1987). 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 (i.e., percent of errorless retrievals). 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 symbolic 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 representational insight (and in turn use symbols) with some symbols and not others, researchers believe the nature of a symbol is important.

When using a scale model as a symbol, children at 30 months of age have great difficulty achieving representational insight whereas children at 36 months of age have little difficulty achieving representational insight (DeLoache, 1987, 1989, 2000). In contrast, when using a photograph as a symbol, children at 30 months of age have little difficulty achieving representational insight. These representations 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 decreasing the physical salience of a symbol) 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 increasing the physical salience of a symbol), children had great difficulty achieving representational insight (e.g., DeLoache, 2000). Individuals are better able to use an object as a symbol when that object’s primary purpose is symbolic (i.e., that symbol has a dominant abstract dimension). Children find it harder to achieve dual representation with symbols that have a dominant concrete dimension (e.g., a scale model) as opposed to a dominant abstract dimension (e.g., a photograph).

One explanation for why children might have difficulty using objects with dominant concrete dimensions as symbols is because they must a) perceive multiple dimensions of a single object and b) switch their attention from the concrete dimension of that object to the symbolic dimension of that object. When presented with a scale model, presumably children initially attend to a concrete dimension of that model (i.e., perceive it as a toy and are not attentive to its abstract properties). When explicitly informed of a relationship between that model and a referent room, children must switch their attention to an abstract dimension of that model. Similarly, when presented with a photograph, presumably children initially attend to an abstract dimension of that photograph (i.e., perceive it as a representation of some other object and are not attentive to its concrete properties). In an experiment where children's attention was shifted toward a concrete dimension of a photograph, children had great difficulty later using that photograph as symbol (Deloache, 1991, Experiment 1).

Young children may have difficulty achieving dual representation with representational objects that have dominant concrete dimensions because they either a) cannot perceive both a concrete and abstract dimension of that object or b) cannot switch their attention from a concrete to an abstract dimension of that object. If the former is true, then we would not expect children to be able to use representational objects in any situation. From previous work, however, we know 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). Even children as young as 2.5 years are able to succeed using a scale model when the physical salience of that model is reduced

(DeLoache, 2000). From this we can infer that young children can perceive both a concrete and abstract dimension of a representational object. Looking at the latter possibility (i.e., that dual representation is difficult to achieve because of difficulties with attention switching), we would expect children who have difficulty switching or inhibiting attention to have difficulty achieving dual representation. This hypothesis requires an examination of the cognitive flexibility literature.

Cognitive flexibility is the ability to switch between or within tasks (i.e., to toggle attention and/or behavior between multiple tasks or between multiple elements of a single task). This flexibility is believed to involve 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. 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 (i.e., 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 (2002a) concluded that perseverative search errors are a mere consequence and not cause of children's inability to achieve dual representation. Although *perseverative searches* may not be a preventing factor in achieving dual representation, *perseverative thinkin*" 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 in Dimensional Change Cart Sort task (i.e., "perseverators"; task explained further below), children who are able to switch (i.e., "switchers") are better able to think abstractly by making categorizations (Kharitonova, Chien, Colunga, & Munakata, 2009). In this paper we explore the possibility that difficulty achieving dual representation may be a function of poor cognitive flexibility. Next, we will explore some of the most prominent explanations for perseverative behavior (and perhaps explanations to be extended to difficulty achieving dual representation) which include a selective attention account (e.g., Kirkham & Diamond, 2003), a working memory account (e.g., Morton & Munakata, 2002), and a rule based account (e.g., Zelazo, Frye, & Rapus, 1996).

Selective attention account

Selective attention is a self-guided component of attention. It can be defined as an individual's ability to engage, disengage, and shift focus from a stimulus. Selective attention develops throughout childhood such that compared to younger children, older children are better able to ignore task-irrelevant stimuli (see Bjorkland & Harnishfeger, 1990; Ruff & Cappozzoli, 2003). Selective attention requires individuals to a) focus their attention on one stimulus while ignoring irrelevant stimuli (e.g., attempting to drive while passing a car accident) or b) focus on a single dimension of a stimulus while ignoring other dimensions of that same stimulus (e.g., perceiving a blue car as only a car and ignoring its color properties). Perseveration occurs when individuals become fixated and have difficulty switching their attention (Ruff & Cappozzoli, 2003). This pull to continue focus on a single object or single dimension of an object is known as attentional inertia (Kirkham et al., 2003; Anderson, Heywon, & Lorch, 1987)

In the Dimensional Change Card Sort task, a standard task used to measure cognitive flexibility (DCCS; Frye, Zelazo, & Pelfai, 1995), children are presented with two model cards (e.g., blue truck, red bird). 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 (i.e., sorted cards are placed in trays face up instead of face down making it harder for children to focus on the current relevant dimension), children perform poorly. Interestingly, children at 3 years 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) or when children 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, & Rosnan, 2003). These findings support the idea that perceiving multiple dimensions of a single object is difficult for young children.

Based on this account, we would expect children to have difficulty achieving dual representation if they children have difficulty engaging in selective attention. To achieve dual representation children must attend to an abstract dimension of an object while ignoring a concrete dimension of that same object. Because we expect young children initially to attend to a concrete dimension of a symbol, these children would have difficulty attending to an abstract dimension of a symbol because of an attentional "pull" toward a concrete dimension. Perseveration (or in this case, difficulty achieving dual representation) may occur as a result of a child having difficulty switching their attention from a concrete dimension of a symbol to an abstract dimension of that symbol.

Working memory account

The active-latent representation account (Morton et al., 2002) is based on the premise that two memory systems (i.e., active memory system and latent memory system) compete during task switching. A latent memory system codes stimulus-specific information (e.g., detecting shape) and builds up 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., Kharitonova, Chien, Colunga, & Munakata, 2009; Brace, Morton, & Munakata, 2006). A repeated active representation will lead to a latent representation such that a weak active representation will lead to a weak latent representation and a strong active representation will lead to a strong latent representation (Yerys & Munakata, 2006). During competition between these systems (i.e., task switching), perseveration occurs when a latent memory system is strong and switching occurs when an active memory system is strong.

Researchers have found support for this account through neural models (e.g., Morton et al., 2002) and through variations of the DCCS (Brace et al., 2006). Brace and colleagues (2006) found that when given behavioral guidance (e.g., scaffolding correct post-switch behaviors), children are able to switch rule dimensions. The proposed explanation for these findings is that scaffolding allows children to build latent memories for the new sorting rule (as opposed to relying on weak active memories for a new sorting rule).

Based on this account, we would expect young children to have difficulty achieving dual representation (i.e., similar to a perseveration) if these children have weak active representations (e.g., attending to an abstract dimension) and strong latent representations (e.g., attending to a concrete dimension) for a symbol. Given the relatively later development of symbolic understanding, we expect young children initially to attend to concrete dimensions of symbols and in turn develop latent representations for symbols. Perseveration (or, in this case, difficulty achieving dual representation) may occur as a result of a child having little experience attending to abstract dimensions of other symbols (e.g., not understanding a representational nature of objects in general). Other researchers have found that experience with symbols (e.g., photographs) aids in the achievement of dual representation (e.g., DeLoache, Simcock, & Marzolf, 2004; DeLoache, 2002; Marzolf & DeLoache, 1994).

Cognitive complexity and control account

The cognitive complexity and control account (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, Frye, & Rapus, 1996). Complexity in this account 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.

Based on this account, we would expect young children to have difficulty achieving dual representation (i.e., similar to a perseveration) if these children cannot create complex rule systems (i.e., this model is a concrete object unless I am asked to use it as a representation in which case this model is an abstract object) for this task symbol. Given the relatively later development of symbolic understanding, we expect young children to only have a basic rule for understanding a model (i.e., this model is a concrete object). Perseveration (or, in this case, difficulty achieving dual representation) may occur as a result of a child having simple, rather than complex, rule systems for understanding symbols.

Each of these accounts provides a framework for explaining perseverative behavior which we believe extends to explaining difficulty achieving dual representation. That is, we believe that individual differences in children's cognitive flexibility (or inflexibility) may predict their ability to achieve dual representation. Based on the idea that cognitive flexibility is an important factor in children's ability to achieve dual representation, we formed the following hypotheses. First, compared to children with good cognitive flexibility, children with poor cognitive flexibility will have more difficulty achieving dual representation. Thus, children who are able to switch sorting dimensions (i.e., "switchers") will have a higher percentage of errorless retrievals than will children who are unable to switch sorting dimensions (i.e., "perseverators") in a scale model task. Second, compared to older children, younger children will have more difficulty achieving dual representation. Thus, children at 3.5 years will have the highest percentage and children at 2.5 years will have the lowest percentage of errorless retrievals in a scale model task. Third, these constructs will interact such that young children with poor cognitive flexibility will have the most difficulty achieving dual representation. Thus, children at 2.5 years who perseverate will have the lowest percentage of errorless retrievals in a scale model task as compared to any other condition. We expect no significant differences in percentage of errorless retrievals among the remaining conditions (i.e., 3 year old children who perseverate; 3.5 year old children who perseverate; 2.5 year old children who switch; 3 year old children who switch; 3.5 year old children who switch).

Method

Participants

A total of 65 children were recruited through public birth announcements. Participants included 23 (11 male, 12 female) 2.5-year-olds (29 – 32 months, *M* = 30.2), 21 (13 male, 8 female) 3.0-year-olds (35 – 37 months, *M* = 36.3), and 21 (7 male, 14 female) 3.5-year-olds (41 – 44 months, *M* = 42.3). Most of these children were Caucasian and only one of these children experienced visual (i.e., corrected vision) or auditory difficulties. Twelve (eight 2.5-year-olds, three 3.0-year-olds, one 3.5 year-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. Children completed two tasks: Dimensional Change Card Sort (DCCS; Frye et al., 1995) and standard procedure Scale Model task (DeLoache, 1987). 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. Coding of behaviors was unseen by children during an experiment.

Materials

DCCS. 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.

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

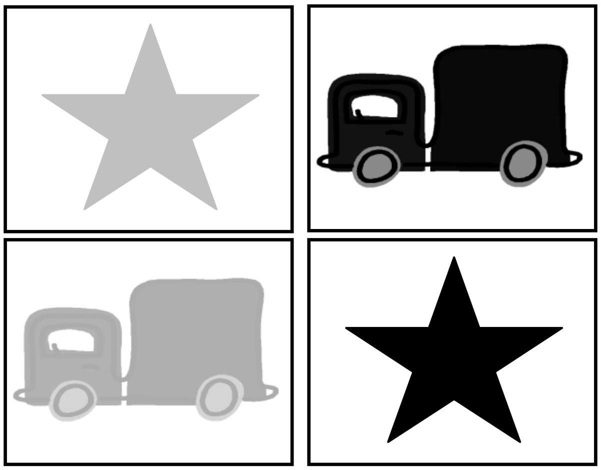

Figure 1. Stimuli used for sorting cards. Model cards (above) included a green truck and a blue star. Sorting cards (below) included a blue truck and a green star.

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. This phase of the study took place in two separate but adjacent rooms. The referent room was a laboratory work room 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 (4cm high). The toys were identified as “big Max” and “little Max,” respectively.

Procedure

DCCS. This procedure closely follows that of Diamond, Carlson, and Beck (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 game[1]. 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 identity 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 (previous

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[1] Conditions were counterbalanced such that half of the children sorted by color first and half of the children sorted by shape first. This was maintained across age and sex. For purposes of this paper we will only describe procedures when color was tested first. In this sample, inconsistent with previous samples, we found a significant effect for order of dimension, $\chi^2(1) = 14.96$, $p < .001$. Potential explanations for this are discussed.

researchers found differences when sorting cards remained face-up). 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. 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 explained 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 hand. While still holding a card, children could change their mind. Hesitations were noted and used in descriptive analyses. 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 two stuffed bears and expressed that the bears like to do the same things (e.g., "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 (e.g., "This is big Max's room and this is little Max's room. They look exactly the same.") and labeled five major objects in each space. The experimenter then completed one or two imitation and practice trials to ensure the child understood directions. She placed the small toy on a desk in the scale model and asked the child to put the large toy in the same place in the referent room. She then hid the small toy in a location within the scale model that would not be used for experimental trials and asked a child to find the large toy 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 trials[2]. Similar to previous studies (e.g., DeLoache, 2000), the experimental trials included three events: hiding event, retrieval one,

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[2] In previous studies, conditions are counterbalanced such that half of the children view a toy being hidden in a scale model. Because there are rarely significant differences in these conditions, all children in this study saw the toy being hidden in the scale model. Conditions were counterbalanced, however, such that half of the children viewed the toy being hidden in one order and half of the children viewed the toy being hidden in the reverse order.

retrieval two. Hiding event: While the child was watching, the experimenter hid the small toy in the scale model (e.g., “Little Max is hiding here.”). She then hid the large toy 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. Retrieval one: The child was then prompted to find the large toy. For each trial, a second researcher 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. After an initial search, the child was prompted by clues to find the toy. Only the first searched location was scored. Retrieval two: The child was then asked to find the small toy in the scale model. Success in retrieval two indicated that the child’s failure to find the toy in retrieval one was not due to memory error. After completing both tasks the child was given a hand stamp and a certificate of appreciation.

Results

DCCS

Consistent with previous studies, we found a non-normal distribution in our pre-and-post switch distribution. We found that 53% of children sorted all eight cards correctly in pre-switch phase and 61% sorted either all cards correctly or incorrectly in post-switch phase (see figure 2). Participants were then categorized as either passing or failing both phases. Passing required a correct sort in six of eight consecutive trials. We looked at hesitations in both sorting dimensions. We found that, 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). From this we propose that children felt confident in their knowledge of the rules for each sorting dimension.

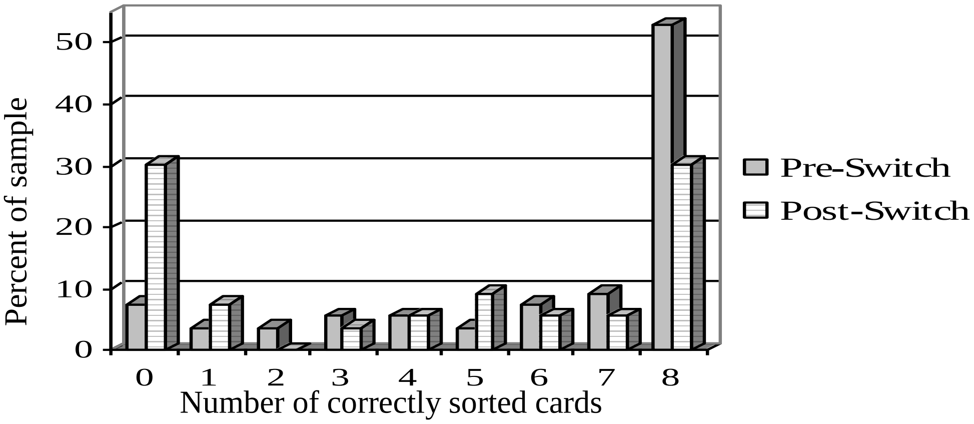

Figure 2. Distribution of correct sorts in pre-and post-switch (n = 53). Based on the distribution, participants were classified as passing or failing pre- and post-switch.

We excluded 16 additional participants (seven 2.5-year-olds, five 3.0-year-olds, four 3.5-year-olds) for failure to successfully sort six of eight cards in pre-switch (leaving an *n* of 36) (see table 1). Interestingly, 14 of these 16 children were assigned to sort by color in pre-switch, $\chi^2(1) = 14.96$, $p < .001$. This result is unique from previous findings (e.g., Munakata & Yerys, 2001; Diamond et al., 2005; Brace et al., 2006) and warrants future investigation.

We did not expect sex differences in performance on the DCCS. To test this we performed a 2 (sex: male, female) x 2 (cognitive flexibility: switchers, perseverators) chi-square. We found no sex differences in cognitive flexibility, $\chi^2(1) = .419$, $p > .10$.

Scale model task

Consistent with previous studies, we found that children found a hidden toy in 39% ($M = 1.55$) of trials in retrieval one (i.e., finding a toy in our large referent room) and 80% ($M = 3.19$) of trials for retrieval two (i.e., finding a toy in our scale model) (see tables 2 and 3). We interpret these results to mean that children’s difficulty achieving dual representation was not a result of poor memory of the hiding location.

Although some researchers have found sex differences in achieving dual representation (e.g., Marzolf & DeLoache, 1994 exp 3; Marzolf, DeLoache, 1999 exp 2), most have not and we did not expect sex differences in our task of dual representation. To test this we performed a *t*-test between sex of participant (male, female) and percent of errorless retrievals in the scale model retrieval one. We found no sex differences in achievement of dual representation, $t(34) = .90$, $p > .10$.

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

Main analysis

We found that 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. To account for this, we randomly selected an equal number of participants who perseverated to match those who switched (leaving a final *n* of 22). This was done within each age group (see table 1).

To test our predictions, we performed a two (cognitive flexibility: switchers, perseverators) by three (age: 2.5, 3, 3.5 years) ANOVA with percent of errorless retrievals as our dependent variable. We expected that these constructs (i.e., cognitive flexibility, age) would interact such that young children with poor cognitive flexibility would have the most difficulty achieving dual representation. We did not find significant main effects for cognitive flexibility, $F(1, 21) = .495$, $p > .10$; age, $F(2, 21) = 4.617$, $p > .10$; or an interaction between cognitive flexibility and age, $F(2, 21) = .481$, $p > .10$. These results are presented in figure 3. We also performed this analysis after excluding 2.5-year-olds (after selection for equal groups, only two 2.5-year-olds remained: one switcher, one perseverator). We again did not find significant main effects for cognitive flexibility, $F(1,18) = .111$, $p > .10$; age, $F(2,18) = 2.78$, $p > .10$; or an interaction between cognitive flexibility and age, $F(2, 18) = .828$, $p > .10$. We found similar results using all age groups and unequal group sizes, $F(2, 35) = .291$, $p > .10$.

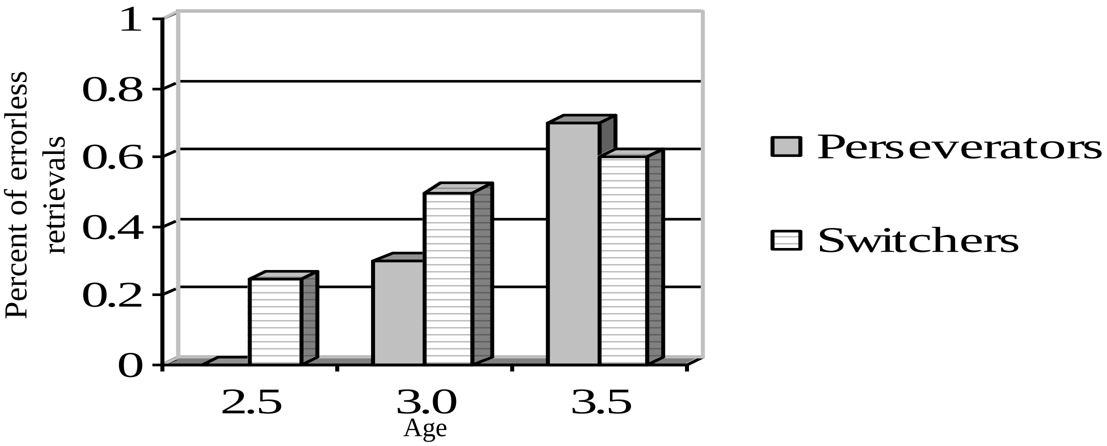

Figure 3. Results of Two-way Analysis of Variance. Percent of errorless retrievals by age and cognitive flexibility. Contrary to our predictions, we did not find a significant interaction between age and cognitive flexibility in regards to percent of errorless retrievals, $F(2, 21) = .481$, $p > .10$

Our sample was ultimately low because of our participants' performance in the DCCS. Before excluding for performance in DCCS (e.g., failure to pass pre- or post-switch), however, we had roughly equal sample sizes within each age group (15, 18, and 20 for 2.5, 3.0, and 3.5 year-olds, respectively). We tested the main effect of age on performance in the scale model task again using a One-way ANOVA with age (2.5, 3.0, 3.5) as a predictor variable and percent of errorless retrievals as a criterion variable. From this we found a significant main effect for age such that 3.5-year-olds had the highest percent of errorless retrievals (*M* = .58, *SD* = .36) and 2.5-year-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.

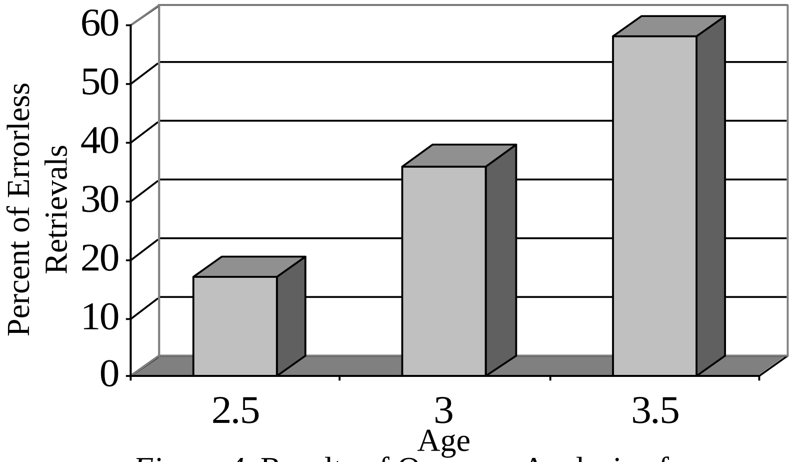

Figure 4. Results of One-way Analysis of Variance. Using a larger sample subset, we found a main effect of age in percent of errorless retrievals, *F* (2,52) = 7.825, *p* = .001.

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 toy in a previously hidden location. To look at the relationship between cognitive flexibility and these perseverative searches we performed a *t*-test with cognitive flexibility (switchers, perseverators) as a predictor variable and number of perseverative searches in the scale model task (i.e., searches to the immediately previous location) as a criterion variable. Although perseverators (*M* = 1.42, *SD* = 1.23) had more perseverative searches than did switchers (*M* = .82, *SD* = .98), this comparison was not significant, *t*(35) = 1.467, *p* > .10. We also did not find any differences when looking at perseverative searches when defined as a search to any previously hiding location (i.e., not necessary the immediately previous location), *t*(35) = .09, *p* > .10. These results are displayed in figure 5.

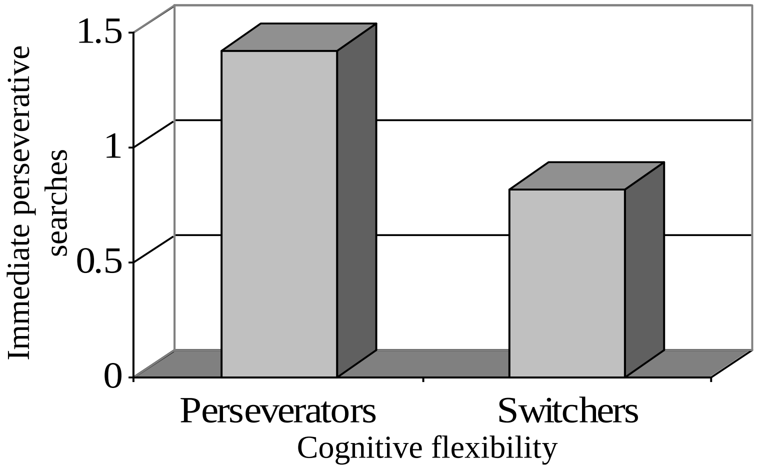

Figure 5. Cognitive Flexibility and Perseverative Searches Perseverators and switchers did not significantly differ in their number of perseverative searches in a scale model task, *t*(35) = 1.467, *p* > .10

Discussion

Although we found some unique findings and some trends in an expected direction, we did not find support for main our hypotheses. Although we did find a main effect for age when using a larger subset of our sample, this main effect was no longer significant using a smaller subset. In addition, we did not find a main effect of cognitive flexibility. Because switchers did have more errorless retrievals than perseverators in two of the three age groups, it is quite possible that a larger sample size would reveal a stronger relationship.

It is also possible that we did not find an effect for cognitive flexibility because of the nature of the task. The DCCS is typically used with children 36 months and older. In our sample, we used children as young as 29 months. Of these younger children, 26% required additional training cards (recall 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. We expect that our lack of an interaction between age and cognitive flexibility is a reflection primarily on the low sample size and age of our sample.

Another potential explanation for our findings is the difference in our referent room (i.e., large hiding space) compared to previous referent rooms. Our referent 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 we might expect our percentages of errorless retrievals to be lower than other researchers but this in not the case. In this study we found that the percentage of errorless retrievals for the referent room (retrieval one) and scale model (retrieval two) were similar to those of previous researchers (see DeLoache, 1987; 2000).

Based on our limited findings, it is difficult to find support for any of the previously discussed theories of perseverative behavior (i.e., Selective Attention, Working Memory, Cognitive Complexity and Control). When speculating, the working memory systems theory seems most plausible given the nature of children's previous experience with symbols. We expect that, in general, children have limited experience with scale models as symbols. If ever presented with a scale model, we would expect children to treat it as a toy. Therefore, when presented with a scale model in this study, our participants may have had a great deal of difficulty perceiving it as a symbol. In terms of a working memory system, this difficulty is consistent with the idea that children have a strong latent representation based on previous experience (i.e., perceiving the model as a toy) and a weak active representation based on the current task (i.e., perceiving the model as a symbol). This theory also includes a graded system of representation. Supporters of this theory believe, for example, that children are able to identify current rules of a task but are unable to behave according to those rules because representations for knowledge and behavior differ in strength. In a scale model task, it would be interesting to assess if children could verbalize their thoughts about the model. According to this theory, perhaps it would be easier for children to answer questions about the location of the large bear than to actually find that bear. There are several additional paths of inquiry for future studies that may help shed light on a relationship between cognitive flexibility and dual representation.

First, the correlational nature of our variables prevents us from making causal statements about cognitive flexibility and dual representation. Although we cannot manipulate cognitive flexibility directly, we could attempt an indirect manipulation. Specifically, we could use 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 using a symbol. Previous researchers have found that scaffolding in the DCCS (i.e., moving from pre- to post-switch incrementally through non-conflict cards as opposed to immediately through conflict cards) aids children in post-switch of the DCCS. Compared to our current correlational design, this experimental design would allow us to make more definitive conclusions about the relationship between cognitive flexibility and dual representation.

Second, future studies could look to resolve some of the age issues we had in this study. Because the DCCS is meant for kids at least three years of age, and really most efficient with children between four and six, researchers could use a more difficult symbol. Previous researchers have found that scale models with little relational similarity to their referent room (i.e., corresponding objects are not in the same place) and maps are more difficult for three-year-old children (the age at which children typically understand and use a scale model) (Marzolf et al., 1999). At the other end, researchers could use a scale model and a different task of cognitive flexibility. Previous researchers have used versions of the A-not-B task with children at 24 months to asses response shifting.

Third, future work in this area should look to add other variables for both discriminant and convergent validity. One variable to include for discriminant validity is a measure participant’s previous experience with symbols. As previously mentioned, experience with symbols aids with understanding and use of other symbols. That is, moving from symbols with which dual representation is easy to achieve to symbols with which dual representation is difficult to achieve. Other variables of interest are measures of basic mechanisms behind cognitive flexibility (e.g., inhibitory control, working memory, attention). We could get at these variables using more simple (e.g., less verbal interaction) measures (e.g., go-no-go, digit span) that may help isolate which aspect of cognitive flexibility aids in achieving dual representation.

Finally, another area to explore surrounds the potential “shape bias” we found in pre-switch performance. We found that of the 16 children who failed pre-switch, 14 were assigned to sort first by color. That is, these children assigned to first sort by color began to sort by shape despite the fact that we never previously asked them to sort these cards by shape and that they were able to identify rules of the “color” game when queried. Previous researchers also excluded participants who fail pre-switch from analyses but these researchers fail to report characteristics of these participants (e.g., to which sorting dimension they were first assigned) (Munakata & Yerys, 2001; Brace et al., 2006). 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. 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). This preference is exhibited when children generalize learned words to unfamiliar objects. A child, for example, may label all four-legged animals “dog” when he/she learns the name of a family pet. To assess this, children are asked to chose an target object’s match from of a group of other objects (each of which matches the target object on only one property – shape, color, or texture) (Diesendruck & Bloom, 2003). In these tasks, 3.0-year-old children are not explicitly told by which property to match and but reliably sort by shape. Our finding of 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. To further investigate the strength of this shape bias, we could manipulate the task and look at speed of processing. First, we could use unfamiliar shapes for model and sorting cards in a standard DCCS task. Because shape bias is supposed to aid children in learning names and categories of unfamiliar objects, we might expect stronger findings (e.g., more difficulty with pre-sort when assigned to sort first by color) with these stimuli. Second, we could investigate the presence of shape bias in adults by using a computerized DCCS task and looking at reaction time as a measure of speed in sorting.

Overall, our data did not support our idea that individual differences in cognitive flexibility are related to achieving dual representation. Our most limiting factor was sample size which was lowered substantially after each exclusion criteria. Future studies should include an exploration of 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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