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The Role of Representational Flexibility in Toddlers' Manual Search

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THE ROLE OF REPRESENTATIONAL FLEXIBILITY IN TODDLERS' MANUAL SEARCH

A Thesis Presented

by

LAUREN E. HARTSTEIN

Submitted to the Graduate School of the
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Psychology

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ABSTRACT

THE ROLE OF REPRESENTATIONAL FLEXIBILITY IN TODDLERS' MANUAL SEARCH

SEPTEMBER 2014

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In the model room task, children watch as a miniature toy is hidden somewhere in a scale model of a room and are asked to find the larger version of the toy in the corresponding place in the actual room. Previous work has shown that children under age three often perform very poorly on this task. One prominent theory for their failure is that they lack the ability to understand the model as both a physical object and as a symbolic representation of the larger room. An alternative hypothesis is that they need to overcome weak, competing representations of where the object was on a previous trial, and where it is in the present trial, in order to succeed in their search. Children aged 33-39 months were tested on measures of inhibitory control, cognitive flexibility, recognition memory, and receptive vocabulary, as well as the model room task. Results showed that performance on the model room task was not predicted by measures of inhibitory control, cognitive flexibility or vocabulary, but was predicted by performance on the Delayed Recognition Span Test (DRST), a measure of recognition memory. These findings lend support to the theory of competing representations. Given the predictive nature of the recognition memory task and the task's sensitivity to lesions in the hippocampus, implications for the development of the hippocampus and its role in success on the model room task are discussed.

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CHAPTER 1

INTRODUCTION

As we move through life, we regularly encounter objects and images that symbolize something else. As adults, we are very good at understanding things like maps and photographs as representations of the places and objects that they depict. Children, however, often struggle to comprehend the symbolic nature of certain objects. For instance, nine-month-old infants will grab at a photograph of an object as if it were the object itself (DeLoache, Pierroutsakos, Uttal, Rosengren, & Gottlieb, 1998).

To further investigate children's understanding of symbolic representation, DeLoache (1987) investigated the use of symbolic models in toddlers' search. In the model room task, children watched as a miniature toy was hidden in a scale model of a room and were then asked to find the larger version of the toy in the corresponding place in a larger room. Until about age three, children performed very poorly on the task. In a variation of the task, children watched the toy being hidden in the larger room and then were lead to believe that a "shrinking machine" had turned the room into the model (DeLoache, Miller, & Rosengren, 1997). When they believed that the model was actually the shrunken room, children's performance improved significantly.

DeLoache suggested that the poor performance seen in children under three on the model room task is due to an inability to form dual representations of the model. In order to successfully complete the task, she argued that participants needed to understand the model as both a physical object in front of them and also as a symbolic representation of the larger room. Troseth, Pickard, & DeLoache (2007) explored whether an observation of lower-level correspondences between the objects in the model and room were sufficient to succeed on the task. Before completing the search task, children were tested on their ability to match a piece of furniture in the model to its matching piece in the room. The results showed that some children who demonstrated an understanding of the correspondence between the objects in the two spaces still failed at the search task. The authors concluded that while an understanding of the correspondence between the hiding locations was necessary for success, it was not sufficient if they failed to appreciate the representative nature of the model.

Sharon and DeLoache (2003) reported that task performance drops off significantly after the first trial, with perseveration errors, where the child searches in the toy's previous location, being the most common error committed. Lack of dual representation can explain failure on the first trial, but cannot fully account for the drop in performance on subsequent trials. To examine the role of perseveration in task performance, Suddendorf (2003) prevented toddlers from perseverating in the model room task by having the child search for the toy in different rooms for each trial. When unable to perseverate, performance improved slightly to just above chance, with 53% of participants succeeding on the 2nd trial and 59% succeeding on the 3rd and 4th trials. O'Sullivan, Mitchell, & Daehler (2001) found no significant change in performance when the previous hiding location was removed from the room and model after each trial. Both papers concluded that preventing perseveration is not by itself sufficient for success on the task.

However, although perseveration could be seen as a failure to inhibit a motor response, Jacques, Zelazo, Kirkham, & Semcesen (1999) suggest that it can be a failure of representational flexibility. It may not be inhibition of a physical response, but the inhibition of a previous representation, that is driving performance. In the case of the model room task, the child needs to switch between their representations of where the target object was previously hidden and where it is currently hidden. Thus, even if the physical object used as the last hiding location is removed, the mental representation of that object may still be salient and distracting to the participant. In line with this idea, Schmidt, Crawley-Davis, & (2007) proposed that failure to locate the object in the model room task is due to conflicting, weak representations of the object's current and past locations and the inability to shift between them. While searching during the first trial, the child has only the memory of where the toy was just hidden in the model. However, on each subsequent trial, the child needs to be able to focus on the salient memory of the toy's current location in the model and tune out the competing memories of where the toy was previously hidden and where they previously searched. This increase in conflicting representations is demonstrated by the common drop in performance seen following the first trial. A lack of representational flexibility has been seen in children this age across a variety of cognitive tasks, such as the flanker task, Dimensional Change Card Sort (DCCS), and the door task. The current study investigates whether poor performance on the model room task is due to competing weak representations by exploring the correlation of toddlers' performance on the model room task with the development of inhibitory control, cognitive flexibility, and recognition memory.

In a study by Berthier, Boucher, & Weisner (submitted), three-year-olds' performance on the model room task was correlated with performance on the door task, a manual search task also conducive to perseverative errors (Berthier, DeBlois, Poirier, Novak, & Clifton, 2000). Baker, Gjersoe, Sibielska-Woch, Leslie, & Hood (2010) found that inhibitory control, as measured by a gift delay task, significantly predicts performance on the door task. The authors conclude that the development of inhibitory control helps explain improvement in manual search abilities at this age. As such, and given the relationship found between performance on the door and model room tasks, it follows that measures of inhibitory control could also predict performance on the model room task.

A commonly used measure of inhibitory control is the flanker task, originated by Eriksen & Eriksen (1974). In the flanker task, participants are asked to press a button corresponding to a target letter. The target letter is flanked by various noise letters, either compatible or incompatible with the target letter. The study found that reaction times were impaired by incompatible flanking letters. The participant's slower speed is attributed to the need to inhibit processing of the noise letters. Rueda, et al. (2004) developed a version of the Eriksen flanker task to measure attention in children. In their task, children must attend to the direction that an image of a fish is facing, while ignoring two fish on either side that are facing either the same way or opposite way as the target fish. The authors concluded that the task is a valid measurement of attention networks in children aged four and older. The task has also been successfully implemented with children as young as three (Zelazo, Anderson, Richler, Wallner-Allen, Beaumont, & Weintraub, 2013). If success on the model room task requires the ability to inhibit searching based on a previous representation of the object and focus attention on its current representation, then we expect that flanker task performance will predict performance on the model room.

The Dimensional Change Card Sort (DCCS), a task originated by Zelazo, Frye, & Rapus (1996), requires children to switch from sorting cards according to color to sorting them according to shape. Children three years of age and younger frequently perseverate, continuing to sort cards by the original dimension after the switch. Researchers commonly use the task as a measure of cognitive flexibility in children (Zelazo, et al., 2013). If poor performance on the model room task is explained by the inability to switch between conflicting representations of the object's location, then we hypothesize that performance on the DCCS will predict search abilities.

Since participants in the model room task need to remember the current hiding location in the model while they transition to the larger room, it is possible that working memory development would play a role in task performance. Following the search, participants are asked to retrieve the small toy from its location in the model as a memory check. Participants typically score highly on the memory check, independent of their ability to locate the larger toy (DeLoache, 1987). As such, it is not expected that poor performance is explained by a simple memory failure. However, it is not enough for participants to have a memory of the toy's hiding location. They need to be able to update their memory in order focus on the toy's current location, ignoring memories of where it was hidden previously. Therefore, in addition to the standard memory check following each trial, participants completed the Delayed Recognition Span Test (DRST) to explore influences of memory on task performance. In the DRST, the participant is asked to identify a novel image in an increasing set of images. Originally developed by Moss, Albert, Butters, and Payne (1986) to examine memory loss in patients with Alzheimer's disease, the DRST is used to study recognition memory. The task was also previously used successfully in children by Jenkins & Berthier (2014). Beason-Held, Rosene, Killiany, & Moss (1999) showed that the DRST is sensitive to hippocampal lesions in monkeys. Given that both the model room task and DRST require participants to update their representations with the presentation of each new item or trial and the hippocampus' role in place learning, we hypothesize that performance on the DRST will predict correct searches on the model room task.

Zelazo, et al. (2013) found that, for children aged 3-6 years, receptive vocabulary was strongly related to performance on the DCCS and flanker task. As such, we incorporated a Picture Vocabulary Task as a measure of receptive vocabulary in order to account for the possible relationship between receptive vocabulary and model room performance.

The present study investigated the abilities important for success on the model room task, beyond those of dual representation. While an understanding of the dual nature of the model is necessary for success on the task, the theory by itself does not sufficiently explain the pattern of performance, such as the significant drop off frequently seen between the first and second trials. This suggests that there are other important skills developing around this time that are necessary for success on the task. The present study explored how children's inhibitory control, cognitive flexibility, and working memory come together to allow them to search successfully. As such, it was expected that performance on the model room task would be related to performance on the flanker task, Dimensional Change Card Sort, and Delayed Recognition Span Test.

The current study has strengths beyond previous studies that examined the model room task. Previous instances of the task typically include only four trials. However, in the present study, participants completed eight trials, with the toy being hidden twice in each location. The present study also looked at data from 45 participants, much more than are frequently run in studies with the model room, allowing for a more complete picture of children's performance.

Lastly, the current study sought to place children's performance on the model room task into a broader developmental framework. Dual representation offers an explanation for performance seen on the task, but nothing in regards to what skills are developing to account for children's success. The current work explores how other important cognitive skills, such as attention, memory, and inhibitory control come into play. In this way, the present study offers a unique exploration of the development of representational abilities.

CHAPTER 2

METHODS

Participants

Forty-nine typically developing children were brought into the laboratory for a single experimental session lasting approximately one hour. Data was collected from 45 participants (20 female), as four participants were either unable to participate due to computer error or unwillingness. Participant age ranged from 33 to 39 months, with a mean of 36.2 months. Participants were contacted through e-mail and phone after being identified from state birth records. Children received a small toy as a token of appreciation for their participation.

Procedure

Early Childhood Behavior Questionnaire (ECBQ)

After the study was explained to parents and they signed the informed consent, they were asked to complete a shortened version of the Early Childhood Behavior Questionnaire (Putnam, S. P., Gartstein, M. A., & Rothbart, M. K., 2006). The full ECBQ contains 201 items, relating to 18 scales. As we were only interested in the scales measuring Attentional Focus, Attentional Shift, Impulsivity, and Inhibitory Control, parents were only given questions from those scales, shortening the questionnaire to 46 items.

Flanker Fish

Children were seated at a table in front of a 15-inch Planar PT1510MX touchscreen monitor. A 5cm button in a box was placed directly to the left of the touchscreen. When the child pressed the button, either one or five fish were displayed on the touchscreen with a hamburger depicted on either side (See Figure 1).

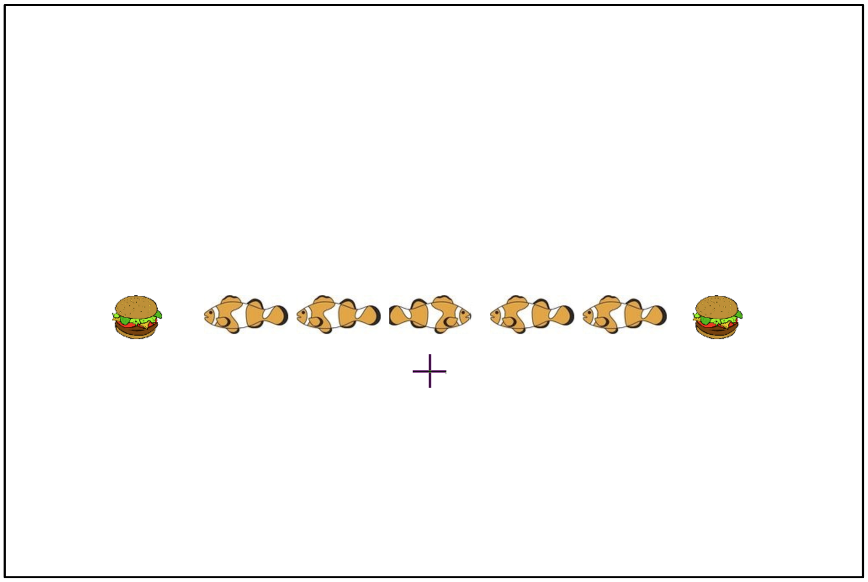

Figure 1: Screenshot of an incongruent trial in the flanker task.

The center of one fish was 3.5cm from the next. The child was seated approximately 40cm from the screen, creating a visual angle of 5 degrees between the centers of each fish. The hamburgers were situated 10cm from the center. In the five fish trials, the four fish flanking the middle fish were either facing the same direction (congruent) or the opposite direction (incongruent). The child was asked to press the button box, which began the trial and brought up the image of the fish. The child was told that they were going to help feed the fish by pressing the hamburger that the fish in the middle was facing and that they should only attend to the middle fish. During trials with one fish, the participant was asked, “Which hamburger does that fish want to eat?” During trials with five fish, both congruent and incongruent, the participant was asked, “Which hamburger does the middle fish want to eat?”

Following a brief practice, during which all trial types were presented, the child began the task. The task consisted of 24 trials presented in a semi-random order, with an equal number of each trial type. The percent of trials correct and reaction time for each trial were measured. Reaction time was measured as the time between when the child pressed the button box to when they pressed the touchscreen.

<u>Delayed Recognition Span Test (DRST)</u>

The apparatus and setup were identical to that used for the flanker task (above). The task procedure was taken from Jenkins and Berthier (2014). Children pressed a button that brought up a single image on the touchscreen. The child was directed to touch the picture, which then disappeared. A second button press brought up two images, the image that was displayed on the previous trial presented in a new location as well as a new image that was not seen in the previous trial. The child was directed to touch the new picture. If the child chose the correct image, then the next trial would consist of three images; the two that were displayed on the previous trials presented in new locations as well as a new image. The child would again be instructed to touch the new picture. The task continued, adding a new image each time the child chose correctly, for up to nine images (See Figure 2).

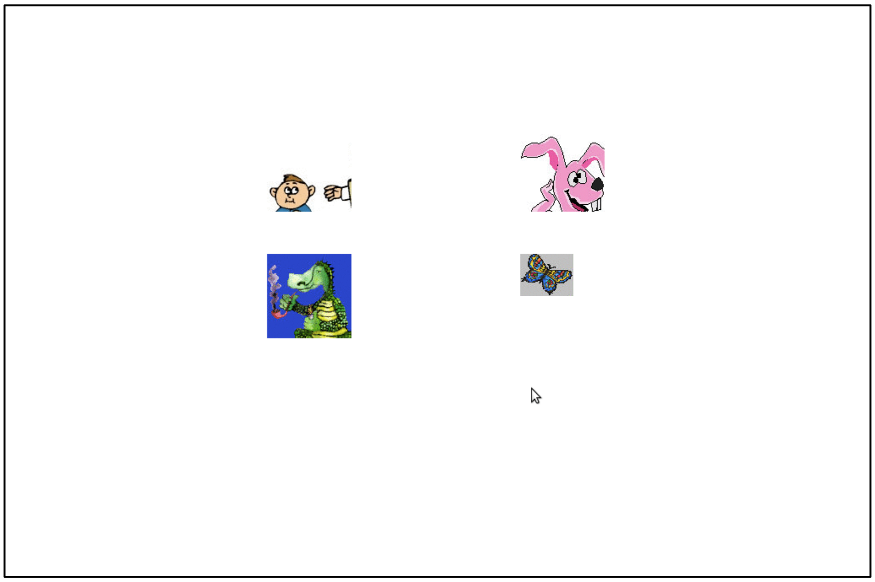

Figure 2: Screenshot of the Delayed Recognition Span Test (DRST)

The trial ended when the child made an incorrect choice or after he or she successfully chose through nine images. The task was then repeated twice, for a total of three trials. The number of images the child was able to remember was averaged across the three trials.

Dimensional Change Card Sort (DCCS)

All task components and instructions were taken from Zelazo (2006). Children were seated in front of a table with two square boxes, measuring approximately 14cm. One box was affixed with a picture of a blue rabbit and the other affixed with a picture of a red boat. Each card measured 3 inches by 4 inches. Children were told that they were going to play the “color game.” In the color game, they were shown cards depicting either a red rabbit or a blue boat. They were instructed to put the red pictures in the box depicting the red boat, and the blue pictures in the box with the picture of the blue rabbit. The experimenter walked the child through the first two cards and then the child was presented with six cards, one at a time, to sort on their own. As each card was presented, the experimenter provided the appropriate label (e.g. “Here is a blue card.”).

After the eighth card was sorted, the experimenter informed the child that they were no longer playing the color game, but were now going to play the “shape game.” In the shape game, cards with a picture of a boat go in the box with the boat and cards with a picture of a rabbit go in the box with the rabbit. The child then sorted six cards according to shape. Between each trial, the experimenter reminded the child to “remember, rabbits go here and boats go here”. As in the color trials, the cards were given the appropriate label when presented (e.g. “Here is a rabbit”.).

The task was scored as pass or fail for both the pre-switch and post-switch trials. The child was considered to have passed the group of trials if they made fewer than two sorting errors.

Picture Vocabulary Test

As a measure of receptive vocabulary, we administered the Picture Vocabulary Test, developed by NIH as part of the NIH Toolbox (Gershon, et al., 2013). The task is run through the NIH Toolbox website using Internet Explorer. The apparatus and setup were identical to that used in the flanker fish and DRST tasks. In the vocabulary task, the child was presented with an audio recording of a word and four images displayed on a touchscreen (See Figure 3).

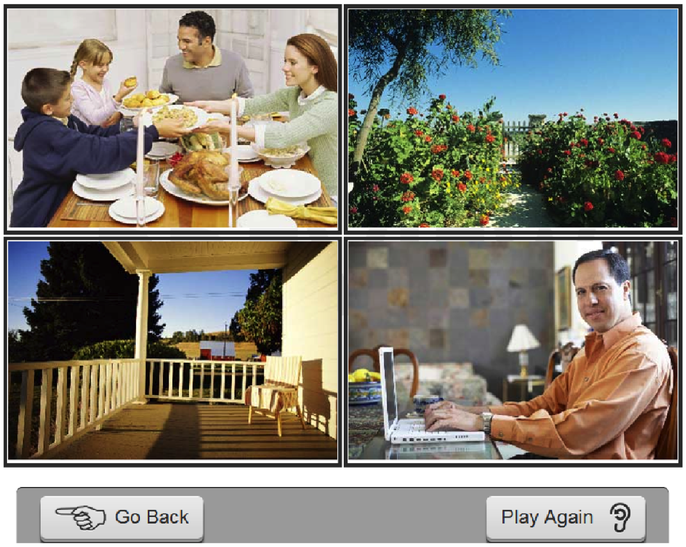

Figure 3: Screenshot from the Picture Vocabulary Test depicting the trial for “porch”.

The child was asked to touch the image that has the same meaning as the word that they heard (e.g. “Click on the picture of porch”). If they were unsure of the word’s meaning, they were encouraged to make their best guess. If the participant hesitated for more than a few seconds, the experimenter prompted them by repeating the word, without using an article so as not to give any indication of the correct image. The difficulty level of the words presented adjusted in accordance with the participant's performance. The task continued for 20-30 trials. Raw scores were provided by the NIH Toolbox software, as well as a computed score, scale score, age adjusted scale score, national percentile, and fully adjusted scale score. A Rasch Item Response model was used to compute an estimate of an individual's ability, known as "theta". A computed score was obtained by multiplying the "theta" by 100 and adding 1200.

Model Room Task

Consistent with DeLoache, Miller, and Rosengren (1997), all parts of the model were constructed to one-fourth scale. The model measured 60cm x 22cm x 41cm.
Children were introduced to "Little Bear" and "Big Bear", which were 7.5cm and 30cm respectively, and shown that they each have their own "house", consisting of a chair, bookcase, basket, and pillow (See Figures 4 & 5).

Figure 4: Model used in the model room task.

Figure 5: Room used in the model room task.

One by one, the experimenter showed the child that each piece of furniture in the model had a corresponding piece of furniture in the larger room. The child was then informed about a hiding game the two bears like to play. They were told that, in the hiding game, "Wherever Little Bear hides in his house, Big Bear hides in the same place in *his* house." To ensure that the child understood the correspondence between the two rooms, the experimenter then placed Little Bear on top of the chair in the model and asked the child to place Big Bear in the corresponding location in the full-scale room. Following the familiarization, the child watched as the experimenter hid Little Bear in the model and was then encouraged to find Big Bear, after being reminded that he's "hiding in the same place as Little Bear." The child was allowed two search attempts, after which the experimenter guided the child to the correct location. The child was then asked to show the hiding location of Little Bear in the model. The task continued for eight trials, with pseudo-random hiding locations. Given that there were four possible hiding spots in the model, participants saw Little Bear placed in each location twice. A participant's score was determined by the number of accurate first search attempts.

CHAPTER 3

RESULTS

Thirty-nine of 45 participants provided complete data. A computer error prevented one participant from completing the Picture Vocabulary test. The DRST was added to the procedure after data had already been collected from six participants. Table 1 shows the means and standard deviations for each task.

Table 1 – Means and Standard Deviations

	Units	N	MEAN	STANDARD DEVIATION
Flanker	Percent Correct Congruent - Percent Correct Incongruent	45	51.30	48.82
DRST	Average images correct out of 9	39	3.43	1.53
DCCS	Pass or Fail	45	.42	.50
Vocabulary	Computed Score from 200-2000	44	645.5	128.10
Model Room	Correct trials out of 8	45	5.31	2.39

Flanker Fish

A difference score was calculated for each participant as the percent of correct incongruent trials subtracted from the percent of correct congruent trials. The flanker fish task was included to measure how well participants are able to control their attention, so the difference score describes how much the child was distracted by the incongruent flanking fish as opposed to the baseline congruent trials. Using either the difference score or just the percent correct on incongruent trials yielded no differences in the analyses. A positive value for the difference score indicates better performance on congruent trials compared with the incongruent trials. Difference scores ranged from -63.33 to 100. Performance on the congruent trials ranged from 16.67 to 100 percent correct, with a mean of 87.35 and standard deviation of 20.87. Performance on the incongruent trials ranged from 0 to 100 percent correct, with a mean of 36.05 and standard deviation of 31.17.

Reaction time, in milliseconds, was measured for each trial as the time from when the participant pressed the button bringing the image of the fish onto the screen until they touched the computer screen to make their selection. A paired t-test revealed that participants were significantly slower on incongruent trials, with a mean reaction time of 5762.55ms, compared with congruent trials, with a mean reaction time of 5167.48ms ($t(44) = 3.16$, $p = .003$). Reaction time was not significantly correlated with accuracy for either the congruent ($r(43) = .21$, $p = .16$) or incongruent ($r(43) = -.08$, $p = .61$) trials.

Delayed Recognition Span Test (DRST)

The memory spans of children on the DRST ranged from one to eight and averaged 3.43.

Dimensional Change Card Sort (DCCS)

Performance for each block of the DCCS was scored as pass or fail. A block was scored as pass if the participant correctly sorted at least five out of six cards. Seventeen of 45 participants successfully passed both the pre-switch and post-switch blocks.

Picture Vocabulary Test

Computed scores on the Picture Vocabulary Test ranged between 327 and 864 out of a possible range of 200 to 2000. The published mean score for children aged 36-48 months is 937. The participants in the present study ranged from 33-39 months of age and so understandably had the lower mean computed score of 645.5.

Model Room Task

While previous studies of the Model Room task have typically used only four trials, we elected to run eight trials to obtain a more precise measurement of abilities. Our initial analysis compared performance on the first four test trials with the last four. A paired t-test revealed no significant change ($t(88)= .55$, $p=.58$). Furthermore, using a Poisson regression with generalized linear modeling, we found that performance on the first four trials significantly predicted performance on the second four trials ($\beta=.46$, $p<.001$). Given the strong relationship seen between performance on the first four and second four trials, all subsequent analyses will use performance across eight trials.

Correct searches on the Model Room task ran the full possible range from zero to eight. Consistent with the findings from Sharon and DeLoache (2003), performance dropped significantly from the first trial to the second trial ($t(44)=3.08$, $p=.004$), with 73.33% of participants succeeding on the first trial and only 46.67% of participants succeeding on the second trial. We also found perseverative errors to be the most common error committed. Sixty-one percent of incorrect searches were perseverative errors, where the participant first looked in the toy's previous hiding location. Following a perseverative error, when given a second attempt to search, participants correctly located the toy on 56% of trials, demonstrating that once they ruled out the toy's last known location, participants successfully located the toy at a rate significantly above chance ($t(30) = 4.43$, $p< .001$).

In order to determine whether participants consistently searched in a "favorite" hiding location, we averaged the number of searches in each of the four possible locations. If a participant searched correctly on all eight trials, they would have searched two times at each location. The only location that significantly differed was the bookcase, which was searched an average of 1.67 times ($t(44) = -2.71$, $p=.01$). This difference is possibly accounted for by the fact that the bookcase was the last hiding location to come into view as the child entered the room from the left.

Correlations

In order to explore the relationships between each variable, we conducted bivariate Pearson correlations. Correlation coefficients are given in Table 2.

Table 2 - Task Correlations

	Model Room	Age	Sex	Vocabulary	Flanker	DRST	DCCS
Model Room							
Age	.29						
Sex	.32*	.27					
Vocabulary	.40**	.03	.22				
Flanker	.03	-.32*	-.04	.11			
DRST	.50**	.36*	.34*	.27	-.09		
DCCS	.23	.28	.13	.12	-.40**	.41**	

*$p < .05$.
**$p < .01$.

Only one of the tasks, the DRST, was significantly correlated with the Model Room task. Of the control measures, sex and vocabulary significantly correlated with the Model Room task. Sex was also correlated with the DRST, while age was correlated with both the Flanker task and DRST. As participants get older, they improve in their ability to control their attention during the flanker task, and therefore perform better on incongruent trials.

Because the calculated difference score was the percent correct of congruent trials minus the percent correct of incongruent trials, we see a negative correlation with age. Among the tasks, the DCCS was correlated with both the Flanker task and DRST.

ECBQ

Since the ECBQ was added to the procedure well into data collection, questionnaire data was only collected for 12 participants. Scales ranged from 2.42 to 6.00 out of a possible 7. Correlations between the four scales measured on the questionnaire and control and task variables can be seen in Table 3.

Table 3 – ECBQ Correlations

	Age	Sex	Vocabulary	DRST	DCCS	Flanker Difference	Model Room
Attentional Shift	.13	.31	.25	.21	.15	.39	.53
Attentional Focus	.12	.22	.16	.04	.44	-.30	.49
Impulsivity	-.07	.23	.22	.05	-.29	.33	.25
Inhibitory Control	.004	-.22	.14	.07	.01	.19	.42

Although our sample size was too small to perform a valid significance test, we can see a strong correlation between performance on the model room task and parental report of attentional shift and attentional focus.

Logistic Regression

We next investigated which variables best predicted performance on the model room task. We performed a Poisson regression using generalized linear modeling (GLM) with a log link function and allowed for overdispersion. In order to get the best fit for the model, performance on the model room task was re-coded to be the number of errors committed out of the eight trials. The results of the regression are shown in Table 4.

Table 4 – Regression using Generalized Linear Modeling

	Coefficient	Std. Error	*t*-Value	*p*-Value
Intercept	5.71	2.98	1.91	.06
Age	-.003	.003	-1.06	.30
Sex	-.22	.32	-.69	.49
Vocabulary	-.001	.0009	-1.08	.29
DCCS	-.07	.31	-.23	.82
Flanker	.0004	.004	.11	.91
DRST	-.26	.12	-2.14	.04

The only significant predictor of errors on the model room task was the DRST (b= -.26, *p*=.04). As performance on the DRST increases from zero to one, the predicted number of errors on the model room task for an average participant decreases from 4.91 to 3.79. As performance on the DRST increases from 0 to 3, errors on the model room task are predicted to decrease to 2.25. See Figure 6 for a depiction of the relationship between the DRST and predicted model room performance.

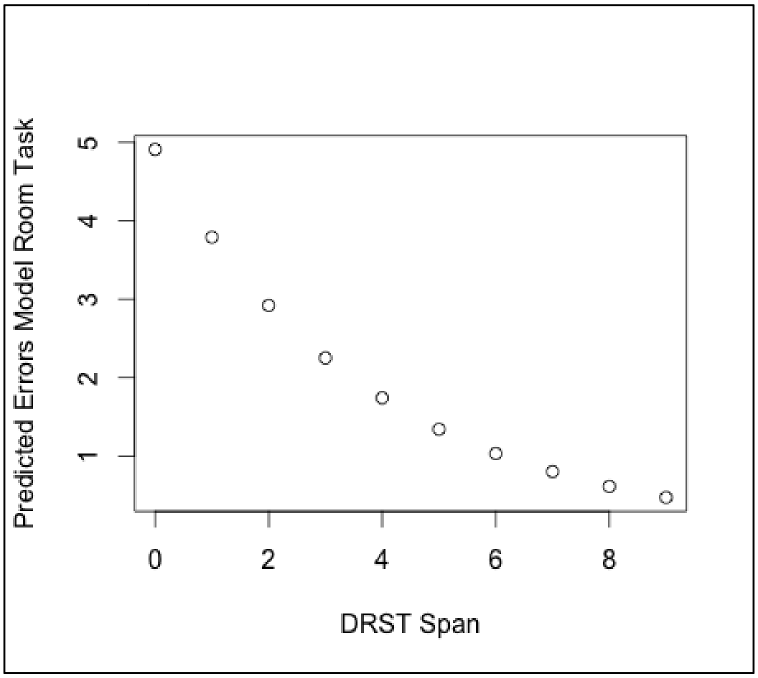

Figure 6: Model Room performance as predicted by DRST

CHAPTER 4

DISCUSSION

Consistent with the findings of Sharon and DeLoache (2003), our results showed that performance on the model room task dropped significantly from the first trial to the second trial, and that perseverative errors were the most common errors committed by participants. However, as demonstrated by O'Sullivan, Mitchell, & Daehler (2001) and Suddendorf (2003), failure on the model room task cannot be fully explained by perseverative errors as preventing participants from perseverating does not drastically improve performance. The present study differed from previous studies in that we used eight trials instead of four. By doubling the number of trials, we likely obtained a better estimate of a participant's abilities on the task.

Almost all participants demonstrated an immediate understanding of the correspondence between the objects in the model and larger room by successfully placing Big Bear in the same location as Little Bear when asked. The handful of participants that didn't immediately understand the correspondence succeeded following a repeat of the instructions. Yet many children who had a clear grasp on the correspondence between the locations failed to locate the toy's hiding location in the test trials. This suggests that success on the model room task requires more than just an understanding of the model's symbolic nature.

Contrary to our hypotheses, there was no evidence to support a predictive relationship between performance on measures of cognitive flexibility (DCCS) or inhibitory control (Flanker task) and performance on the model room task. Given the relatively large subject pool and small correlation coefficients measured between the tasks, it is unlikely that failure to find the predicted relationship was due to insufficient sensitivity in the study. However, we did find that performance on the model room task was significantly predicted by performance on a measure of recognition memory (DRST), even after controlling for age, sex, and receptive vocabulary. This relationship makes sense when we consider that both tasks require the participant to continually update their representations with the presentation of each new item. In the DRST, the participant must maintain the memory of the images already seen on the previous presentation, while continuing to update that memory with the presentation of each additional image. As pictures are repeated across the three trials, success on the DRST also requires the participant to focus on the memory of images presented in the current trial and not get distracted by the memory of when they were presented in a previous trial. Similarly, the model room task requires participants to update their memory to include the toy's current location and ignore the competing memories of where the toy was hidden previously. The cognitive demands of the DRST and the relationship found between the two tasks provides support for the theory proposed by Schmidt, Crawley-Davis, & Anderson (2007) that failure on the model room task is due to weak, conflicting representations of the toy's location, as both tasks require the participant to choose between the conflicting memories of previous trials and the current trial.

To date, the DRST has only been used with children in one other study (Jenkins & Berthier, 2014). It has previously been studied in individuals with Alzheimer's disease (Moss, Albert, Butters, and Payne, 1986) and non-human primates. Performance on the DRST was initially thought to be only due to the hippocampus as lesions to the hippocampus were shown to negatively impact performance in rhesus monkeys (Beason-Held, Rosene, Killiany, & Moss, 1999). However, more recent work has demonstrated that performance on the DRST is also impaired by disruptions to dopamine receptors in the prefrontal cortex of rhesus monkeys (Moore, et. Al, 2005).

The hippocampus goes through a period of development from ages 18 to 24 months, in which a number of place learning abilities come online (Sluzenski, Newcombe, & Satlow, 2004). Children in this age range showed improvements in their abilities to represent multiple locations and learn the relations among objects, both skills necessary for success in the model room task. Brain imaging has shown that hippocampal volume also increases sharply around age two, continuing to grow slowly beyond that point (Utsunomiya, Takano, Okazaki, & Mitsudome, 1999). But development of the hippocampus continues well beyond age two, with hippocampal volume peaking at preadolescence (Uematsu, et. Al, 2012) and myelination of the hippocampus not reaching adult level until after age 11 (Ábrahám, et. Al, 2010). The current study suggests a possible continuation in the development of the hippocampus and its connections, and corresponding abilities, around 3 years of age that warrants further investigation.

Recent research conducted with macaques demonstrates the hippocampus' role in spatial memory in a nonnavigational task (Forcelli, et al., 2014). Macaques with hippocampal lesions showed decreased performance on a task in which they need to locate a food reward inside each of eight boxes using only the box's spatial location as a cue. The model room task requires children to map the locations in the model onto the corresponding locations in the larger room. It also requires them to navigate within the larger space in order to locate the hidden toy. Given the hippocampus' role in both spatial learning and performance on the DRST, the present study suggests the importance of the hippocampus in the ability to succeed on the model room task.

Although ECBQ data was collected from only 12 participants, we can see some interesting trends emerging in the relationships between the scales measured and the different tasks included in the study. The strongest correlations obtained were between performance on the model room task and the scales of attentional shift and attentional focus. While no statistical conclusions can be drawn given the lack of questionnaires obtained, these relationships would support the proposed theory that success on the model room task requires shifting attentional focus between the conflicting representations of the hidden toy's location. Additional data collection would be needed to better understand the strength of these relationships.

We know that physically preventing participants from perseverating on the model room task does not drastically improve performance (Suddendorf, 2003). However, Jacques, Zelazo, Kirkham, & Semcesen (1999) proposed that perseveration is not necessarily an inability to inhibit a motor response, but might be the inability to inhibit a representation or shift between representations. The flanker task and DCCS were chosen as tasks for this study to explore this idea, as they both require the participant to focus their attention on the correct mental representation to succeed. However, both tasks require the participant to respond using a motor action. It is possible that failure to inhibit a motor response may have overpowered the children's ability to control their focus, thereby impacting what we were measuring. The data from the questionnaires collected suggest that attentional focus and shifting might play a role in performance on the model room task. Perhaps we might have seen the hypothesized relationships between the cognitive abilities if we had selected tasks that don't require a motor response.

The present study demonstrates a predictive relationship between memory span ability as measured by the Delayed Recognition Span Test and performance on the model room task. Given the DRST's sensitivity to hippocampal lesions and the hippocampus' known role in place coding and spatial navigation abilities, the findings of this study suggest a possible link between hippocampal development and success on the model room task. The results of this study offer insights into the mechanisms behind the shift in cognitive abilities observed in children around 3 years of age and suggest directions for future inquiry.

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