Prefrontal Cortical Development and Manual Search in Two Tasks

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INTRODUCTION

A cognitive transition occurs around 2.5 to 3 years-of-age (e.g., Flavell, Miller, & Miller, 1993; Piaget, 1952) and coincides with the marked development of the prefrontal cortex (Diamond, 2001; Huttenlocher, 1990). Among the tasks where this transition occurs are the DeLoache (1987) model room task, the DCCS (Zelazo, et al. 2003), and the door task (Berthier et al., 2000; Hood, Prasada, & Carey, 2000). The door task involves asking children to find a ball that has been rolled behind an occluder to stop next to a highly visible barrier wall (Fig. 1). Children are repeatedly reminded that the "wall stopped the ball" and that the "ball was behind this door because it stopped next to the wall." Monte-Carlo simulations of the door task show that failure pattern on the task can be explained by the children acting on the basis of where the ball was seen previously or where they reached previously.

Given the pattern of failure in the door task, one immediately thinks of a failure of executive function. Price and Berthier (submitted) investigated whether the development of executive function might be central to solving the door task. We tested children around the age of success on the door task with three tests working memory and a test of inhibitory control. The inhibitory control task, but not the working memory tasks, predicted performance on the door task with children who passed the inhibitory control task being 3.46 times more likely to be correct on the door task trial than children who failed the inhibitory control task. Baker, Gjersoe, Sibieslska-Woch, Leslie & Hood (submitted) used a similar design and showed that a delay of gratification task was correlated with performance on the door task. The combined data point to inhibitory control as important for success in the door task. The construct of inhibitory control is fractionated into several different factors that are intercorrelated. Generally, these factors involve response inhibition, representational inhibition, and attentional inhibition. We do not know whether these inhibitory functions are separable in 3-year-olds, and if so, what aspect of inhibition is key in solving the door task. One goal of the current proposal is to investigate inhibitory control in 3-year-olds and relate developments of inhibitory control to performance on search tasks.

In the current experiment we tested individual children on both the door and model room task in order to determine if performance was correlated on the two tasks.

Figure 1: Door Apparatus from Berthier et al. (2000). The ball rolled behind the doors and out of view of the child. The child then opened the 3rd door to correctly locate the ball which was stopped by the barrier.

Figure 2: Model Apparatus from model room study. The photograph on the far right is a model of the room located to the adjacent photograph. Each piece of furniture in the model is to scale.

METHODS

Participants: 14 toddlers (7 females, 7 males) between 2 ½ and 3-years-of age participated in the study. One child was excluded due to inability to complete one of the tasks. The final sample was 13 toddlers.

Apparatus: *Task 1:* The apparatus used is the same from Berthier et al. (2000). The apparatus consists of a ramp that includes dowels on the side in order to form a track for a ball to roll down. Additionally, a removable panel with four doors is placed in front of the ramp *Task 2:* The apparatus was based on DeLoache (1987). A bench, laundry basket, bookcase, and pillow were all placed in a room along with a teddy bear. An exact replica of the room, furniture, and bear were all created.

Procedure:

Task 1: After familiarization, the toddlers were asked to locate the ball's position after it was rolled down the ramp by the experimenter. Between each of the 8 trials, the experimenter pointed out that the ball stops behind the door where the the wall is.

Task 2: After familiarization, the toddler watches the experimenter hide little bear in one of the four hiding spots in the replica. The toddler was then instructed to find big bear in the life-size room in the same hiding spot.

RESULTS

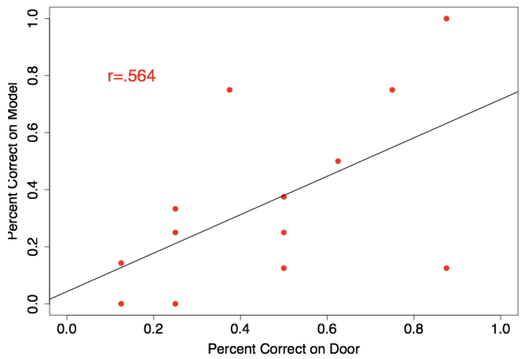

Figure 3: Scatterplot of performance on the two tasks.

The proportion correct was calculated from the video tape record for each child. Performance ranged from 15% to over 100% correct on the tasks as expected. A linear regression showed that performance on the two tasks was correlated at 0.564 ($p<.04$), but performance on the two tasks was not correlated with the child's age (door task r=-.007; DeLoache task r=.03).

DISCUSSION

The results show that individual children's performance on these two tasks is highly correlated. Heretofore, success on the DeLoache task has been ascribed to the child's ability to maintain dual mental representations of the model as a model and a real object and success on the door task has been ascribed to improvements in inhibitory control. The current results suggests that there may be a unitary explanation for success on these tasks, as Schmidt, Crawley-Davis, and Anderson (2007) have suggested that the difficulty on the model room task results not from an inability in representing the two aspects of the model, but from difficulty in attending to conflicting representations of the solution. This hypothesis is essentially a suggestion that failure in the model room task is a failure of cognitive control. A similar explanation for the door task could be made both in terms of coordination across multiple visual fixations involve in a particular trial or of memories of previous searches and current locations.

Contact and Download Information

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