

Learning Through Doing:

How Individual Differences in Executive Function Predict Action Memory in Preschoolers

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Introduction

- Laboratory tasks that assess memory for actions represent more closely everyday memories in contrast to typical memory tasks which generally involve verbal learning only (Zimmer et al., 2001).

- In adults, the enactment effect is a robust phenomenon and results in better memory for phrases enacted physically as compared to similar phrases learned verbally (Koriat & Pearlman-Avnion, 2003).

- The enactment effect may be the result of multimodal encoding opportunities provided by the enacted event (e.g., visual and motoric; Bäckman, Nilsson, and Chalom, 1986).

- Evidence for the enactment effect in 6- to 10-year-olds is equivocal; some studies show the enactment effect even in the youngest age groups while others show developmental improvements (Foley & Ratner, 2001)

- Recall patterns of enacted phrases show evidence of strategy use which requires cognitive capacity (Mecklenbräuker, Steffens, Jelenec, & Goergens, 2011) and is related to executive function (Garon, Bryson, & Smith, 2008).

- Cognitive abilities such as working memory and cognitive flexibility may be related the enactment effect and allow children to process the multimodalities of enactment.

- Working memory is the ability to encode, maintain, and manipulate information to achieve goal-oriented behavior (Unsworth & Engle, 2007).
- Cognitive flexibility is the ability to switch from one mental representation to another as task demands change (Zelazo, Müller, Frye, & Marcovitch, 2003).

Method

Participants

- Twenty-four 4-year-olds (M age = 4.54 years, SD = .26), twenty-four 5-year-olds (M age = 5.44 years, SD = .26), and twenty-four 6-year-olds (M age = 6.50 years, SD = .33) participated in the study.

Design and Procedure

Enactment Task

- Children were presented with two 6-item action phrase lists (see Figure 1); each phrase consisted of a verb and noun familiar to young children (e.g., Push the Button).
- Each list was learned using a different method of encoding.
 - In the verbal task, children were asked to repeat each phrase the experimenter said.
 - In the self-performed task, children were asked to imitate the action performed and repeat the phrase said by the experimenter.

Working Memory Tasks

Auditory Backward Word Span (Carlson, Moses, & Breton, 2002)

- Children were presented with lists of words and asked to recite the lists backwards.
- Children were given three 2-word lists. If children reproduced one 2-word list correctly, list size was increased by one, repeating the procedure with 3-, 4-, and 5-word lists.

Visual Digit Span (Case, Kurland & Goldberg, 1982)

- Children were presented with cards depicting frogs and ladybugs, and asked to count the number of ladybugs while disregarding the frogs.
- Children were given three sets of two cards and asked to remember how many ladybugs were on each card. If children remembered the amount of ladybugs on one two card set correctly, set size increased by one, repeating the procedure with 3-, 4-, and 5-card sets.

Cognitive Flexibility Task

Dimensional Change Card Sort, Borders Version (DCCS-BV; Zelazo, 2006)

- Children were instructed to sort cards flexibly that varied on two dimensions (i.e., shape and color) to conflicting target cards (e.g., if they were sorting yellow flowers and green cars they had to match them to green flowers and yellow cars).
- After six trials, children were asked to switch rules and sort by the opposite dimension.
- Children who passed the task played the borders version. Children were instructed to sort by one dimension (e.g., color) if the card had a border and the other dimension (e.g., shape) if it did not.

Action Phrase Lists

1. Break the Stick	1. Open the Book	1. Cut the Cake
2. Twist the Bottle Cap	2. Pour the Milk	2. Blow the Bubbles
3. Tear the Paper	3. Drive the Car	3. Hug the Teddy Bear
4. Bite the Carrot	4. Cradle the Baby	4. Ring the Bell
5. Honk the Horn	5. Hammer the Nail	5. Throw the Ball
6. Push the Button	6. Brush your Teeth	6. Stack the Blocks

Figure 1. Lists of noun-verb action phrases

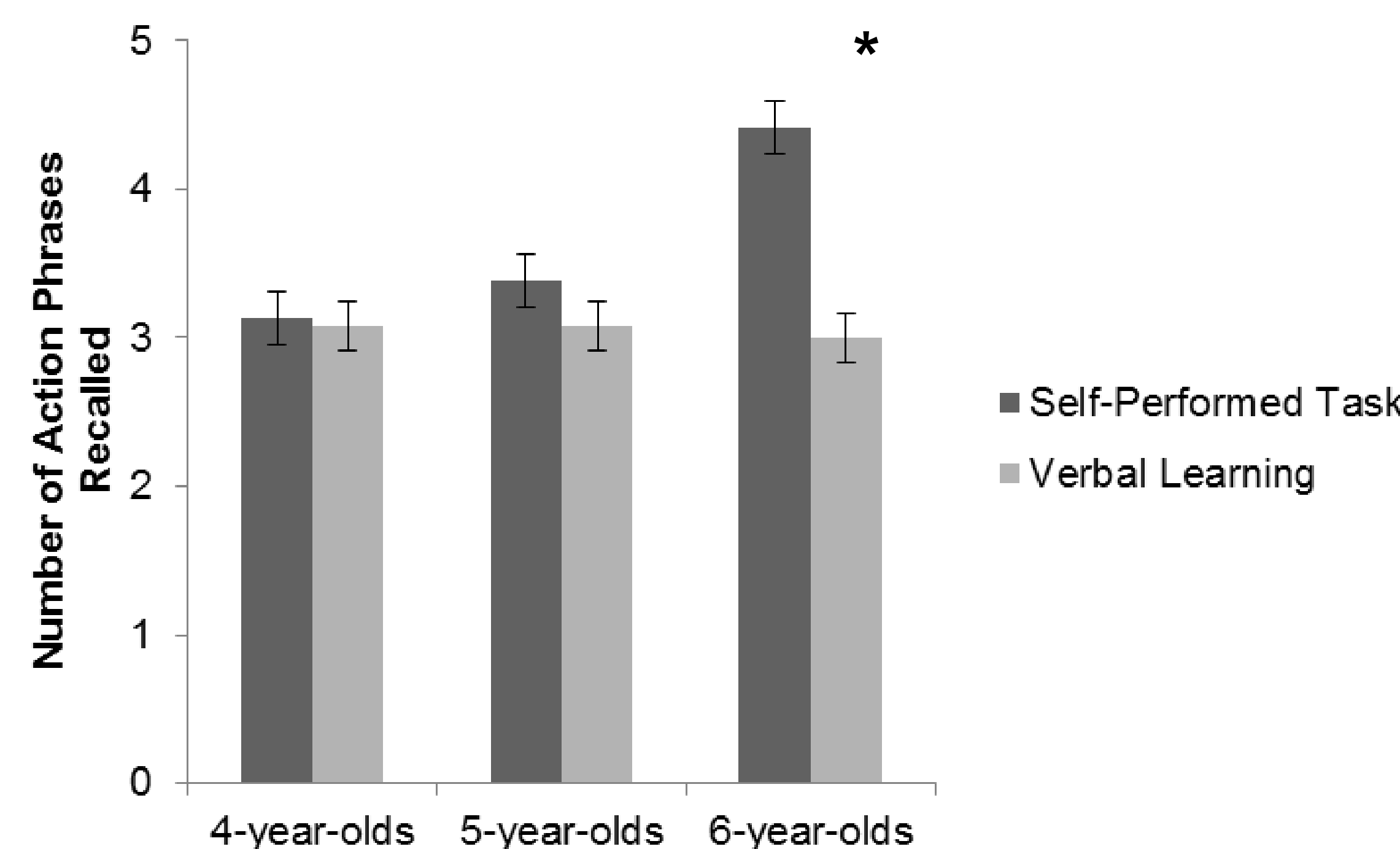


Figure 2. Recall of self-performed and verbally learned action phrases by age
* $p < .05$

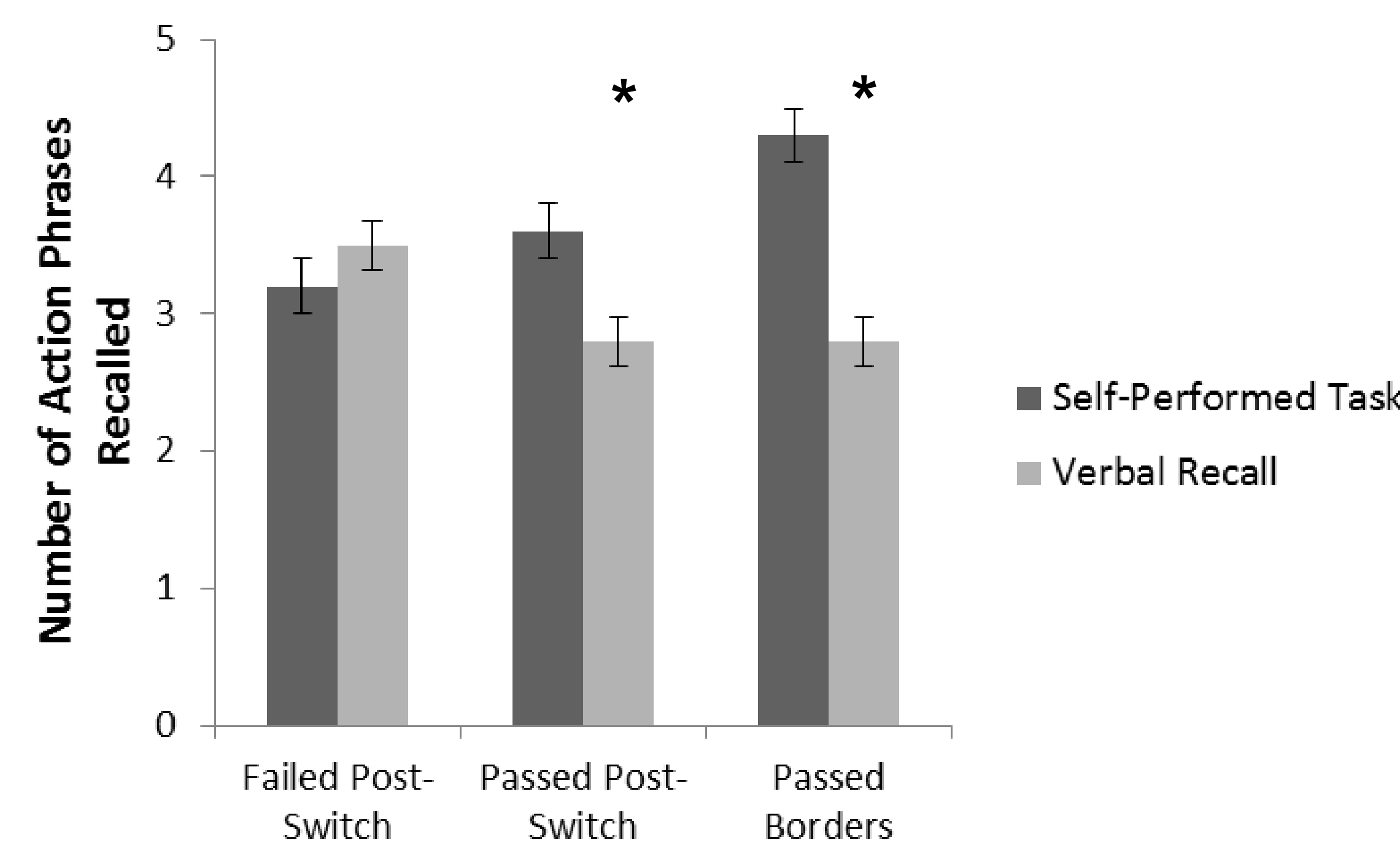


Figure 3. Recall of self-performed and verbally learned action phrases by DCCS-BV performance
* $p < .05$

Results

- A difference score was created by subtracting the number of recalled phrases learned verbally from the number recalled phrases learned through enactment to quantify the enactment effect.

- Working memory tasks (i.e., auditory backward word span and visual digit span) were significantly correlated, $r(70) = .4$, $p < .001$, and a composite score was created by averaging the z-scores of the two tasks.

- A hierarchical linear regression was performed with the difference score as the dependent variable, and the independent variables entered in two steps: (1) age, and then (2) the working memory composite.
 - Age significantly predicted the enactment effect, $\beta = .658$, $t = 2.59$, $p = .01$, $R^2 = .09$, such that increased age resulted in increased expression of the enactment effect (see Figure 2).
 - Addition of working memory composite did not significantly improve prediction, R^2 change = .02, $F = 1.63$, $p = .21$.

- A second hierarchical linear regression was performed with difference score as the dependent variable, and the independent variables entered in two steps: (1) age, and then (2) DCCS-BV.
 - Age significantly predicted the enactment effect, $\beta = .658$, $t = 2.6$, $p = .01$, $R^2 = .09$.
 - The addition of DCCS-BV significantly improved predication, $\beta = .516$, $t = 2.13$, $p = .04$, $R^2 = .14$, indicating that DCCS performance significantly predicts the enactment effect, over and above age, R^2 change = .06, $F(1,69) = 4.52$, $p = .04$, (see Figure 3).

Discussion

- Expression of the enactment effect increased with age; 6-year-olds were more likely to remember enacted phrases better than those learned verbally while 4- and 5-year-olds were not.

- Working memory abilities were not related to the enactment effect above and beyond age.

- Cognitive flexibility predicted the enactment effect even when age was already included in the model.
 - The ability to represent multiple dimensions of a stimulus item may allow for children to encode successfully the multimodal properties of an enacted event.

- The present study provides evidence that improved memory for actions is related to executive function processes.

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