Organization is the Key to Success: The Differential Effects of Executive Function on Sorting and Clustering Strategies in Preschoolers

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Introduction

- Organizational strategies involve: (a) sorting similar information into semantic groups during learning and, (b) clustering similar information together during recall (Schwenk et al., 2009).
- Children younger than 8 years old frequently fail to use organizational strategies spontaneously (Baker-Ward, Ornstein, & Holden, 1984), but can be trained to do so (Schlagmüller & Schneider, 2002). However, children trained to use a sorting strategy are more likely to show increased recall than those trained to cluster (Schwenk et al., 2009).
- In 8- to 12-year-olds, executive function (i.e., flexible goal directed behaviors that assist in problem solving; EF; Marcovitch & Zelazo, 2009) predicts clustering, but not sorting (Schleepen & Jonkman, 2012). In preschoolers, it is possible that EF plays a significant role in the use of both clustering and sorting as they are less efficient organizational strategy users. Acquiring a new skill is effortful and taxes cognitive resources requiring higher levels of EF for successful task completion (Huang-Pollock & Karalunas, 2010).
- The current study examined the relationship between sorting and clustering strategies and two cognitive abilities associated with EF —cognitive flexibility (CF) and working memory (WM) —in 4- to 6-year-olds. Children were presented with an organizational strategy use task, a measure of CF (Dimensional Change Card Sort; DCCS), and a measure of WM (Backwards Digit Span; BDS).

Methods

Participants

- Twenty-four 4-year-olds (*M* age = 4.40 years, *SD* = .27), 24 5-year-olds (*M* age = 5.32 years, *SD* = .24), and 24 6-year-olds (*M* age = 6.49 years, *SD* = .31) participated in the study.

Design and Procedure

Organizational Strategy Use (Schwenk et al., 2009)

- The experimenter demonstrated a sorting strategy by organizing 6 cards into 2 categorically similar groups —body parts and vegetables —and had children explain why the pictures were sorted into 2 categories.
- Children were then presented with 9 cards containing pictures from 3 categories (i.e., furniture, fruits, and animals; see Figure 1).
- During a 1 minute study period, children were asked to "sort the pictures in groups that belong together, and try to remember the pictures together that belong together."
- After a 30 second delay, a free recall test was administered.
- Recall was scored as the number of items generated during free recall.
- Both sorting and clustering were assessed by calculating Ratio of Repetition scores (RR; Bousfield, 1953).

Dimensional Change Card Sort, Borders Version (Zelazo, 2006)

- Children were instructed to sort cards 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 sorting by one dimension, children were asked to switch rules and sort by the other dimension.
- Children who sorted at least 5 trials correctly passed the postswitch condition, and played the borders version. Children were instructed to sort by one dimension if the card had a border and the other dimension if it did not.
- Performance was scored as the total number of cards sorted correctly across all phases.

Backwards Digit Span (Carlson, Moses, & Breton, 2002)

- Children were asked to reproduce in reverse order three lists each of 2, 3, 4, and 5 digits.
- Testing was completed after children failed to reproduce all three lists of a specific length.
- Performance was scored based on the longest list children reproduced correctly. Children who failed to reproduce a 2-digit list were assigned a score of 0.

Figure 1. Examples of Organizational Strategy Task Pictures

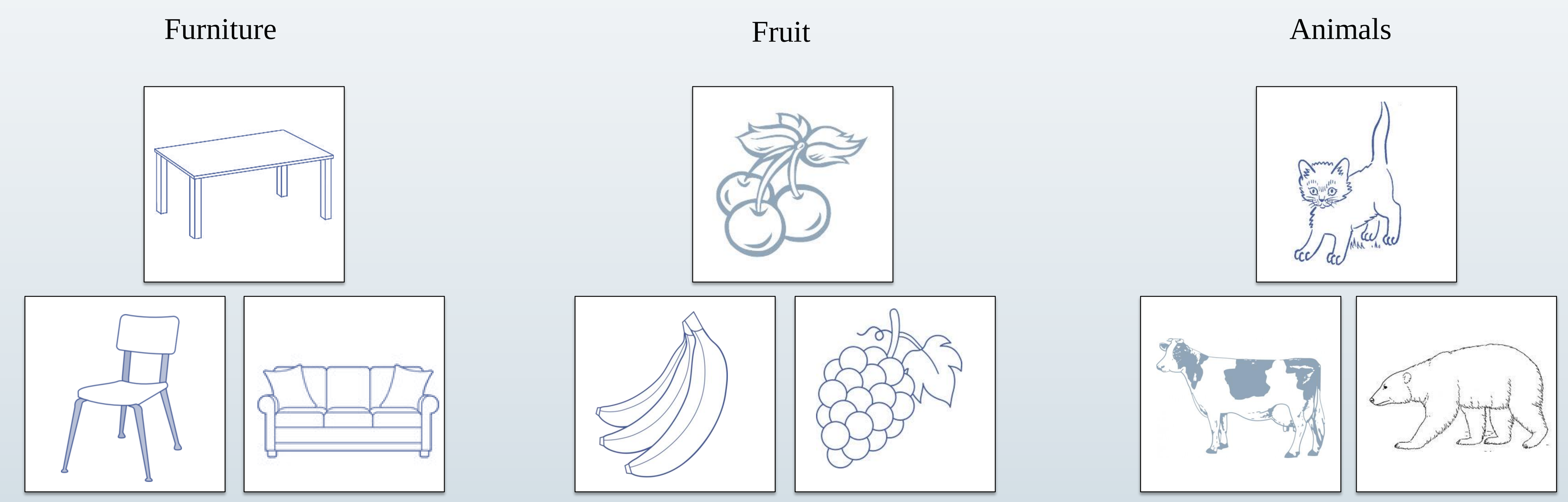

Table 1
Regression of clustering scores on AGE and EF composite

Variable	B	SE(B)	β	ΔR²
Step 1				.19**
AGE	.93**	.24	.43**	
Step 2				.08*
AGE	.48	.29	.22	
EF Composite	.78*	.30	.35*	

Note. **p* <.05 ***p* <.001

Table 2
Regression of sorting scores on AGE and EF composite

Variable	B	SE(B)	β	ΔR²
Step 1				.14**
AGE	.72**	.22	.37**	
Step 2				.02
AGE	.51	.28	.26	
EF Composite	.37	.29	.18	

Note. ***p* <.001

Table 3
Regression of recall on AGE, EF composite, and clustering scores

Variable	B	SE(B)	β	ΔR²
Step 1				.19**
AGE	1.28**	.32	.44**	
Step 2				.12*
AGE	.52	.37	.18	
EF Composite	1.30*	.39	.43*	
Step 3				.17**
AGE	.02	.23	.01	
EF Composite	.47	.25	.16	
Clustering	1.10**	.22	.49**	

Note. **p* <.05 ***p* <.001

Table 4
Regression of recall on AGE, EF composite, and sorting scores

Variable	B	SE(B)	β	ΔR²
Step 1				.19**
AGE	1.28**	.32	.44**	
Step 2				.12*
AGE	.52	.37	.18	
EF Composite	1.30*	.39	.43*	
Step 3				.01
AGE	.41	.39	.14	
EF Composite	1.23*	.41	.40*	
Sorting	.18	.17	.12	

Note. **p* <.05 ***p* <.001

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Results

- Performance on the DCCS and BDS was significantly correlated, $r(70) = .52$, $p < .01$, and an EF composite score was created by averaging the z-scores of the two EF variables.
- Two hierarchical linear regressions were performed with clustering and sorting as the dependent variables, and the predictor variables entered in two steps: (1) age, and then (2) the EF composite.
  - Age predicted increased clustering, $R^2 = .19$, $F(1, 68) = 15.67$, $p < .001$, and sorting, $R^2 = .14$, $F(1, 68) = 10.56$, $p = .002$.
  - Above and beyond the effects of age, children with higher EF scores produced more clusters, $\Delta R^2 = .08$, $F(1, 67) = 6.92$, $p = .01$ (see Table 1). In contrast, EF ability did not further predict sorting scores, $\Delta R^2 = .02$, $F(1, 67) = 1.60$, $p = .21$ (see Table 2).
- The contribution of sorting and clustering to free recall was also of interest as older children show enhanced memory when they engage in both strategies (Schleepen & Jonkman, 2012). Two hierarchical linear regressions were performed with recall as the dependent variable, and the predictor variables entered in three steps: (1) age, (2) EF composite, and then (3) clustering or sorting performance.
  - Age predicted increased recall, $R^2 = .19$, $F(1, 68) = 16.09$, $p < .001$, and the addition of EF composite contributed significant variance to the model, $\Delta R^2 = .12$, $F(1, 67) = 11.07$, $p = .001$.
  - Strategy type predicted recall differently. Children who clustered more recalled more items, $\Delta R^2 = .17$, $F(1, 65) = 20.27$, $p < .001$ (see Table 3), but sorting did not predict performance on the free recall task, $\Delta R^2 = .01$, $F(1, 65) = 1.14$, $p = .29$ (see Table 4).

Discussion

- Consistent with findings in older children (Schleepen & Jonkman), EF abilities predict clustering, but not sorting, in preschoolers.
  - Sorting may not require high levels of EF because hands-on materials assist in organization rather than requiring manipulation of information mentally (Schwenck et al., 2009).
  - On the other hand, clustering strategies involve the mental manipulation of information, and requires complex goal-directed processing.
- Additionally, clustering, but not sorting, results in greater memory for list items when children are trained to use both strategies in concert.
  - This indicates that when using both aspects of organizational strategies (i.e., organizing information at both encoding and recall) the ability to cluster results in the most efficient and beneficial strategy use.

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