



# The Development of Cognitive Flexibility Beyond the Preschool Period

Anthony Steven Dick<sup>1</sup> and Willis F. Overton<sup>2</sup>  
Department of Neurology, The University of Chicago<sup>1</sup>  
Department of Psychology, Temple University<sup>2</sup>



## Introduction

In the present study, we provide further evidence that cognitive flexibility develops beyond the preschool period. We also present a measure that can be used to assess this development from preschool through later childhood.

Developmental investigations of executive function have documented considerable improvement through childhood, particularly in the area of cognitive flexibility. Tasks that have been used to assess this development include the Dimensional Change Card Sort (DCCS) and the Wisconsin Card Sort (WCST). In the DCCS, children sort picture cards by one dimension (e.g., color), and then by a second dimension (e.g., shape). The average four-year-old, but not the three-year-old, is able to flexibly shift rules. The WCST is similar, except (a) it is too difficult for preschoolers; (b) there are more potential matching dimensions, and (c) participants are not explicitly told the sorting rule. In both tasks, inflexibility results in perseveration on the prior sorting rule. A fairly sudden development on the DCCS seems to mark a kind of “4-year-shift” in the child’s cognition, although performance on the WCST does not ceiling until age 10-12 (Chelune & Baer, 1986). This suggests a more protracted development of cognitive flexibility.

## Prior Research

To further investigate this development we used a recent addition to this family of sorting tasks called the Flexible Item Selection Task (FIST; Jacques & Zelazo, 2001). Participants must abstract a relevant matching dimension and to switch flexibly to a new matching dimension. In the standard FIST (referred to here as a 2-Match FIST; see Figure 1), children are presented with three picture cards, and they must select two cards that match in one way (i.e., the first selection). Thus, they must *abstract* a relevant dimension (e.g., color) on which two objects are alike. Next, the child must flexibly *abstract and switch* to a second dimension (e.g., shape).

Investigating preschoolers, Jacques & Zelazo (2001) reported the following pattern of development: (a) 2-year-olds are unable to pass the critical measures of the task; (b) most 3-year-olds show poor performance on both selections; (c) 4-year-olds show good performance on the first selection, but have difficulty with the second; and (d) 5-year-olds perform better at the second selection, but are still only correct 50% of the time. This leaves open the question of whether there is continued development on this task beyond the preschool period.

## The Present Study

To investigate this further development, we manipulated the FIST by adding potential matching dimensions (shape, size, color, and number), and varying the degree of conflict among the stimulus attributes. We used the standard “2-Match” version from Jacques and Zelazo (2001), and developed four new versions.

**Participants.** Participants were 77 predominately Caucasian children. They were divided into three age groups: twenty-eight 6-year-olds (*M* age = 78.68 months), twenty-eight 8-year-olds (*M* age = 102.64 months), and twenty-one 10-year-olds (*M* age = 126.67 months). To represent the adult sample, twenty eight Temple University undergraduates (*M* age = 273.61 months) were also recruited.

**General Design.** Each participant received all versions of the FIST, as well as the WCST, the PPVT-R, and backward digit and backward word span tasks.

### Versions of the FIST:

- 2-Match: three stimulus cards that can be matched on two possible dimensions (Figure 1A).
- 3-Match A: three stimulus cards that can be matched on three possible dimensions (Figure 2A).
- 3-Match B: three stimulus cards that can be matched on three possible dimensions, but two of the cards match on more than one dimension (Figure 2B).
- 4-Match: four stimulus cards that can be matched on four possible dimensions (Figure 3A).
- 6-Match: four stimulus cards that can be matched on six possible dimensions (Figure 3B).

## Results

Table 1. Intercorrelations and Partial Correlations Among Measures for All Age Groups

	1	2	3	4	5 <sup>a</sup>	6 <sup>b</sup>	7	8	9	10	11	
1. Perseverative Errors	—	-0.61***	-0.51	-0.46***	-0.45***	-0.36***	-0.37***	-0.42***	-0.44***	-0.52***	-0.56***	
		(-0.53***)	(-0.21*)				(-0.25*)	(-0.20*)	(-0.25*)	(-0.20**)	(-0.27**)	
2. Categories Achieved		—	-0.40***	0.40***	0.35***	0.29**	0.24*	0.26**	0.24*	0.40***	0.37***	
			(-0.37***)				(-0.10)	(-0.05)	(-0.04)	(-0.20**)	(-0.14)	
3. Failure to Maintain Set			—	-0.17	-0.12	-0.14	-0.02	0.05	0.01	-0.08	0.0	
				(-0.00)	(-0.16)	(-0.10)	(-0.03)	(-0.15)				
4. PPVT-R Raw Score				—	0.80***	0.78***	0.44***	0.52***	0.53***	0.66***	0.65***	
5. Total BWS <sup>c</sup>					—	0.82***	0.34**	0.58***	0.50***	0.63***	0.63***	
6. Total BWS <sup>d</sup>						—	0.44***	0.50***	0.40***	0.56***	0.56***	
7. 2-Match %							—	0.44***	0.43***	0.44***	0.43***	
8. 3-Match A %								—	0.44***	0.76***	0.76***	
9. 3-Match B %									—	0.63***	0.63***	
10. 4-Match %										—	0.85***	
11. 6-Match %											—	

Note. Numbers 1-3 are Wisconsin Card Sort (WCST) variables. PPVT-R = Peabody Picture Vocabulary Test-Revised. BWS = Backward Digit Span. BWS = Backward Word Span. All values in parentheses represent partial correlations controlled for age in months. PPVT-R, BWS, and BWS, *N* = 95 except where marked, a *N* = 94. For partial correlations, *df* = 88. \* *p* < .05. \*\* *p* < .01. \*\*\* *p* < .001.

**Correlations.** The FIST measures showed convergent validity with the WCST, and shared a working memory component with the backward span measures. However, the fact that the relations between FIST and WCST performance remain significant when the span measures are controlled indicates that working memory processing in and of itself may not constitute the singular component of cognitive flexibility (Table 1).

**Rasch Analysis.** Rasch analysis was used to assess the reliability of individual measures of the FIST, to establish a general developmental trend, and to confirm the assumption of unidimensionality of the measure. See Rasch Analysis supplement.

**Analysis of Variance (ANOVA).** Figures 1-3 present results of separate Task x Age (4) ANOVAs for each of the five versions of the FIST. Successful shifting on the 2-Match was achieved by age 8. Successful shifting on the 3-Match versions remained difficult even for 10-year-olds. Even 10-year-olds and adults had difficulty shifting to the last selection on the 4-Match, and shifting to the last selection on the 6-Match was difficult until the age of 10.

## Discussion

Several findings are of note:

- Rasch analysis establishes reliability of FIST measures, and establishes that the measures tap a single latent dimension (labeled “cognitive flexibility” for convenience).
- The FIST shares a cognitive flexibility component with the WCST, and these share a working memory component as measured by backward span tasks.
- The FIST is a reliable and valid measure of executive function/cognitive flexibility that can be used in the same form from preschool through elementary school. More difficult versions are still challenging for older children and adults.
- Further research is needed to establish the precise nature of cognitive processes underlying the executive function construct of cognitive flexibility.

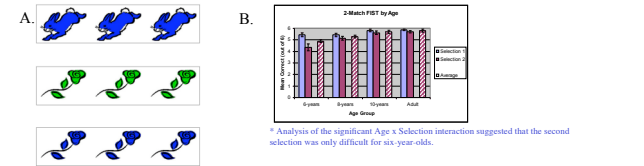


Figure 1. A. The 2-Match Version of the FIST. In this example, cards 1 and 3 match because of color, and cards 2 and 3 match because of shape. Size and number are the constant dimensions. B. Mean performance (out of 6 trials) for 6, 8, and 10-year-olds and adults.

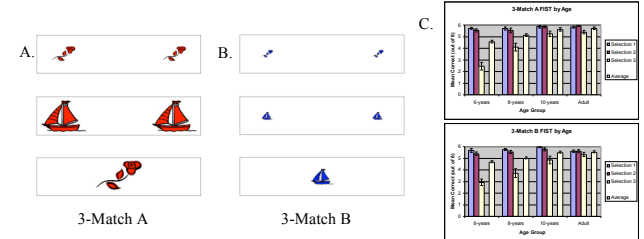


Figure 2. A. The 3-Match A version of the FIST. In this example, cards 1 and 3 match because of size, cards 2 and 3 match because of number. Color is the constant dimension. B. The 3-Match B version of the FIST. In this example, cards 2 and 3 match because of shape, and cards 1 and 2 match because of size and because of number. Color is the constant dimension. C. Mean performance (out of 6 trials).

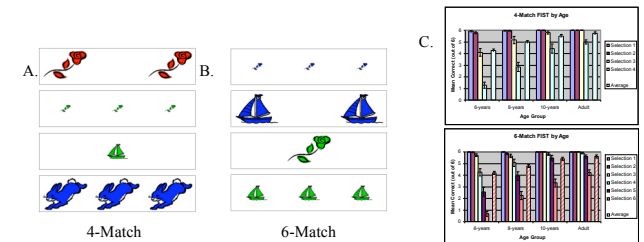


Figure 3. A. The 4-Match version of the FIST. In this example, cards 1 and 2 match because of shape; cards 2 and 3 match because of color; cards 2 and 4 match because of number; cards 1 and 4 match because of size. B. The 6-Match version of the FIST. In this example, cards 1 and 2 match because of color; cards 1 and 3 match because of shape; cards 1 and 4 match because of number; cards 2 and 3 match because of shape; cards 2 and 4 match because of size and because of number; cards 3 and 4 match because of color. C. Mean performance (out of 6 trials).