

Background

Differences in young children's cognitive abilities are predictors of later academic achievement (Welsh et al., 2010).

- **Working memory**, the ability to hold information in memory temporarily while inhibiting distractions, is important for performance on mathematical tasks (see Raghubar et al., 2010).
- **Semantic verbal fluency** (i.e., fluency), or the controlled search and retrieval of words from long-term memory (Baddeley, 1996; Ratcliff et al., 1998), may also be important.
 - Associated with the efficiency of working memory functions (Auzma, 2004)
 - Highly correlated with executive functioning and attention capacity (Hurks et al., 2004)
 - Predicts both concurrent and future mathematics performance (Andersson, 2008; Swanson, 2011)
 - Ability to strategically search and retrieve information from memory may help students to better attend to, process, and apply instructional guidance
- However, little is known about the combined influence of working memory and fluency in math learning.

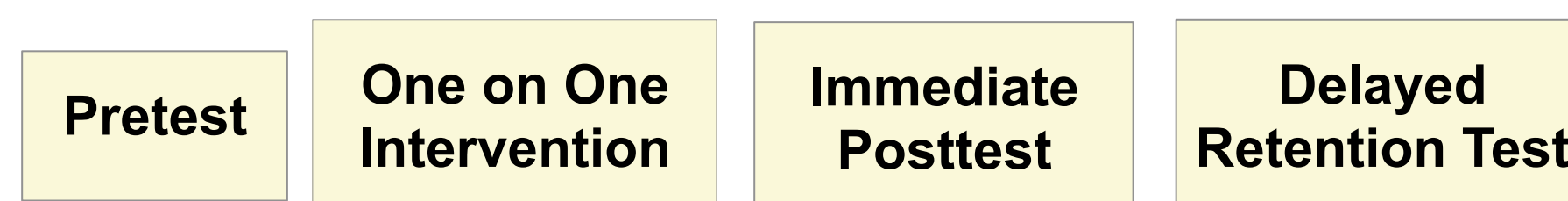
Current Study

Domain: Mathematical equivalence

- Concept that two sides of an equation are the same amount
- Foundational for algebra (Falkner, Levi, & Carpenter, 1999)
- Operational View: View "=" as a command to carry out arithmetic operations
 - $3 + 5 + 6 = _ + 6$, most get 14 or 20
- Relational View: View "=" as meaning two sides of an equation have the same value

Participants: 122 2nd and 3rd graders with less than 75% or higher on either a conceptual or procedural knowledge measure at pretest

Design:



- During the intervention, students received instruction on the concept of math equivalence either *before* or *after* being asked to solve and explain challenging problems.
 - **Conceptual Instruction:** Children were taught the relational meaning of the equal sign in the context of five non-standard number sentences
 - **Intervention Problem Solving**
 - 4 standard arithmetic problems
 - 8 math equivalence problems
- $6 + 3 + 4 = 6 + _ \quad 3 + 4 + 8 = _ + 8$

Measures

Executive Function Tasks

- **Working Memory:** Backward Digit and Letter Spans (Davis & Pratt, 1995)
- **Semantic Verbal Fluency:** Given 1 minute each to name as many items as possible from two categories (i.e., animals and food; NEPSY II, 2007)

Math Equivalence Assessment

- Rittle-Johnson et al., 2011

Conceptual Knowledge – understanding the principles governing a domain	Procedural Knowledge – knowledge of specific action sequences to correctly solve a problem
Explicit – Equal Sign Knowledge <i>What does the equal sign mean?</i>	Learning Items – Same as those practiced during the intervention $7 + 6 + 4 = 7 + _$
Implicit – Equation Structure Knowledge $3 + 5 = 5 + 3$ True or False	Transfer Items – Different from those practiced during the intervention $8 + _ = 8 + 6 + 4 \quad 6 - 4 + 3 = _ + 3$

Table 1: Summary of Hierarchical Multiple Regression Analyses for Variables Predicting Overall Math Equivalence Performance (N=118)

Predictors	ΔR^2	Posttest			Retention Test			
		B	SE B	β	ΔR^2	B	SE B	β
Block 1	.25				.22			
Grade		13.07	6.49	.17*		4.69	5.27	.08
Pretest ME Score		.98	.19	.43**		.82	.16	.45**
Block 2	.09				.06			
Grade		12.49	6.16	.16*		4.37	5.12	.07
Pretest ME Score		.74	.20	.32**		.70	.16	.38**
Working memory		6.19	2.59	.20*		1.92	2.15	.08
Fluency		2.25	.84	.21**		1.90	.70	.22**
Total R^2	.34				.28			
F	14.33**				11.03**			

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

Results

- Controlling for grade and prior math equivalence knowledge, hierarchical regression models indicated that both working memory and fluency predicted students' overall mathematical equivalence knowledge at posttest (see Table 1).
- However, at the retention test, students' working memory was no longer significant, whereas fluency still predicted math equivalence over and above grade, prior knowledge, and working memory.
- Additional analyses indicated that fluency predicted outcomes on both procedural and conceptual knowledge subscales at posttest and retention test, whereas working memory only predicted procedural knowledge at posttest.
 - Findings for **procedural knowledge** show a similar pattern as seen in Table 1 for overall mathematical equivalence knowledge. Both working memory ($\beta = .24, p < .01$) and fluency ($\beta = .19, p < .05$) predicted students' procedural knowledge at posttest. At retention test, only fluency ($\beta = .26, p < .01$) remained significant.
 - For the **conceptual knowledge** subscale, only fluency predicted students' conceptual knowledge at both posttest ($\beta = .48, p < .01$) and retention test ($\beta = .15, p = .05$) over and above grade, prior ME knowledge and working memory.

Conclusion

- While both working memory and fluency seem to impact immediate learning of math equivalence, only fluency remains important for knowledge retention.
- Similarly, while both working memory and fluency impacted learning of procedural knowledge, only fluency predicted gains in conceptual knowledge.
 - Instruction focused on key concepts, so ability to strategically search and retrieve information from memory (i.e., fluency) may help students to better attend to, process, and apply conceptual instruction.
- Future mathematics studies with young children should account for the dynamic relations between different aspects of cognitive ability.

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