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The role of feedback type and working memory capacity during problem solving

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Feedback: What is it?

Any information the learner can use to confirm, reject, or modify prior knowledge in the target domain (Mory, 2004)

None | Yes/No | Correct response | Explanation

Amount of information varies on a continuum

I focus on minimal corrective feedback in a problem-solving setting that is used to help learners detect errors and generate correct alternatives (Dempsey, Driscoll, & Swindell, 1993)

Feedback is Often Recommended

"Optimal approaches should include… timely feedback" (Alfieri et al. 2011)

"Feedback…should be incorporated into all classrooms" (Steedly et al. 2008)

"The importance of feedback in promoting learning is inarguable" (Moreno, 2004)

Meta-analyses confirm feedback's positive effects on average
(e.g., Alfieri et al., 2011; Bangert-Drowns et al., 1991; Kluger & DeNisi, 1996)

Yet the effects of feedback vary, suggesting some types of feedback are more beneficial than others

Feedback Type

Outcome Feedback

Provides informati
learner's answer

$3 + 4 + 5 = 5 + \boxed{17}$

Most common in educational and research contexts (Hattie & Timperley, 2007; Pianta et al., 2007)

Related to positive effects compared to no feedback for children's problem solving (Baroody et al., 2013; Bohlmann & Fenson, 2005; Tudge et al., 1996)

Strategy Feedback

rmation about
vas obtained

Recommended by several researchers (Earley et al., 1990; Clifford, 1986; Kamins & Dweck, 1999)

Better than outcome feedback in terms of strategy selection (Luwel et al., 2011)

And potentially transfer (Schunk & Swartz, 1993)

Cognitive Demands

Though strategy feedback has potential advantages, it may tax cognitive resources to a greater extent

- Strategy feedback less common than outcome feedback; more cognitive resources used when something is unfamiliar
  (e.g., Anderson, 1982; Kirschner et al., 2006)

- Strategy feedback concerns more complex information (generally multi-step solutions generate a single answer); more cognitive resources used when content is complex
  (e.g., Sweller et al., 1998)

Individual Differences in WM Capacity

Due to the potentially high demands of strategy feedback, it may not be effective for all learners

Working memory is the cognitive system that is used to select, regulate, and process task-relevant information, including feedback (Alloway, 2006)

Further, working memory capacity varies across individuals, with some demonstrating higher WM capacity than others (Conway et al., 2005)

Individual Differences in WM Capacity

Those with higher WM capacity may be more capable of learning from certain feedback types

For children with lower WM capacity:

- Cognitive demands of strategy feedback may overwhelm limited resources, create cognitive overload
- May benefit instead from familiar outcome feedback

For children with higher WM capacity:

- Strategy feedback may represent desirable difficulty; may place greater demands but not enough to overwhelm resources (Bjork, 1994)

Current Study

Examined the cognitive demands of outcome- and strategy-feedback and whether their impact on learning outcomes depended on learners' WM capacity

Hypotheses:

For children with lower WM capacity, outcome-feedback more effective than cognitively-demanding strategy-feedback

For children with higher WM capacity, strategy feedback may be as or more effective than outcome feedback

Math equivalence problems

Concept that two sides of an equation represent the same amount and are interchangeable

- Problems contain operations on both sides of the equal sign

$$3 + 7 + 8 = 3 + \_$$

$$6 + 4 = \_ + 8$$

- Problems are both novel and difficult for elementary school children in U.S.

(e.g., McNeil & Alibali, 2005; Rittle-Johnson et al., 2011)

Participants and Design

Participants: 64 second- and third-grade children

- *M* age = 7.9 yrs; Range = 6.8 – 9.8 yrs
- 35 girls, 29 boys
- Predominantly African American (98%)

Session 1: Pretest (20 minutes)

- Excluded if score >80% on pretest measures

Session 2: One-on-one intervention & posttest (60 minutes)

Session 3: Two-week retention test (20 minutes)

Tutoring Intervention

1. Exploratory Problem Solving
   - Attempt to solve 12 math equivalence problems
   - Randomly assigned to 1 of 2 conditions
     - Outcome Feedback (n = 33)
     - Strategy Feedback (n = 31)

2. Rate subjective cognitive load

3. Brief conceptual instruction

Exploratory Problem Solving

Find the number that goes in the blank.

$3 + 4 + 8 = 3 + \square$

Outcome Feedback: Report numerical answer.

"Good try, but you did not get the right answer. [Child's answer] is not the correct answer."

Strategy Feedback: Report problem solving strategy.

"Good try, but that is not a correct way to solve that problem. [Child's strategy] is not a correct way to solve it."

Rate Subjective Cognitive Load

Adopted language from three existing items.

Effort: “I had to work hard to solve these problems.”
(NASA Task Load Index, Hart & Staveland, 1988, 5 point scale)

Frustration: “I was stressed and irritated when I solved these problems.”
(NASA Task Load Index, Hart & Staveland, 1988, 5 point scale)

Task Difficulty: “How easy or hard was it so solve all of those problems?”
(Paas, 1992, 7 point scale)

Brief Conceptual Instruction

Let's take a look at this problem.

3 + 4 = 3 + 4

There are two sides to this problem, one on the left side of the equal sign and one on the right side of the equal sign…

The equal sign means that the left side of the equal side is the SAME AMOUNT AS the right side of the equal sign. That is, things on both sides of the equal sign are *equal* or the *same*.

Posttest and Retention Test

Procedural Learning Items ($\alpha = .69$)	Procedural Transfer Items ($\alpha = .76$)
$8 = 6 + \_\_$	$\_\_ + 2 = 6 + 4$
$3 + 4 = \_\_ + 5$	$8 + \_\_ = 8 + 6 + 4$
$3 + 7 + 6 = \_\_ + 6$	$5 + 6 - 3 = 5 + \_\_$
$7 + 6 + 4 = 7 + \_\_$	$5 - 2 + 4 = \_\_ + 4$

Used at Posttest & Retention Test

(Matthews, Rittle-Johnson, McEldoon, & Taylor, 2012; Rittle-Johnson, Matthews, Taylor, & McEldoon, 2011)

Working Memory Assessment

Backward Digit Span Task (Wechsler, 2003)

6, 2, 9, 4

Experimenter

4, 9, 2, 6

Child

Series length: *min* = 2 numbers in a row, *max* = 8

Scores consisted of the number of series the child correctly recalled (M = 3.4, SD = 1.3, range = 7)

Results

Procedural Learning

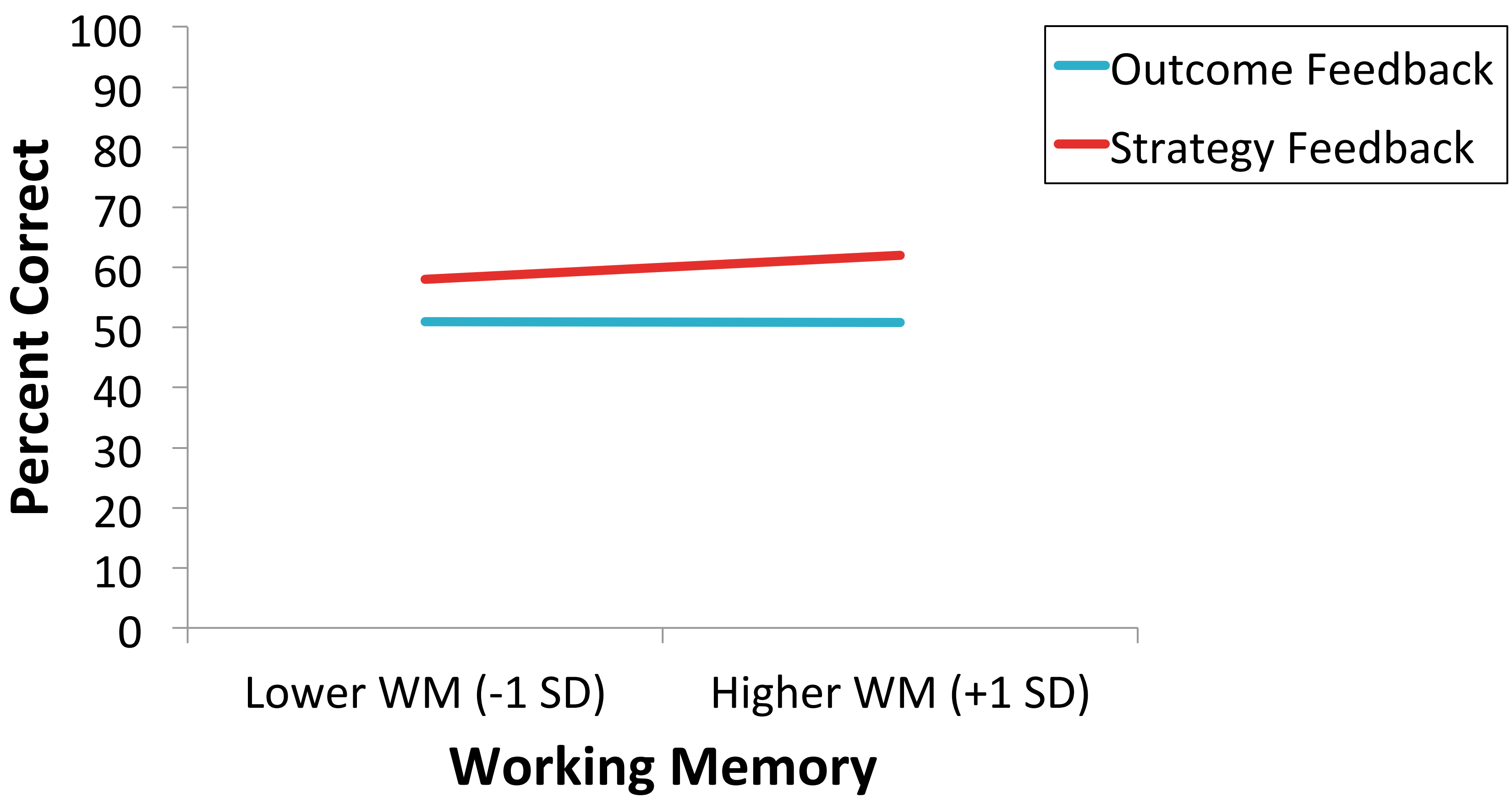
Procedural Transfer

- Collapsed across posttest and retention test

Cognitive Load

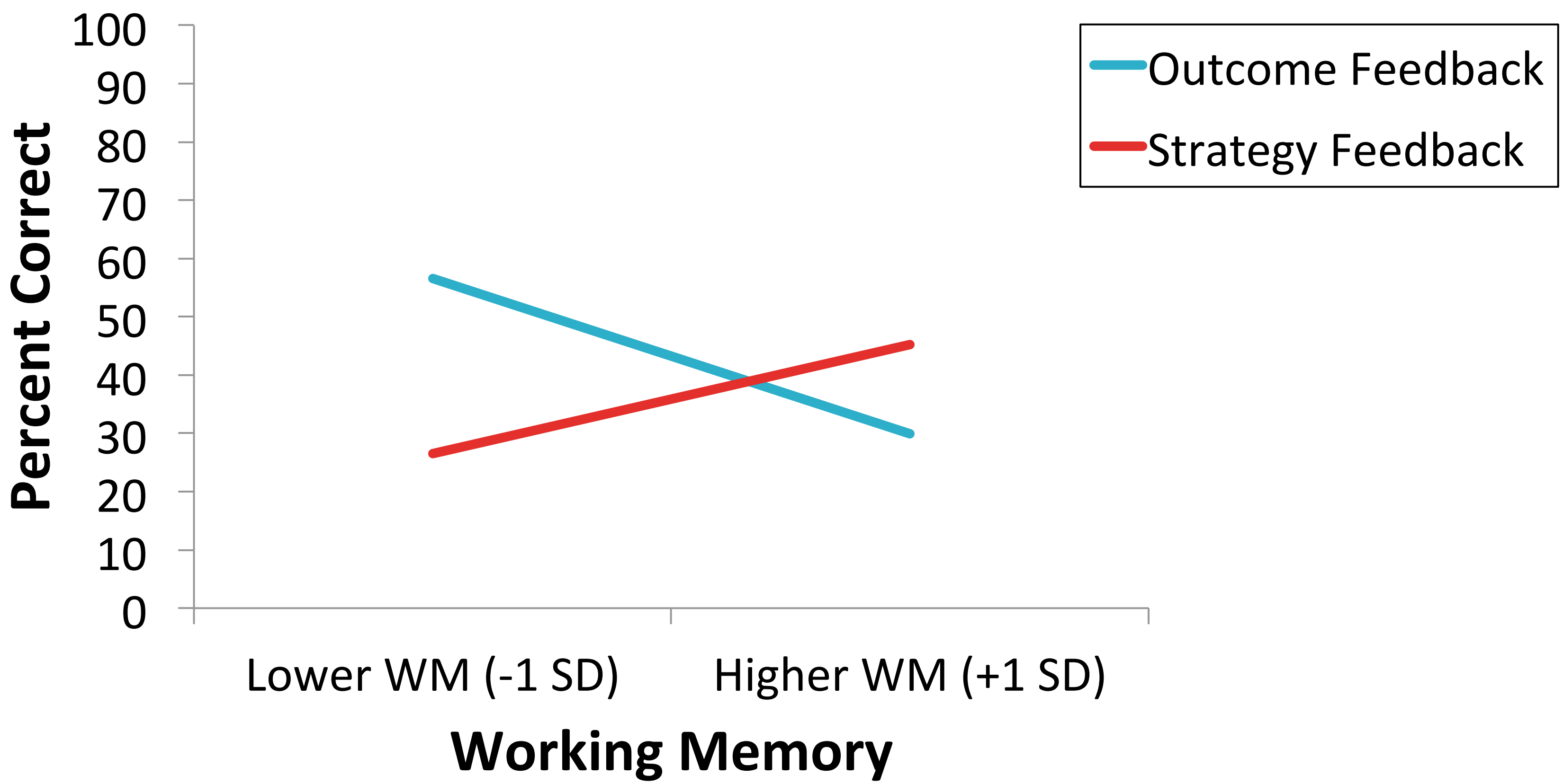
- Effort
- Frustration
- Task Difficulty

Procedural Learning



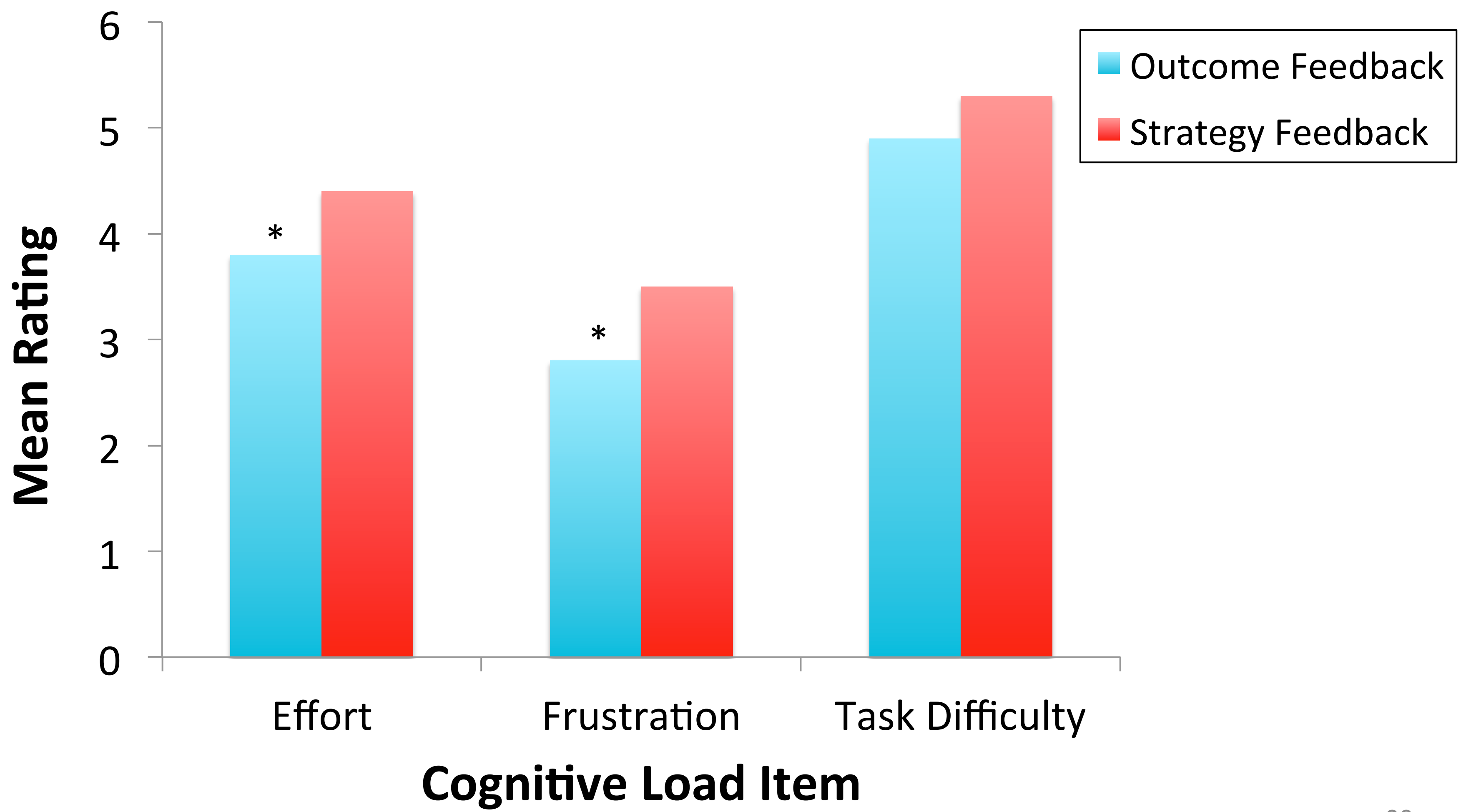
No effects of condition or WM. All children perform similarly on procedural learning.

Procedural Transfer



Condition by WM interaction. Outcome FB better for lower WM learners. No difference for higher WM learners.

Cognitive Load



Summary and Discussion

In contrast to researchers' suggestions, we found no evidence that strategy-feedback is more effective than outcome-feedback and some evidence that it can be detrimental

(e.g., Earley et al., 1990; Luwel et al., 2011)

For children with lower WM capacity, outcome-feedback better than strategy-feedback

For children with higher WM capacity, the differences were not reliable

Summary and Discussion

One reason for detrimental effects of strategy-feedback may be cognitive overload

(e.g., Sweller et al., 1998)

Suggest that educators should consider the content and cognitive demands of feedback

Suggest that WM capacity is a key individual difference to consider in learning contexts

(e.g., Alloway, 2006)

Thank You

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