Self-Explanation as a Tool for Discovering Early Algebra Procedures: The Importance of Working Memory Capacity

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How can self-explanation help students develop math skills?

To develop new problem-solving approaches, students must integrate new information with relevant prior knowledge (Chi et al., 1989).

Self-explanation is one learning technique that can support such knowledge integration during learning (Atkinson et al., 2000).

Self-explanation is often elicited by showing students a correct answer and asking them to explain the underlying rationale.

> **3 + 7 = ☐ + 6**
>
> Alex got 4, which is the right answer.
>
> How do you think Alex got 4?
>
> Why is 4 the right answer?

However, self-explanation does not always help (e.g., Matthews & Rittle-Johnson, 2009; Mwangi & Sweller, 1998).

Self-explanation may be especially beneficial when used as a **discovery tool**, prior to instruction.

When students solve problems prior to receiving instructions, they must discover what information is most relevant.

Self-explanation may help guide students in selecting relevant information and integrating this information with their prior knowledge during discovery learning.

Students who are higher in **working memory capacity** may be best equipped for such guided discovery learning through self-explanation.

Working memory capacity enables students to actively select and retrieve relevant information in the face of interfering information (Rosen & Engle, 1997).

Current Study

We tested these ideas by tutoring children about **mathematical equivalence** (that quantities on both sides of the equal sign equal the same value), a critical concept for learning algebra (Carpenter et al., 2003; Knuth et al., 2006).

Method

N=115 2nd-4th grade students at a suburban public school

Pretest → Individual Tutoring Session → Immediate Posttest → 2-Week Retention Test

4 Tutoring Conditions: 2 (Order of Instruction) x 2 (Problem Solving Condition)

Order of Instruction: Students received instructional explanations about the equal sign either before problem solving (**Instruct→Solve**) or after (**Solve→Instruct**).

Problem Solving Condition: During problem solving, students either **self-explained** or completed additional **practice** (to control for time on task).

Solved 6 equations (+6 additional in practice condition)

8 + 4 = 5 + ☐

Assessments

Near Transfer: Solve 7 Equations — **8 + ☐ = 8 + 6 + 4**

Far Transfer (retention only) — **43 + ☐ = 48 + 76**

Working Memory Measure: Backwards Digit Span (Wechsler, 2003)

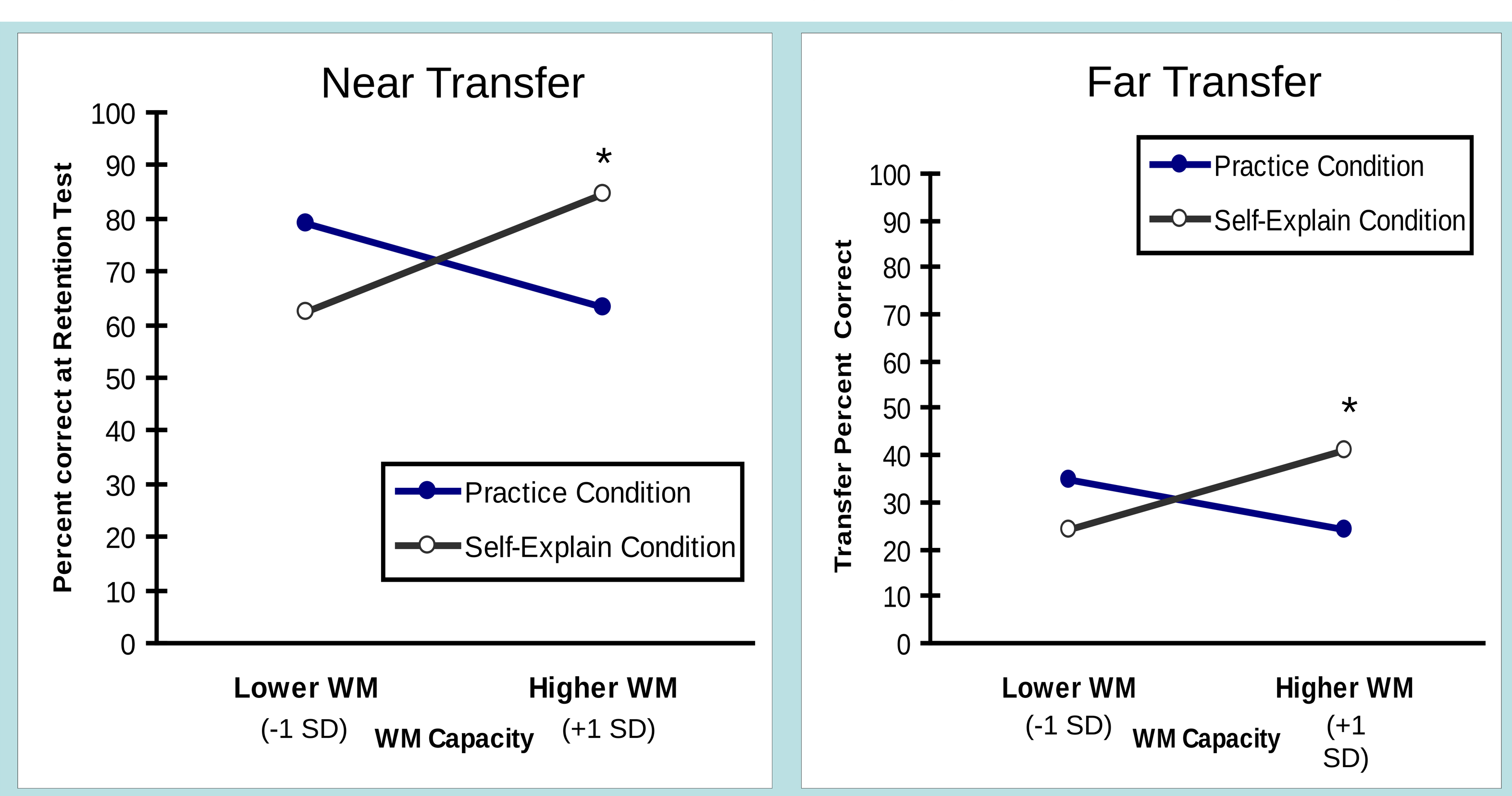
Retention Test Results

Order x Condition x WM marginal interactions:

Near Transfer, B=15.73, p<.10; Far Transfer, B=9.90, p<.10.

Solve → Instruct Condition

Condition x WM interaction: Near Transfer, B=13.32, p=.03; Far Transfer: B=9.86, p<.02



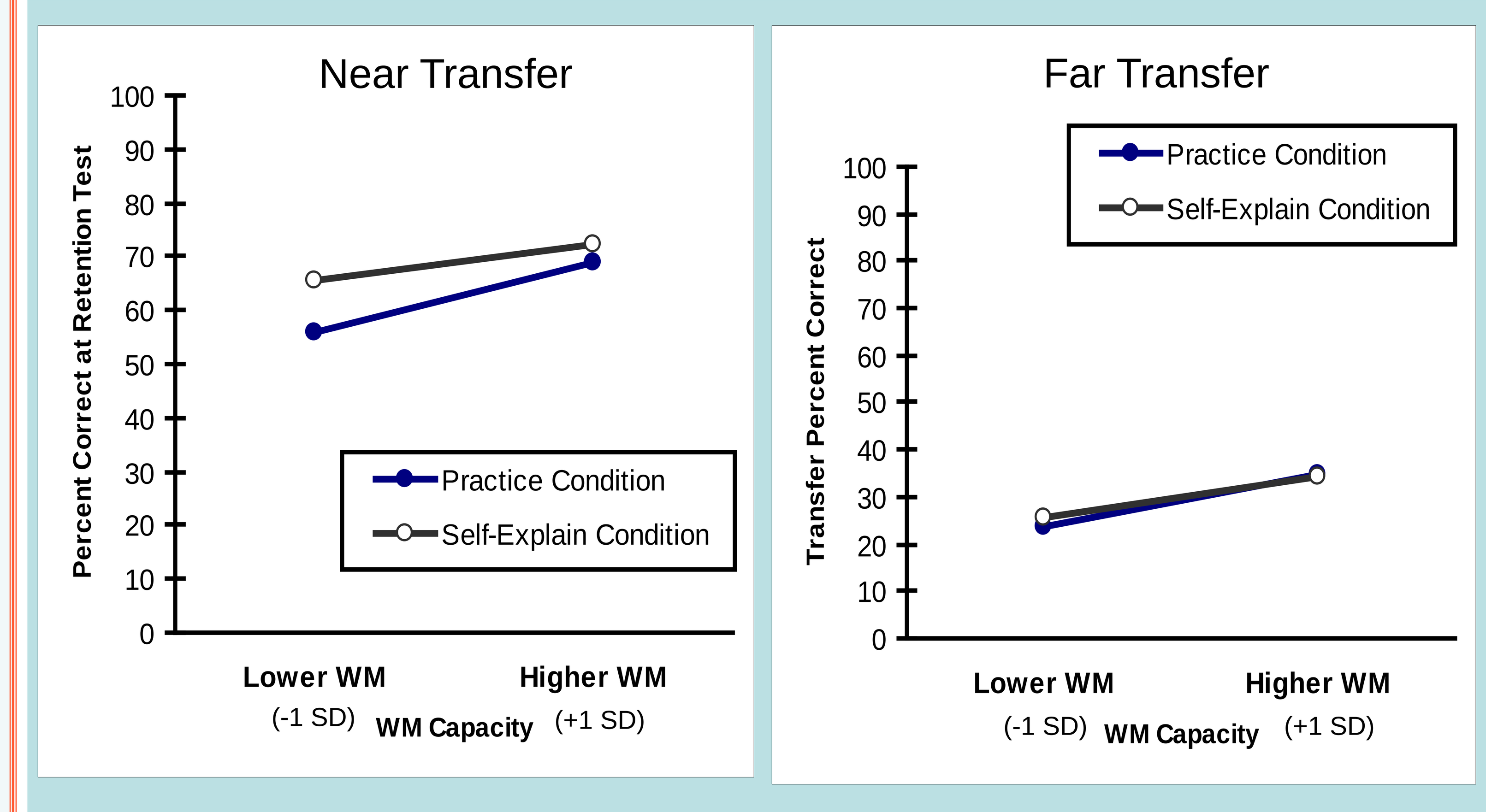
*At +1SD, condition B=17.74, p<.05, one-tailed

*At +1SD, condition B=14.56, p<.03, one-tailed

Students with higher working memory benefited most at transfer in a guided discovery learning condition.

Instruct → Solve Condition

No Condition × WM interactions: Near Transfer, B=-2.37; Far Transfer, B=-.95, ns



Self-explaining after instruction did not impact learning differently than practice alone (for students higher or lower in working memory).

Conclusion

- Self-explanation prompts only helped when children learned by discovery and were high in working memory capacity. This was true for near and far transfer problems on a 2-week retention test.
- The benefits of discovery learning may be heightened for students higher in working memory capacity, if guided by a self-explanation activity that draws attention to relevant information.
- When designing optimal learning environments, it is important to consider learners' cognitive abilities.

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