Is There A Role for Cognitive Processes in Interventions for At-Risk Students with and without Disabilities?

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- Despite important advances in LD intervention research, the dominant approach to intervention – direct skills instruction – fails to meet the needs of a substantial portion of students at risk for LDs and students with LDs.
- This, combined with the heterogeneity of LDs, suggests the need to identify innovative approaches that target the specific needs of subgroups of students with LDs.
- One approach for identifying subgroups is to focus on the cognitive, linguistic, and socio-emotional processes related to learning (e.g., working memory, oral language, anxiety).

In this talk, we use the term cognitive processes broadly to include these three domains.

- The role of cognitive processes in instruction has a shaky history. "Perceptual-motor training" and "aptitude X treatment interactions" were explored decades ago and proved unsuccessful. These ideas were largely put aside.
- The topic has re-emerged with a dominant focus on WM training. The literature suggests promise for WM training for improving WM capacity (e.g., Melby-Lervag & Hulme, 2012: mean ES = 0.55 on verbal WM tasks).
- But transfer for at-risk learners to reading and math outcomes is lower than what's found for many direct skills interventions.

Our Research Program Focuses on Other Roles for Cognitive Processes in the Treatment of LDs

In this talk, we focus on integrating cognitive training with direct skills intervention. The goal is to strengthen cognitive resources while building and facilitating transfer to academic performance.

We present 2 studies illustrating this approach at first grade.

Doug's study: Does WM training, conducted with reading stimuli and in the context of direct skills reading intervention, have added value over direct skills intervention alone on reading comprehension outcomes?

Lynn's study: Does language comprehension instruction, embedded in direct skills word-problem intervention, have added value over word-problem intervention alone on word-problem outcomes?

Exploring the Value of Working Memory Training When Combined with Skills-Based Instruction in Reading Comprehension

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Importance and Purpose

- In a 5-year program of research, we developed and validated a reading comprehension program for 1st graders, and a WM training program, to be conducted as part of the reading program, in hopes of making it effective for children with severe reading difficulties.
- In Years 1-3, we developed a program that combined decoding instruction and fluency practice (DF) with reading comprehension (Comp) instruction. Although generally effective, it wasn't effective for all.
- In Years 4-5, we explored whether adding a WM training component to DF+Comp provided added strengthen. We had 3 study groups in Years 4-5:
  - WM+DF+Comp
  - DF+Comp
  - Control

Importance and Purpose

- Why develop a reading comp program at 1st grade?
- Amy Elleman conducted a comprehensive review of about 22 studies of reading comp programs in K-2. Of these, we found only 4 studies meeting these criteria: (a) RCTs, (b) 1st grade at-risk children, (c) standardized, normative measures of word recognition and comprehension, (d) intent to treat analyses.
- Baker et al. (2000), Mathes et al. (2006), Schwartz (2005), and Taylor et al. (1991).
- Each of the researchers' reading programs was superior to controls on word-level skills, but not reading comprehension.

Importance and Purpose

- The reading programs in the 4 studies reflected an approach popular across decades: explicit strategy instruction to compensate for cognitive and linguistic weaknesses.
- When implemented with fidelity, it accelerates the progress of aspects of many children's reading, writing, and math (e.g., Graham & Perin, 2007; Kroesbergen & VanLuit, 2003). But there 2 important caveats. One, it rarely has strengthened reading comp among young at-risk students.
- Two, there are always non-responders. RTI implementation in the past decade shows this (e.g., Al Otaiba & Fuchs, 2006; Ikeda et al. 2005; McMaster, Fuchs, Fuchs; Telzrow et al., 2000; Vaughn et al., 2010).

Importance and Purpose

- Which brings me to working memory (WM).
- WM is mostly about executive attention (e.g., Engle et al., 1999). It may be considered a process, or set of processes, that help us store information and act on that information by updating and transforming it while ignoring irrelevant information.
- According to Engle et al., executive attention should be viewed as a *domain-general* process that sets limits on attentional resources.

Importance and Purpose

If so, then successful WM training should strengthen WM performance (near transfer) and academic performance (far transfer) because it strengthens the "muscle" that powers competent performance on real-world tasks.

In accord with this "domain-general" perspective on WM, cognitivists have developed WM training that separate (and decontextualize) WM processes from how we use them to perform academic and non-academic tasks. "CogMed" is a popular WM training program consisting of such decontextualized tasks.

Importance and Purpose

- Correlational evidence connects WM and academic performance, including reading comprehension (e.g., Cain, 2004).
- Meta-analyses of training studies show WM training exerts short-term improvements on verbal and non-verbal WM tasks.
- But the short-term effects are not sustained, and transfer effects to academic tasks are modest especially in children with learning problems (Melby-Lervag & Hulme, 2012; Shipstead et al., 2012).
- One explanation of such outcomes may be the of the training from the academic tasks.
- One aim of our work was to connect, or embed, WM training in reading instruction; to combine the two so the cognitive training tasks become more like academic tasks. WM training may thus be an important supplement to explicit, skills-based instruction. Hence, WM+DF+COMP vs. DF+COMP vs. Control.

Teachers & Schools

In 2 consecutive years, we recruited 70 teachers in 13 schools in the Metropolitan-Nashville School District.

School characteristics
- Free or Reduced Lunch: M = 74.6% (range: 40.8%-99.1%)
- African-American: M = 41.4% (18.2%-95.5%)
- 95% to 100% attendance: M = 71.6% (59.3%-95%)
- Below proficien in reading: M = 59.6% (38.0%-79.9%)

Students

- Teachers nominated poorest readers without behavior or attendance problems. We screened them in 2 steps.
- First, we tested them on TOWRE Sight Word Efficiency and Decoding Efficiency; rapid letter naming and sound naming tasks; WIF; and WRMT - WI and WA subtests. A factor score was calculated for each student. The top 20% were eliminated.
- Remaining students were administered WASI Vocabulary and Matrix Reasoning. Those with T scores less than 37 on both subtests were excluded.
- Students were randomly assigned to the 3 study groups within schools whenever possible. There were no significant differences on the screening measures.

Tutoring: General Description

- Children were tutored 1:1, 45 min per session, 3 times per wk for 20 wks (60 lessons). 45 hrs.
- Decoding/Fluency (DF): 25 min
- Reading Comprehension (Comp): 20 min
- In WM+DF+Comp, WM training was embedded in both DF and Comp activities.
- Instructional time was equal for the 2 treatment groups; so, less reading instruction in the WM+DF+Comp group.
- Tutors followed lesson guides (but did not memorized or read guides). Sessions were audiotaped.

DF Component

- DF training and practice were implemented with 10 texts ordered by difficulty. Performance on a DF placement test determined where in the sequence of texts a student started. Students' responsiveness to instruction during the lessons determined if they repeated or skipped lessons.
- The DF component comprised letter sounds, decodable words, sight words, and reading connected text with fluency and accuracy.

DF: Sight Word + WM Training

Complex span tasks were embedded in sight word instruction.

- **Word & Seek**: Students read words specified and then covered them with cards. The tutor chose 1 word for the students to find.
- **Remember the Word**: Students read a series of words with a grapheme or digraph specified and covered them with cards. Then the student recalled the covered words in forward order.
- **Word Reverse**: Students read specified words and covered them; then recalled the covered words in backwards order.
- **Make-A-Sentence Recall**: Students read specified words, made a sentence with them, covered them, recalled the covered words in forward order.

Reading Comprehension Component

Pre-Reading
- Vocabulary
- **Ambiguous pronouns**
- Background knowledge

Post-Reading
- **Main idea**
- Reasoning
- Inference-making

Pre-Reading: Ambiguous Pronouns

- This was a sentence level activity requiring use of logical inferencing and text clues to resolve ambiguous pronouns.
- **WM version**: Student is provided with 3 sentences. For each, she is asked to identify the correct pronoun antecedent. Then she is encouraged to recall all the 3 antecedents in correct order.

Post-Reading: Main Idea

- Who is the most important person? Naming all the characters; choosing the one who is most important.
- What was the most important thing? Naming all the things and events that happened; then the most important of the lot.
- Putting the 2 together to express the main idea.
- **WM Version:** Remembering main ideas in correct order across units of text.
- More difficult variations.

Fidelity

- **Testing.** 1 wk after training (or re-training for post-treatment testing), each RA "tested" project staff on all measures. RAs had to show at least 90% accuracy when administering and scoring every test. If < 90%, the RA completed additional training.
- **Tutoring.** Checklists were used to estimate adherence to the tutoring protocols. Before tutoring, the RAs had to show at least 90% accuracy when tutoring project staff. During the 20-wks of tutoring, there were 3 "live" fidelity checks of each RA. Averaged across RAs and occasions, fidelity was 93% (84% to 98%).

Testing and Scoring

All RAs were unfamiliar with the children they tested at pre- and post-treatment, and were "blind" to the children's study group.

Selected tests of each RA were scored again by a different RA. Interscorer agreement was calculated on 15% of the data at pre- and post-treatment.

Measures

- **Cognitive measures**
  - Working Memory: Listening recall (WMTB) and Counting Recall (WMTB)
  - Short-term Memory: Digit Recall (WMTB) and Non-word Recall (WMTB)
  - Updating: *N*-back
- **Reading measures**
  - Word Reading: TOWRE (Sight Word Reading Efficiency); WRMT (Word Identification); Word Identification Fluency (WIF; Form A)
  - Non-word reading: WRMT - Word Attack, TOWRE-Phonemic Decoding Efficiency
  - Reading Comprehension: WRMT (Passage Comprehension); ITBS (Reading Comprehension)
- **Listening comprehension measure**
  - WRMT (Listening Comprehension) , QRI-Passage Retell, and QRI-Passage Comprehension

Factor Scores

We computed pre-treatment and post-treatment factor scores.

1. **WM:** WMTB-Listening Recall & Counting Recall
2. **Short-Rerm Memory:** WMTB-Digit Recall and WMTB- Non-word Recall.
3. **Word Reading**: Test of Word Reading Efficiency (TOWRE)-Sight Word Efficiency and Word Identification Fluency; Woodcock Reading Mastery Test-Revised (WRMT), Word Identification
4. **Non-Word Reading**: TOWRE-Phonemic Decoding Efficiency and WRMT-Word Attack.
5. **Phonological Awareness**: Sound Segmenting; Timed Sound Blending; & Untimed Sound Blending.
6. **Reading Comprehension**: Iowa Test of Basic Skills & WRMT – Passage Comprehension.
7. **Listening Comprehension**: WRMT – Listening Comprehension; Qualitative Reading Inventory – Passage Retell; & QRI-passage comprehension.

Because we had only 1 measure of pre-and post-**Updating**, we used the raw score.

Treatment Effects

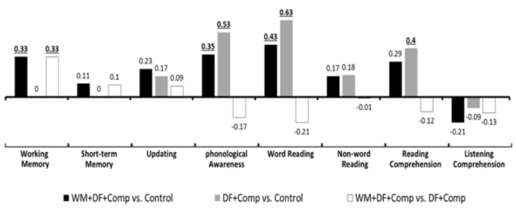
We did *not* find cohort main effects or interactions between cohort and study groups. Thus, cohort was dropped from further analyses.

We investigated group differences on post-treatment WM, short-term memory, updating word reading, non-word reading, reading comprehension, and listening comprehension.

Due to small to medium school effects (ICCs = 3%~19%), we used 2-level models in which students were nested within schools.

At the student level, we examined treatment effects by controlling relevant pre-treatment scores.

Results



Note: Results are post-treatment factor scores controlling for the relevant pretreatment measure.

Discussion

- The WM+DF+Comp group performed significantly better than the DF+Comp and Control groups on WM. WM+DF+Comp students also outperformed controls on phonological awareness and reading recognition, as did DF+Comp students.
- Most importantly, only DF+Comp children did better than controls on comprehension. WM+DF+Comp students did not.
- In other words, WM training (as we operationalized it) improved WM performance, but did not improve any aspect of reading performance beyond the effects of DF+Comp.
- What's next? We may get better at integrating WM tasks into word reading and reading comprehension instruction. When WM+DF+Comp beats DF+Comp, a good question will be, "Is the causal mechanism cognitive training or stronger skills instruction?

Switching Gears

- We next focus on embedding WP-specific language instruction in WP intervention.
- Again we work at first grade.
- But here, we attempt a tighter connection between embedded instruction and direct skills intervention.

Embedding Language Comprehension Instruction within Word-Problem Intervention

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Why Focus on WPs at First Grade?

- First-grade number knowledge intervention with speeded arithmetic practice dramatically narrows the arithmetic achievement gap.
- At the same time, the WP achievement gap widens dramatically. This is problematic because
  - WPs represent a major emphasis in almost every strand of the math curriculum.
  - WP performance is a strong predictor of wages in adulthood.
- Yet, early math research has focused dominantly on number knowledge and arithmetic, with only minor focus on WPs, in the service of supporting number knowledge.

Why Focus on Language Comprehension to Improve WP Performance?

- Based on Kintsch et al. (1985), WP solving is an interaction between language comprehension (LC) processes and math problem-solving strategies that rely on reasoning and WM.
- When faulty problem solving is computationally modeled with math problem-solving errors v. LC errors (Cummins et al.,1988)
  - Correct problem representation depends more on LC
  - Changing wording in minor ways dramatically affects accuracy.
- Common assumption: Students have the LC for understanding problem statements and building an appropriate problem model.
- But for at-risk children, this assumption is shaky. This suggests that an instructional focus on LC processes as well as the mathematical aspects of WP solving may be needed.

Why *Embed* Language Instruction in WP Intervention?
(instead of providing conventional language therapy)

- Language therapy improves oral language comprehension, but transfer to academic performance is limited (Catts & Kamhi, 2017), despite a strong association between LC and academic performance.
- Transfer from language therapy to academic performance may be especially difficult for at-risk students who
  - Have an inadequate foundation of academic skill
  - Experience substantial challenges with transfer.
- This argues for conducting language instruction in the context of direct skills intervention. We adopted this approach in the present study.

WP Intervention

- We rely on a form of schema-based instruction, explicitly teaching step-by-step problem-solving strategies to reduce demands on reasoning and WM.
- This includes strategies for understanding WPs as belonging to WP types and strategies for building WP models.
- At grade 1, we address the 3 major problem types
  - Total: 2 or more parts are combined to form a total
  - Difference: 2 quantities are compared
  - Change: an event occurs to increase or decrease a starting amount

WP Intervention

We teach the mathematical structure of each problem type.

- Role playing the problem type s central mathematical event using intact number stories (no missing quantities), concrete objects, & the child s/tutor s names
- Connecting the central mathematical event to
  - A visual schematic (into which story quantities can be entered; this is faded quickly, used only as needed)
  - A hand gesture (to quickly remind students of the schematic)
  - A problem-type sentence
    - Total: P1 + P2 = T
    - Difference: B – s = D
    - Change: St +/- C = E
- Then introducing problems (with missing quantities) using role playing, the problem type s schematic, hand gesture, and problem type sentence.

WP Intervention

We then teach step-by-step strategies for building WP models and solving problems.

- RUN through the problem.
  - <u>R</u>ead the problem.
  - <u>U</u>nderline the word that indicates what the problem is mostly about.
  - <u>N</u>ame the problem type.
- Write that problem type s sentence.
- Enter relevant quantities from the WP statement into the problem type sentence while crossing out extra numbers.
- Solve for the missing quantity.

Total Problem

Kathy has 5 pencils and 3 erasers. Pamela has 7 pencils. How many <u>pencils</u> do the girls have in all?

T

Combine or "Total" Problem

Kathy has 5 pencils and 3 erasers. Pamela has 7 pencils. How many <u>pencils</u> do the girls have in all?

T

P1 + P2 = T

Combine or "Total" Problem

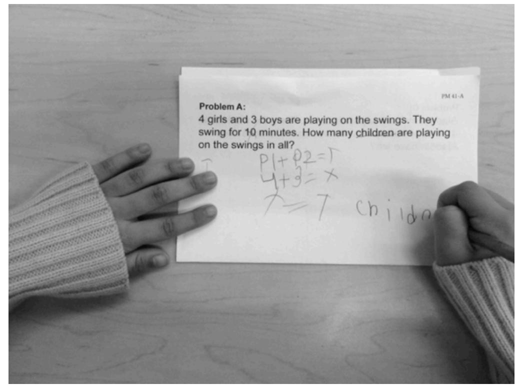
Kathy has 5 pencils and ~~3~~ erasers. Pamela has 7 pencils. How many <u>pencils</u> do the girls have in all?

T

P1 + P2 = T

5 + 7 = x

x = 12 pencils



Embedded Instruction

WP Vocabulary and Language Constructions

- Combine Problems
  - Joining words (e.g.,)
  - Superordinate categories (e.g., +)
- Compare Problems
  - Compare words (e.g., , - words)
  - Adjective *-er* v. verb *-er* words (e.g., v.)
- Change Problems
  - Cause - effect conjunctions (e.g.,)
  - Implicit quantity change verbs (e.g.,)
  - Time passage phrases (e.g., ,)
- Confusing cross-problem constructions (e.g., v. *then … more*)
- "Tricky" labels (e.g., questions with superordinate category words, without a label, noun that's the wrong label [as in money questions])

Embedded Language Instruction

WP Vocabulary and Language Constructions

- We do NOT teach vocabulary and language construction as key words.
- Explicitly teach why searching for key words and numbers, without reading the problem and without figuring out the problem type, often produces wrong answers.
- To help children appreciate this, we have them check the work of "other children" (worked problems we've prepared). Students find errors and explain how/why errors occurred. Worked examples
  - Rely on key words to select the wrong operation
  - Misuse irrelevant numbers
  - Fail to recognize 2-step problems.

Study Overview

- Risk = low arithmetic & math concepts/applications at start of 1st grade
- 400 (391 after attrition) students randomly assigned to 4 conditions
  - WP intervention
  - WP intervention + embedded LC instruction
  - Number knowledge intervention to answer the question
    Is transfer from number knowledge and arithmetic to WPs sufficient to support WP outcomes?
  - Control (school program, most with math intervention)
- Each active intervention condition
  - Lasted 15 weeks, 3 sessions per week, 30 min per session
  - Included 5 min of speeded, strategic arithmetic practice (to control of arithmetic skill)

3-Level models
accounting for schools (21) and classrooms (186)

Arithmetic Outcome

WPS[LC] = WPS = NK > C

<u>Effect Sizes</u>

NK v. C = 0.59

WPS v. C = 0.65

WPS[LC] v. C = 0.79

WP Outcome

WP[LC] > WP > NK = C

<u>Effect Sizes</u>

NK v. C = 0.09

WP v. C = 1.08

WP[LC] v. C = 1.75

WP[LC] v. WP = 0.47 (p < .001)

WP Language Outcome

WP[LC] > WP = NK = C

<u>Effect Sizes</u>

NK v. C = 0.17

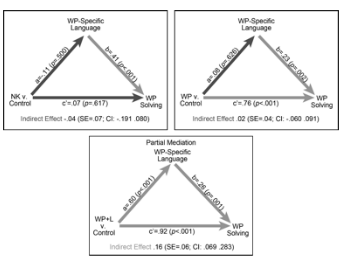
WP v. C = 0.16

WP[LC] v. C = 0.56

WP[LC] v. WP = 0.41

Does WP Language Mediate Condition Effects on WPS Outcomes?

Each multi-level model controls for pretest WPS and arithmetic.



Conclusions

- On WPS, NK intervention does not provide added value over control (ES=0.09), despite that NK intervention improves arithmetic skill (ES=0.59). So transfer from arithmetic to WPS is not sufficient to support WP development.
- On WPS, embedding LC instruction in WP intervention offers added value over WP intervention alone (ES=0.41).
- This added value accrues in part as a function of mediation via children's improved understanding of WP language.
- Results provide causal evidence for the role of LC in WPS.

Next Step

Does a link between WPS and RC, via LC, provide direction for understanding comorbid difficulty across WPS & RC?

2 P20 HD075443

- We test effects of intervention that explicitly connects WPS, RC, & LC in a sample of students with comorbid difficulty
- Study conditions
  - Direct skills <u>WP</u> intervention with embedded <u>WP</u>-L instruction
  - Direct skills <u>RC</u> intervention with embedded <u>RC</u>-L instruction
  - Control
- Conduct 2 tests of the "comorbidity hypothesis"
  - Whether reciprocal effects occur for
    - WPS intervention on RC outcomes
    - RC intervention on WPS outcomes
  - Whether LC improvement serves as a mediator of reciprocal effects, which would suggest LC is a process that links WPS & RC