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# Working Memory and Reading Difficulties

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# Reading Difficulties

## WHAT ARE THEY?

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## HETEROGENOUS

- Reading Comprehension
- Reading Fluency
- Reading Accuracy
  - Decoding (phonics)
  - Recognition (sight words)

# Reading Difficulties

## WHAT CAUSES THEM?

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- Genetics
- Inadequate instruction
- Hearing loss
- Specific Language Impairment (SLI)
- Auditory Processing Disorder (APD)
- Poor visual processing
- Poor visual attention
- Phonological processing deficit
- Phonemic awareness
- **Working memory**

# Working Memory

## WHAT IS IT?

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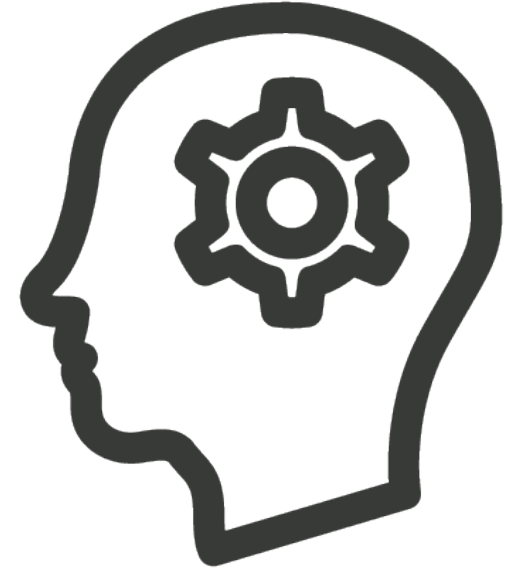
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### SHORT-TERM MEMORY

- Temporarily store information
- Maintain with rehearsal

### WORKING MEMORY

- Manipulate stored information
- Hold information during interference
- Develops from age 4 to early adulthood
- Deficits tend to become worse over time



# Working Memory

WHAT IS IT?

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## VERBAL MEMORY

Reading difficulties

## VISUOSPATIAL MEMORY

ADHD

# Reading & Working Memory

## RESEARCH THUS FAR...

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- There's a lot of research showing a correlation (coexistence) between reading difficulties and verbal working memory deficits
- This has led to the assumption of causation
- Causation can be tested with direct manipulation
- But at the moment there is no evidence that working memory training improves reading accuracy in children with reading difficulties

# Reading & Working Memory

## THE RESEARCH

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### **Question 1.**

Does verbal working memory training improve reading?

### **Question 2.**

Does reading training improve verbal working memory?

# Reading & Working Memory

## PARTICIPANTS

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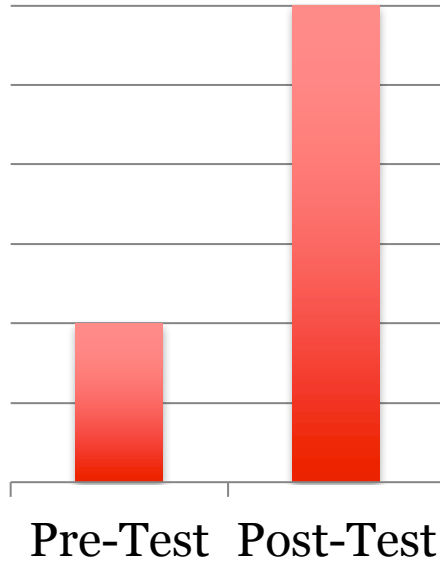
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- 7 to 12 years of age
- Reading accuracy below the average range expected for their age (lowest 15%)
- Verbal working memory difficulties below the average range expected for their age (study 1)
- No attention/behaviour difficulties

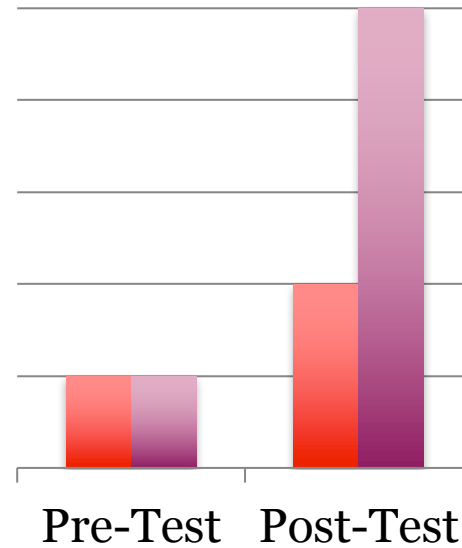




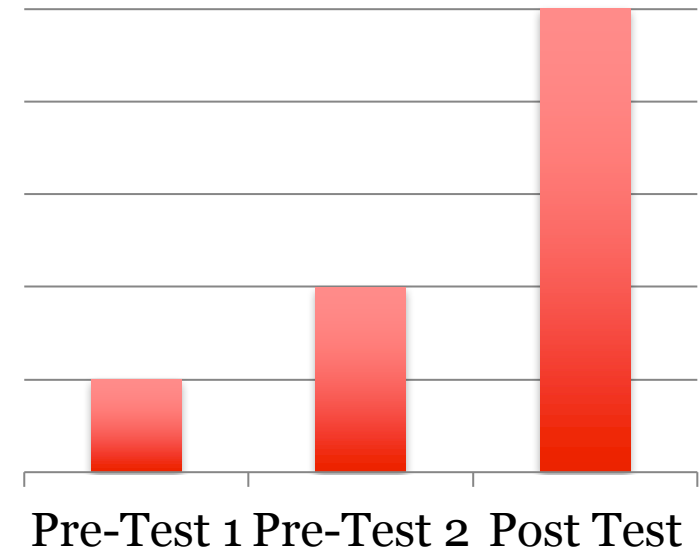
PreTest / PostTest ✗



Control Group ✓



Double Baseline ✓



# Method

## STUDY 1 DESIGN: CASE STUDY



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Design
Eligibility Test
Test 1
<b>Baseline 1 – No Training (8 weeks)</b>
Test 2
<b>Training 1 – Working Memory Training (8 weeks)</b>
Test 3
<b>Baseline 2 – No Training (8 weeks)</b>
Test 4
<b>Training 2 – Reading Training (8weeks)</b>
Test 5

# Method

## STUDY 1 DESIGN: CASE SERIES

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One-on-One training

Delivered via Skype

Adaptive

8 weeks per training type

3 training sessions per week

30 minutes per session

# Method

## STUDY 1 DESIGN: WORKING MEMORY TRAINING

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### Animal N-Back

“Cat – Dog – Pig – Horse”

“Penguin – Fish – Tiger – Rabbit – Possum – Lion”

### Listening Recall

“Pilots fly Planes”

“True”

“Cameras take photos ”

“True. Planes, Photos”

# Method

## STUDY 1 DESIGN: READING TRAINING

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Decoding

Sight Words

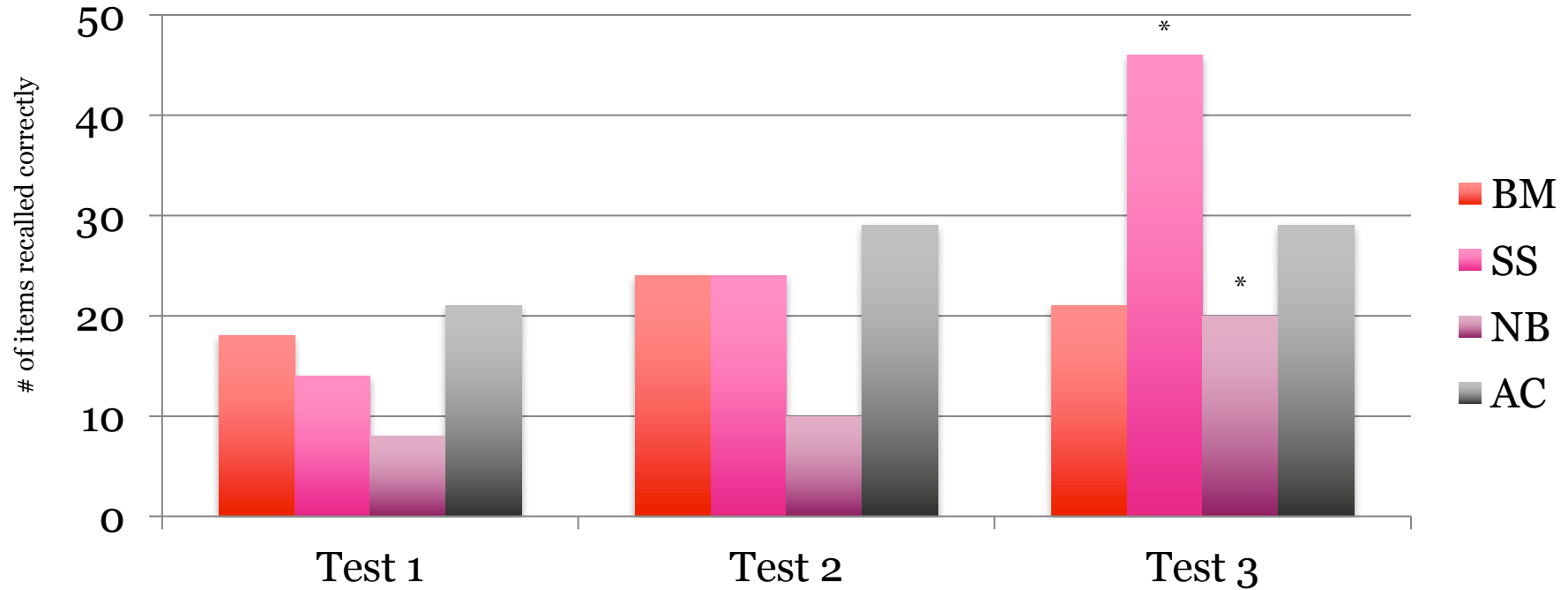
Reinforced Reading (Text Reading)

# Working Memory

DOES WORKING MEMORY TRAINING IMPROVE WORKING MEMORY?



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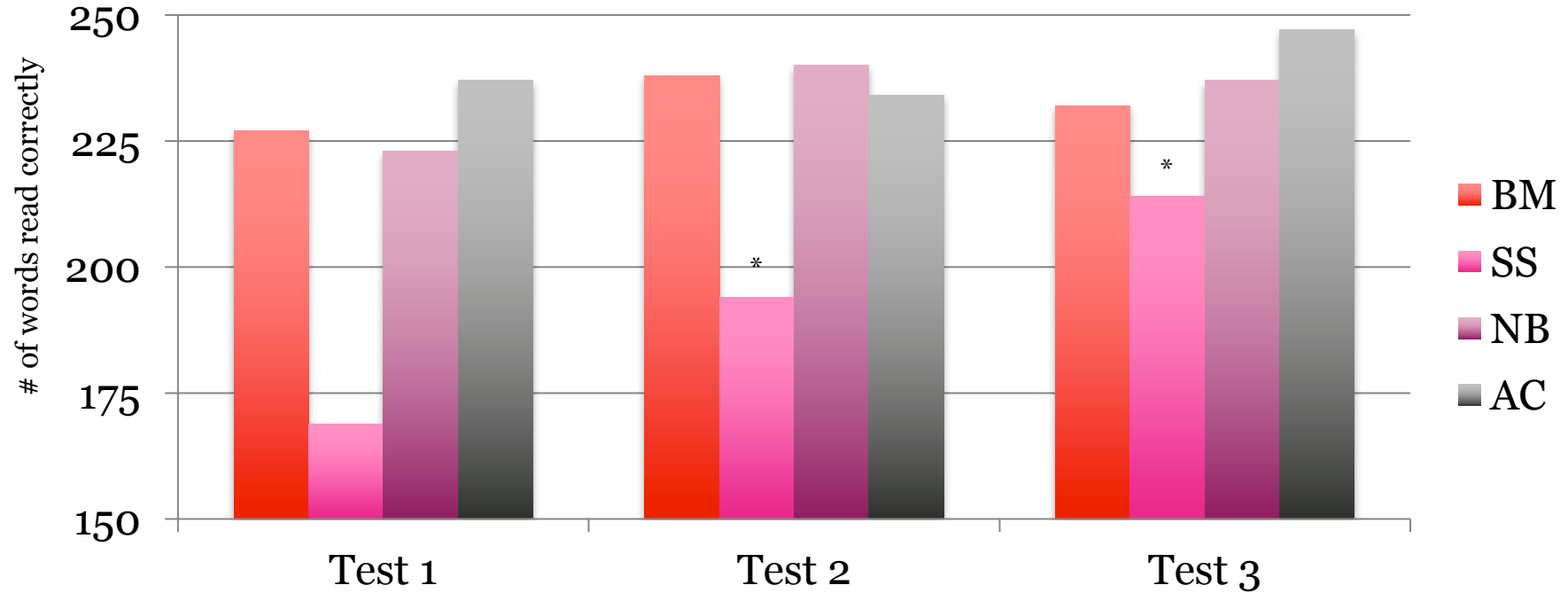


# Reading

## DOES WORKING MEMORY TRAINING IMPROVE READING?



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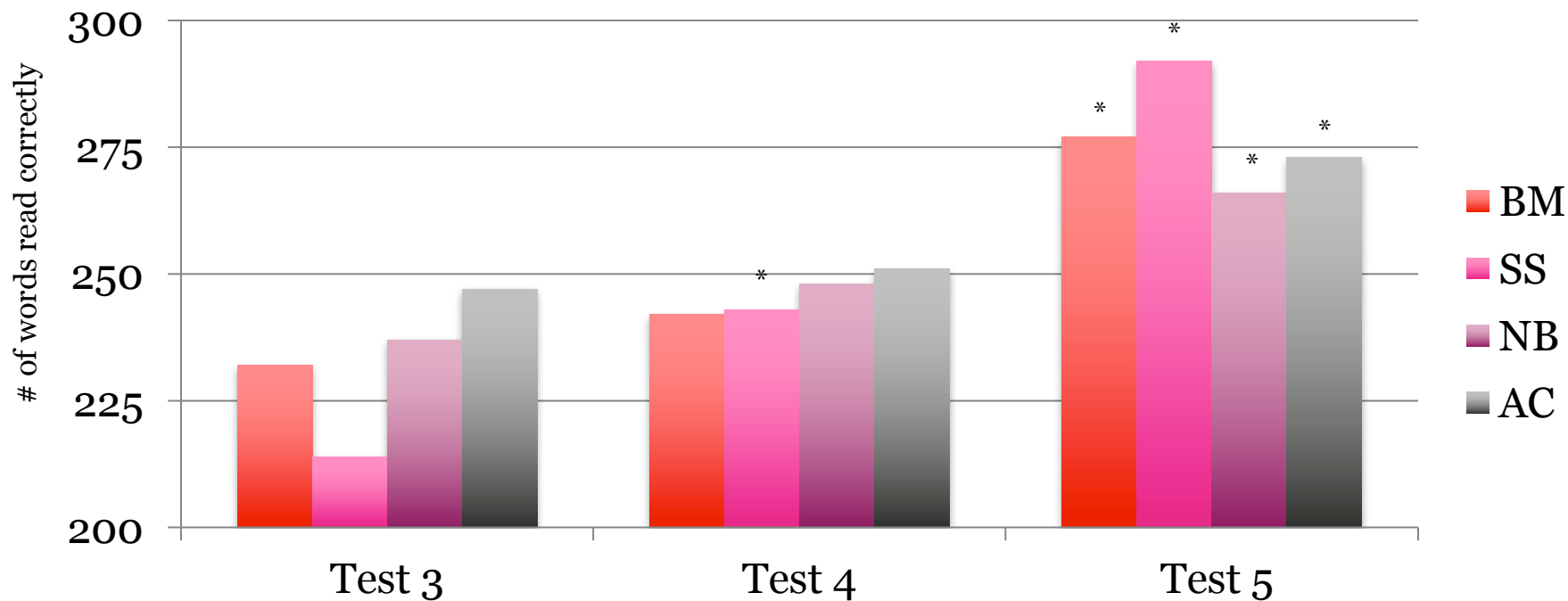


# Reading

## DOES READING TRAINING IMPROVE READING?



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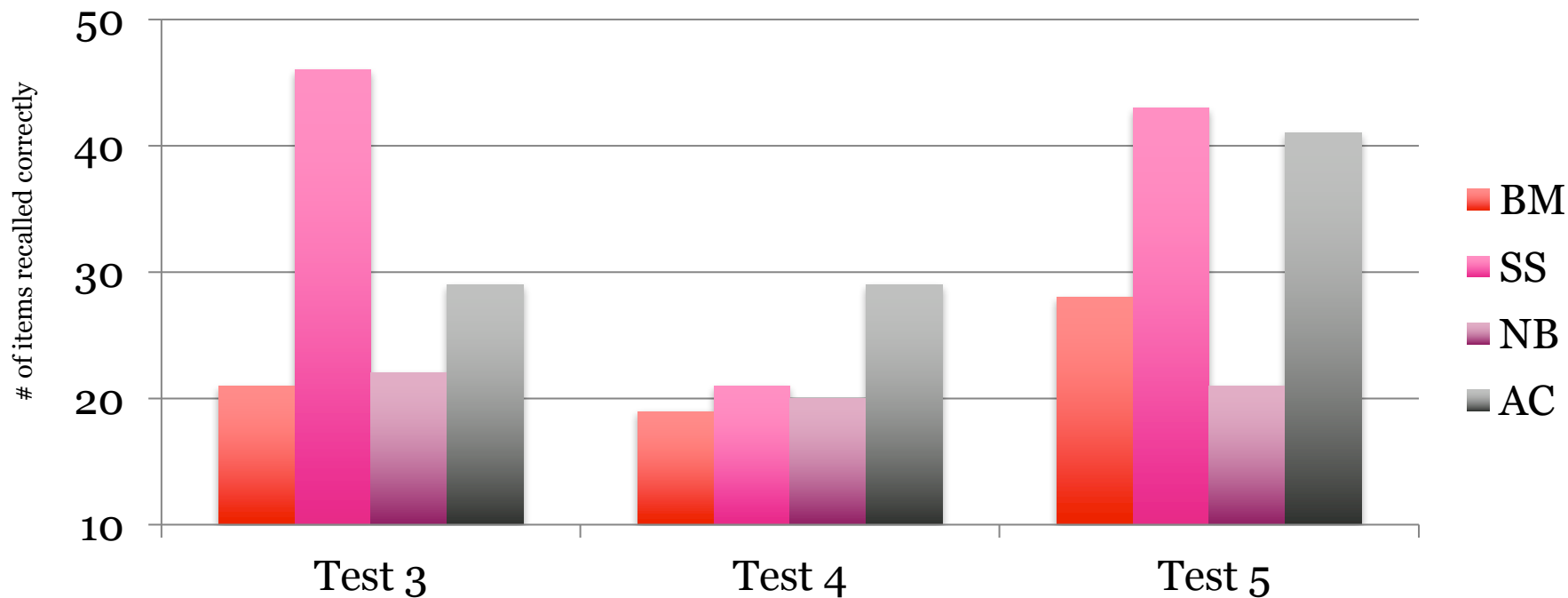


# Working Memory

## DOES READING TRAINING IMPROVE WORKING MEMORY?



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# Working Memory & Reading

## STUDY 1 CONCLUSIONS

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### TAKE HOME MESSAGE

1. Verbal working memory scores can be improved following verbal working memory training (supports existing research)
2. Verbal working memory training does not improve word reading accuracy (supports existing research)
3. Reading accuracy training does not improve verbal working memory
4. Poor readers with poor verbal working memory can improve word reading accuracy, without first improving verbal working memory

# Reading & Working Memory

## THE RESEARCH

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### Question 1.

Does verbal working memory training improve reading?

### Question 2.

Does reading training improve verbal working memory?

# Method

## STUDY 2 DESIGN

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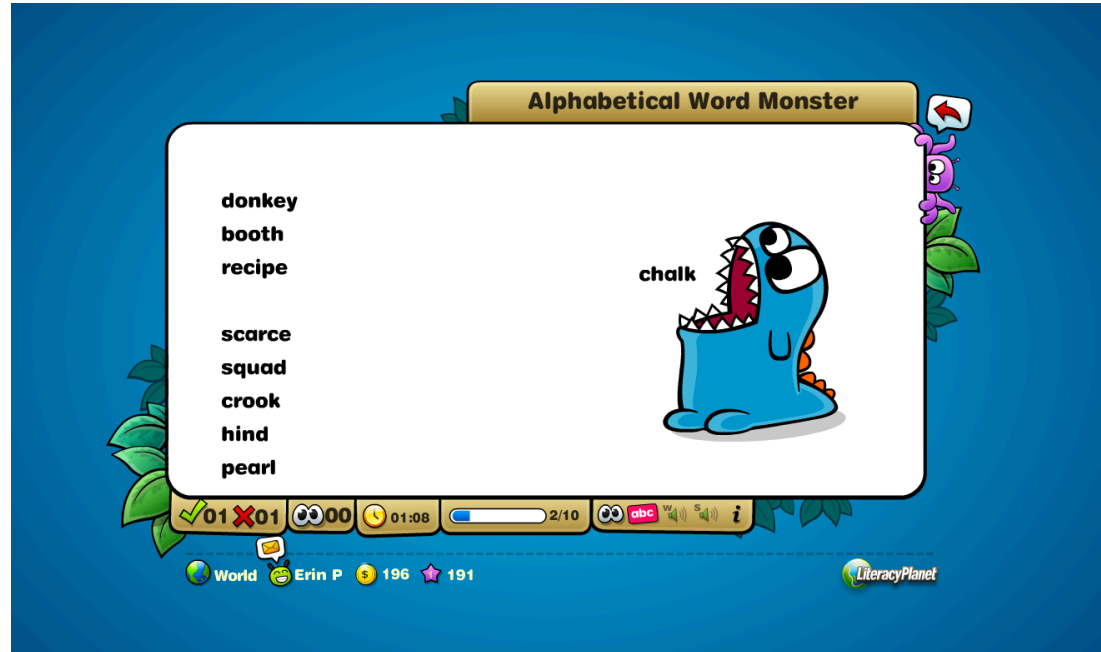
Design
Test 1
<b>Baseline – No Training (8 weeks)</b>
Test 2
<b>Reading Training (8 weeks)</b>
Test 3
<b>Reading Training (8 weeks)</b>
Test 4

# Method

## 'SIGHT WORD' TRAINING



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# Method


## PHONICS TRAINING



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**I Spy Game (b, c, d, f, g)**

**b**



0 0 03:23 1/10 ? i

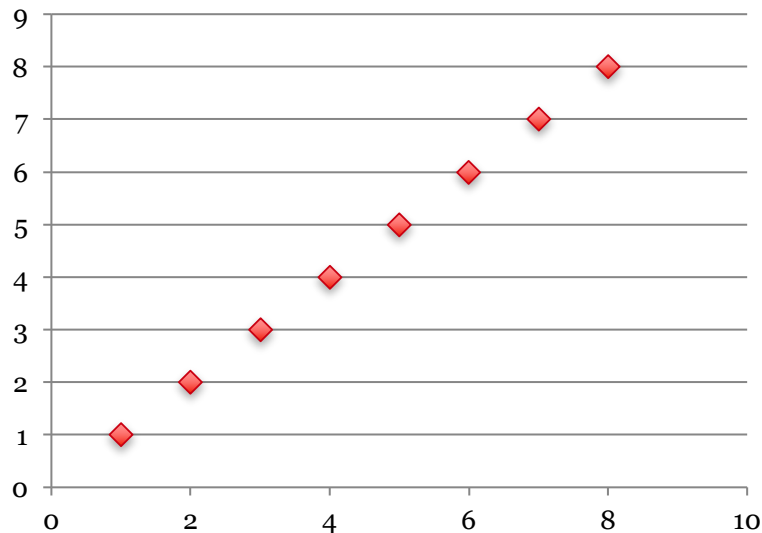
World Erin P \$ 39 ☆ 39

LiteracyPlanet

# RCT results

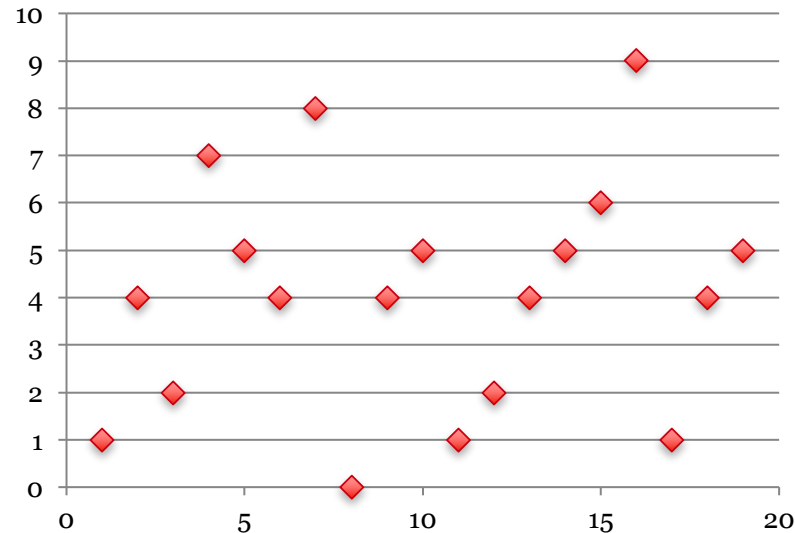
## CORRELATIONS

Reading Improvement



Verbal Working Memory Improvement

Reading Improvement



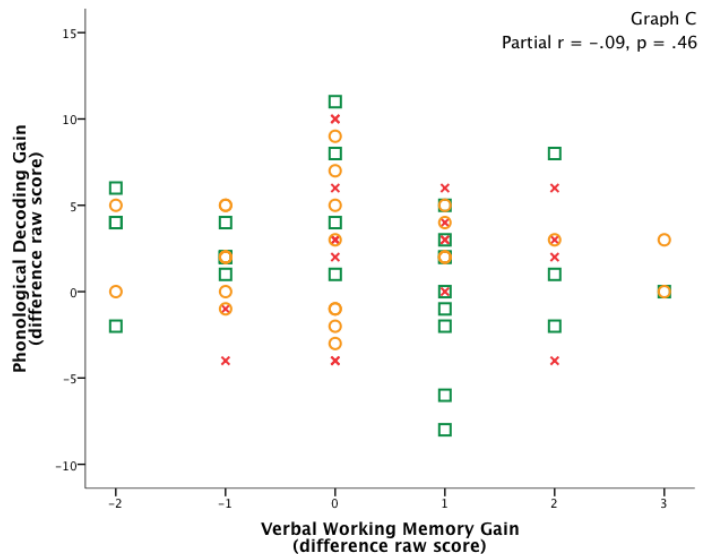
Verbal Working Memory Improvement

# Working Memory & Reading

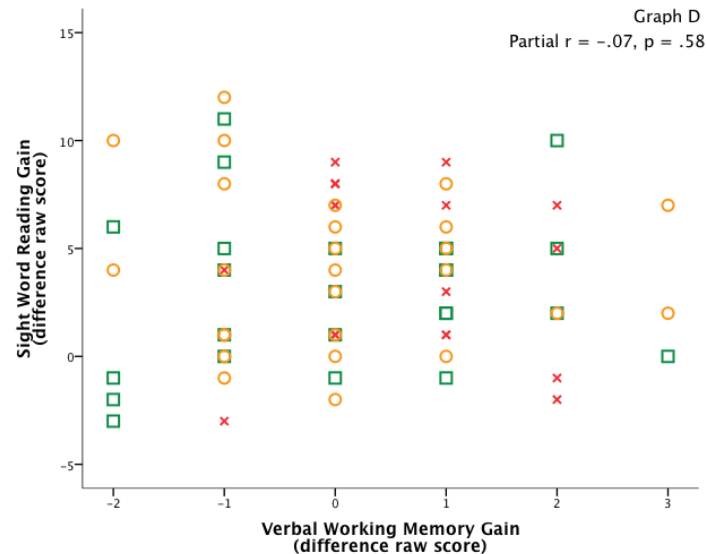
## STUDY 2



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Phonological Decoding  
“Phonological Route”



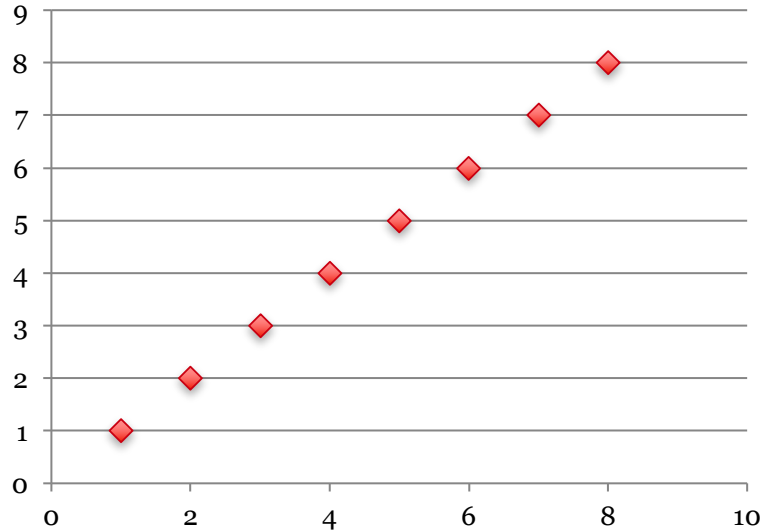
Sight Word Recognition  
“Lexical Route”



# RCT results

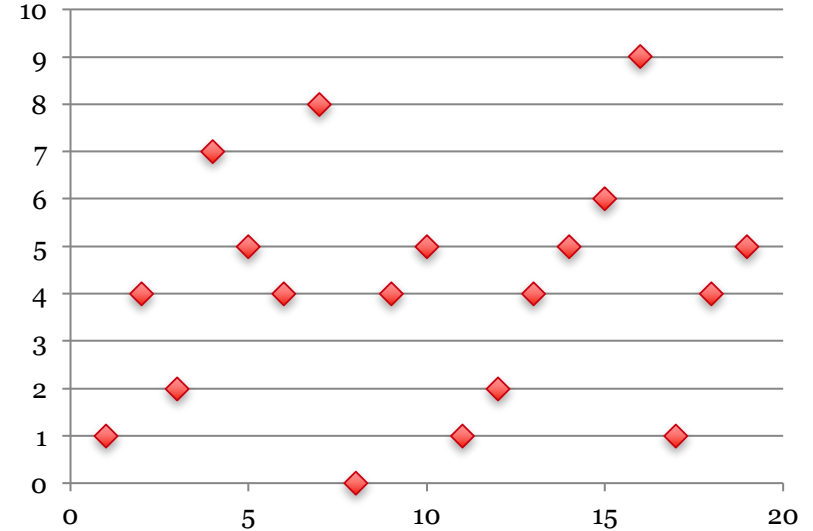
## CORRELATIONS

Reading Improvement



Verbal Working Memory

Reading Improvement



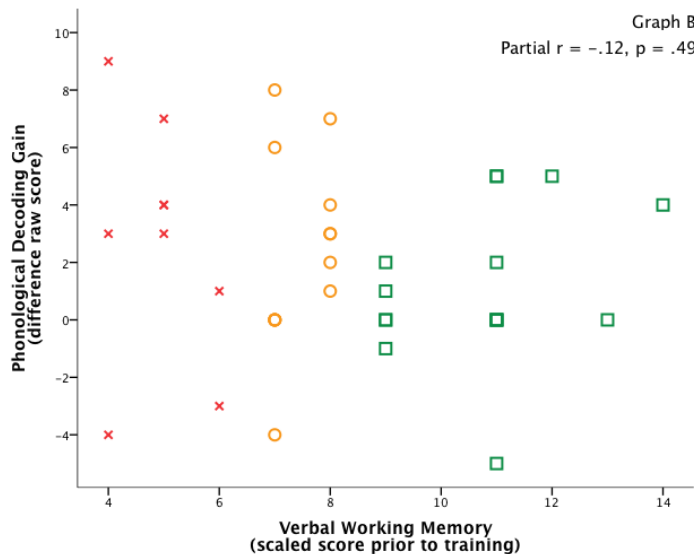
Verbal Working Memory

# Working Memory & Reading

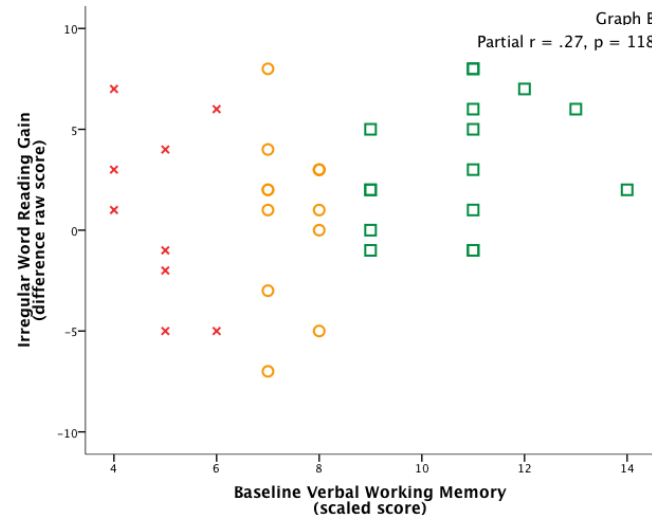
## STUDY 2



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Phonological Decoding  
“Phonological Route”



Sight Word Recognition  
“Lexical Route”

# Working Memory & Reading



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## STUDY 2 CONCLUSIONS

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### TAKE HOME MESSAGE

1. Again (as in Study 1), we demonstrated that reading training does not improve verbal working memory
2. Again (as in Study 1), we showed that children with working memory difficulties improved their reading skills, and furthered this by showing they improved just as much as those without WMD
3. Plus, they can improve even with a less tailored online program

# What now?

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This research suggests:

If a child has a Reading Difficulty and a Working Memory difficulty you  
can (and should) treat the Reading Difficulty



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Thank you

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# Important References

## DUAL ROUTE MODEL OF READING

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: a dual route cascaded model of visual word recognition and reading aloud. *Psychological review*, 108(1), 204.

## BADDELEY'S WORKING MEMORY MODEL

Baddeley, Alan. "The episodic buffer: a new component of working memory?." *Trends in cognitive sciences* 4.11 (2000): 417-423.

Baddeley, A. (2012). Working memory: theories, models, and controversies. *Annual review of psychology*, 63, 1-29.



# Important References

## WORKING MEMORY

Swanson, H. L. (2003). Age-related differences in learning disabled and skilled readers' working memory. *Journal of Experimental Child Psychology*, 85(1), 1-31.

Swanson, H. L., Zheng, X., & Jerman, O. (2009). Working memory, short-term memory, and reading disabilities: A selective meta-analysis of the literature. *Journal of Learning Disabilities*.



# Important References

## WORKING MEMORY IN THE CLASSROOM

Alloway, T. P. (2006). How does working memory work in the classroom?. *Educational Research and Reviews*, 1(4), 134.

Gathercole, S. E., Lamont, E., & Alloway, T. P. (2006). Working memory in the classroom. *Working memory and education*, 219-240.

Holmes, J., & Gathercole, S. E. (2014). Taking working memory training from the laboratory into schools. *Educational Psychology*, 34(4), 440-450.





# Important References

## WORKING MEMORY TRAINING & READING/SPELLING

Alloway, T. P., Bibile, V., & Lau, G. (2013). Computerized working memory training: Can it lead to gains in cognitive skills in students? *Computers in Human Behavior*, 29(3), 632-638.

Alloway, T. (2012). Can Interactive Working Memory Training Improve Learning?. *Journal of Interactive Learning Research*, 23(3), 197-207.

Ardila, A., Ostrosky-Solis, F., & Mendoza, V. U. (2000). Learning to read is much more than learning to read: A neuropsychologically based reading program. *Journal of the International Neuropsychological Society*, 6(07), 789-801.

Johnson-Glenberg, M. C. (2000). Training reading comprehension in adequate decoders/poor comprehenders: Verbal versus visual strategies. *Journal of Educational Psychology*, 92(4), 772-782.

Lorusso, M. L., Facoetti, A., & Bakker, D. J. (2011). Neuropsychological treatment of dyslexia: Does type of treatment matter? *Journal of Learning Disabilities*, 44(2), 136-149.

Melby-Lervåg, M., & Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Developmental psychology*, 49(2), 270.

Melby-Lervåg, M., Redick, T. S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of “far transfer”: Evidence from a meta-analytic review. *Perspectives on Psychological Science*, 11(4), 512.



# Important References

## READING TRAINING

Banales, E., Kohnen, S., & McArthur, G. (2015). Can verbal working memory training improve reading?. *Cognitive neuropsychology*, 32(3-4), 104-132.

McArthur, G., Kohnen, S., Jones, K., Eve, P., Banales, E., Larsen, L., & Castles, A. (2015). Replicability of sight word training and phonics training in poor readers: a randomised controlled trial. *PeerJ*, 3, e922.