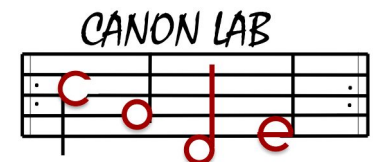


Investigating the Role of Cognitive Abilities in Computational Thinking for Young Learners

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 @SaladwithaC



*Computing for ANYONE:
Designing for equity and inclusion*

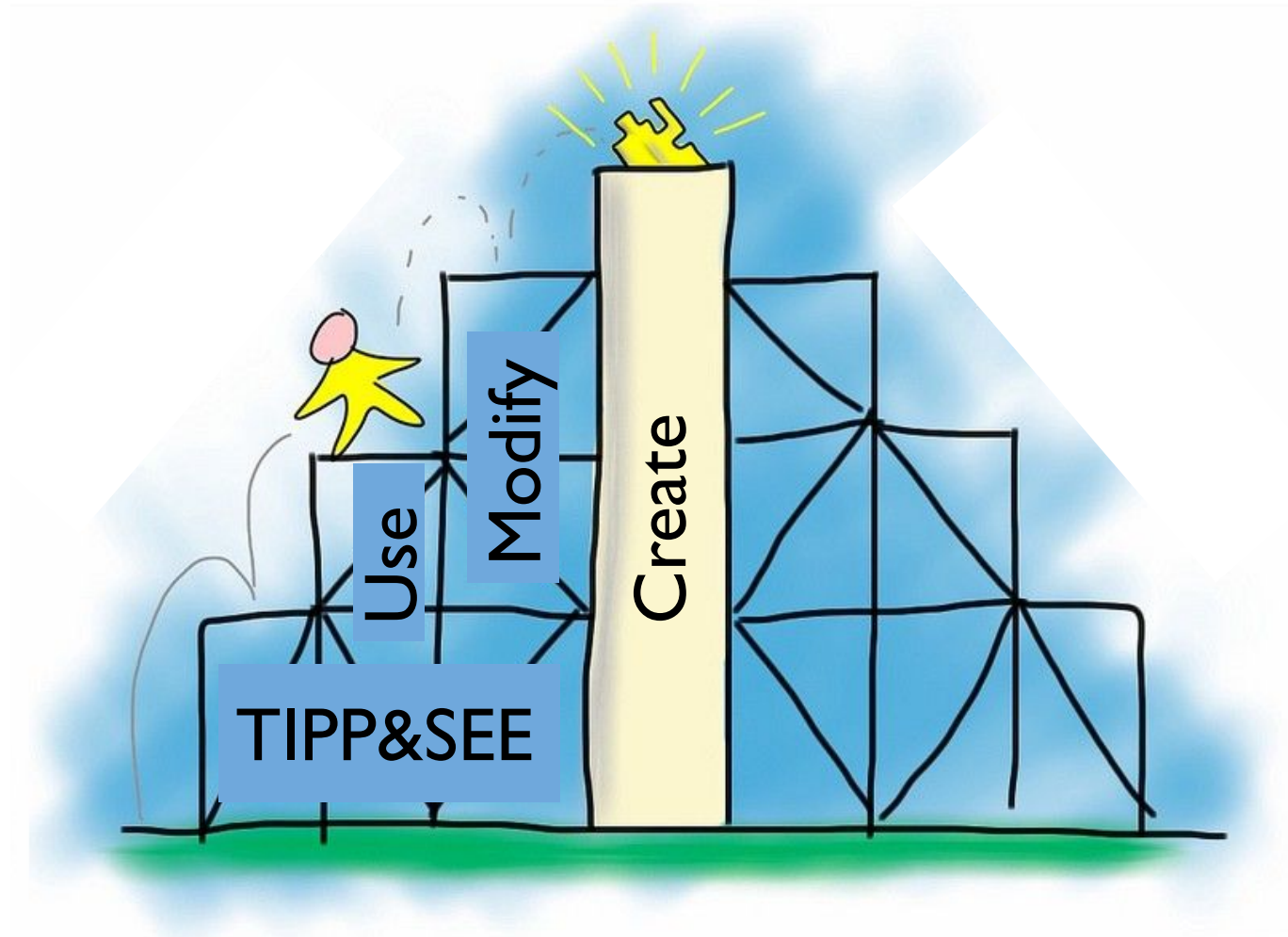


Goal: Explore the Relationship between Cognitive Abilities and CT Performance

- At early ages, learners develop foundational cognitive abilities
- Other fields, like math, science, & reading, have long studied cognitive abilities, but rare in CS
- Research Questions:
 - How are working memory, pattern recognition, & long-term retrieval associated with performance on events, sequence, & loops?
 - How much does TIPP&SEE support students with differing cognitive abilities?
 - For which computational thinking concepts does TIPP&SEE support students with differing cognitive abilities?

1st type of CS instruction: Use → Modify → Create

Learning Outcome



2nd type of CS instruction:



Title

Sprites

Instructions

Events

Purpose

Explore

Play

Students learned through the Scratch Act I curriculum

- Students in our study were 9-10 years old (4th grade).
- Classrooms were randomly assigned to TIPP&SEE or Control (Use → Modify → Create only) conditions
- Scratch Act I covered events, sequence, & loops.
- Students took an assessment at the end of each module.

Scratch ACT I



Exploratory Factor Analysis to Match Questions to Concepts

	Remember	Understand
Scratch Basics	Events & Sequence Assessment: Q2 & Q3	---
Events	---	Events & Sequence Assessment: Q4a & Q4b
Sequence	---	Events & Sequence: Q6 & Q7b Loops: Q5a, b, c
Loops	---	Loops Assessment: Q1, Q2, Q4, Q5a, b, c

We used the Woodcock-Johnson IV Tests of Cognitive Abilities

- WJ IV tests are **not malleable to instruction**, but to **development**
- Purpose: Allow for comparison of important cognitive abilities
- We conducted 4 tests:
 - Numbers Reversed & Verbal Attention: Short-term working memory
 - Pair Cancellation: Pattern recognition
 - Visual-Auditory Learning: Long-term retrieval

Weak correlations between performance on CT assessments and working memory & long-term retrieval

Concept	Q	Numbers Reversed		Verbal Attention		Visual-Auditory Learning	
		TS	C	TS	C	TS	C
Scratch	E&S Q2	.323**	—	—	—	—	—
Basics	E&S Q3	—	.270**	—	.277**	—	.431**
Events	E&S Q4a	.218*	—	.335**	—	.420**	.219*
	E&S Q4b	.237*	—	.391**	—	.416**	.235*
Sequence	E&S Q6	.263*	—	—	—	.222*	.223*
	E&S Q7	—	—	—	.235*	.294**	.361**
Loops	L Q1	—	—	—	—	—	.258*
	L Q2	—	.306**	—	.399**	—	.372**
	L Q4	—	.238*	.240*	.317**	—	.381**
Sequence & Loops	L Q5a	.442**	.321**	.410**	.258*	.347**	.358**
	L Q5b	.432**	.334**	.268*	.340**	.342**	.468**
	L Q5c	.285**	.285**	.276*	.331**	.365**	.360**

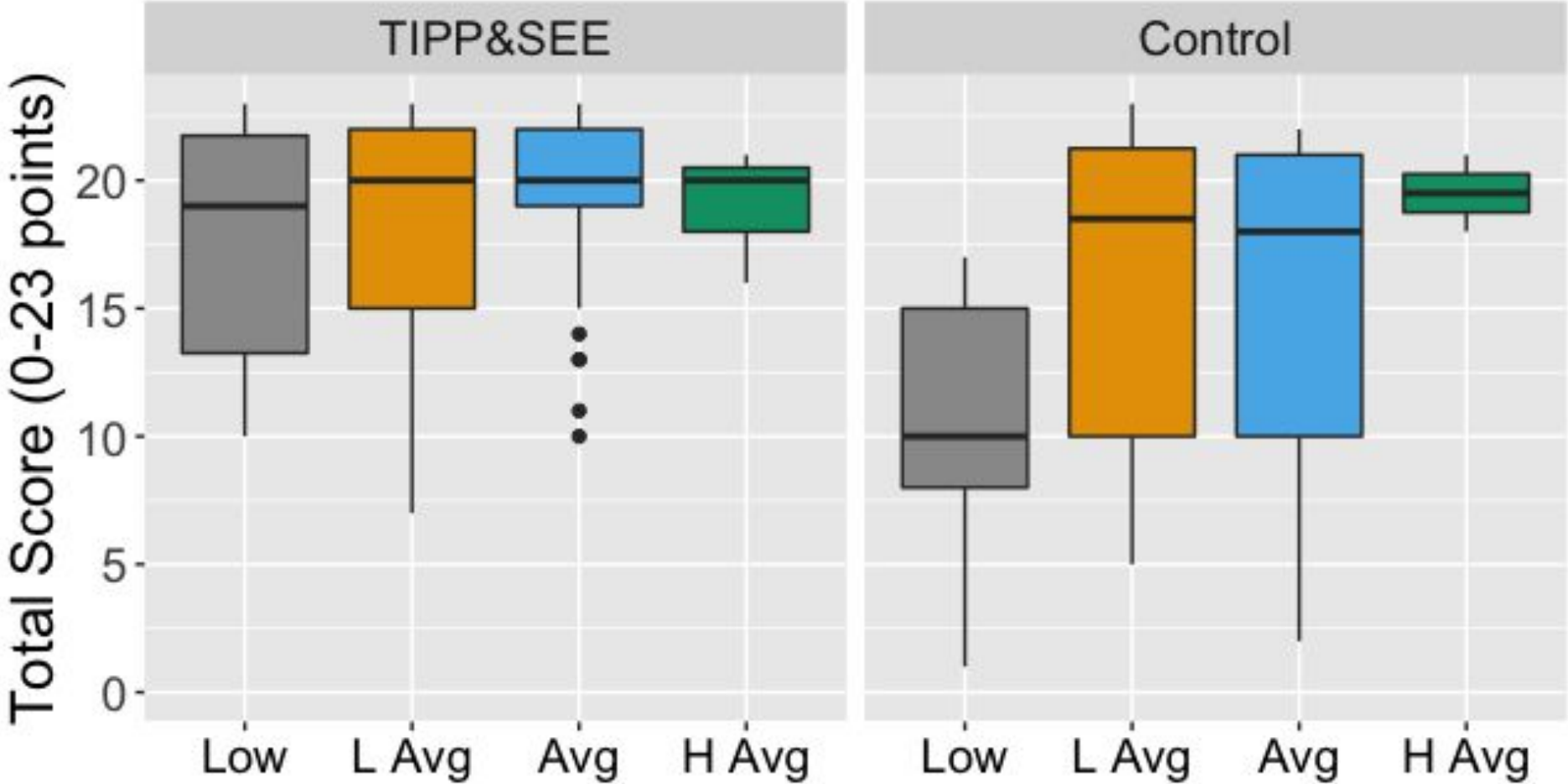
* $p < .05$; ** $p < .01$

Correlations increased with more complex CT concepts

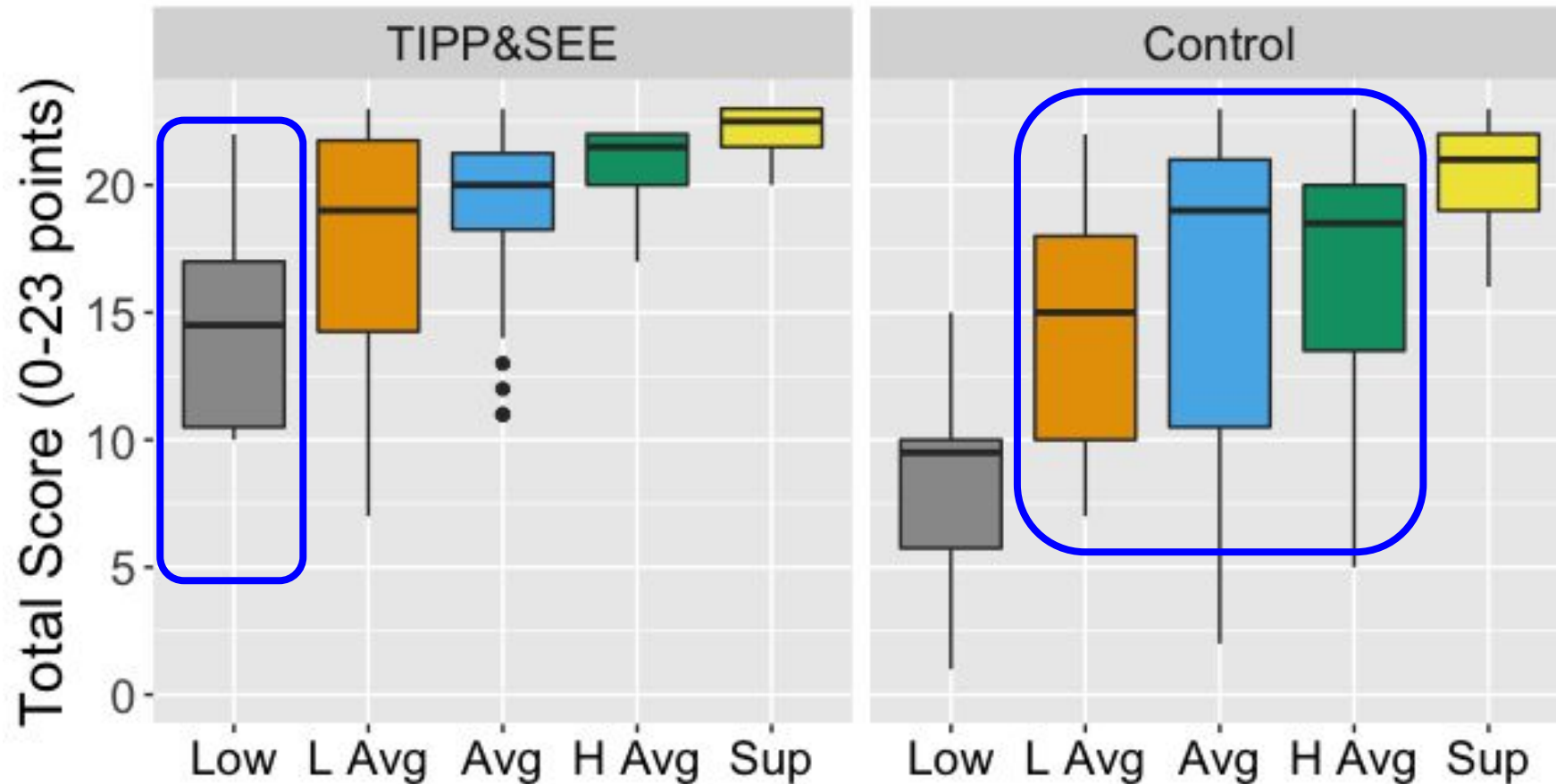
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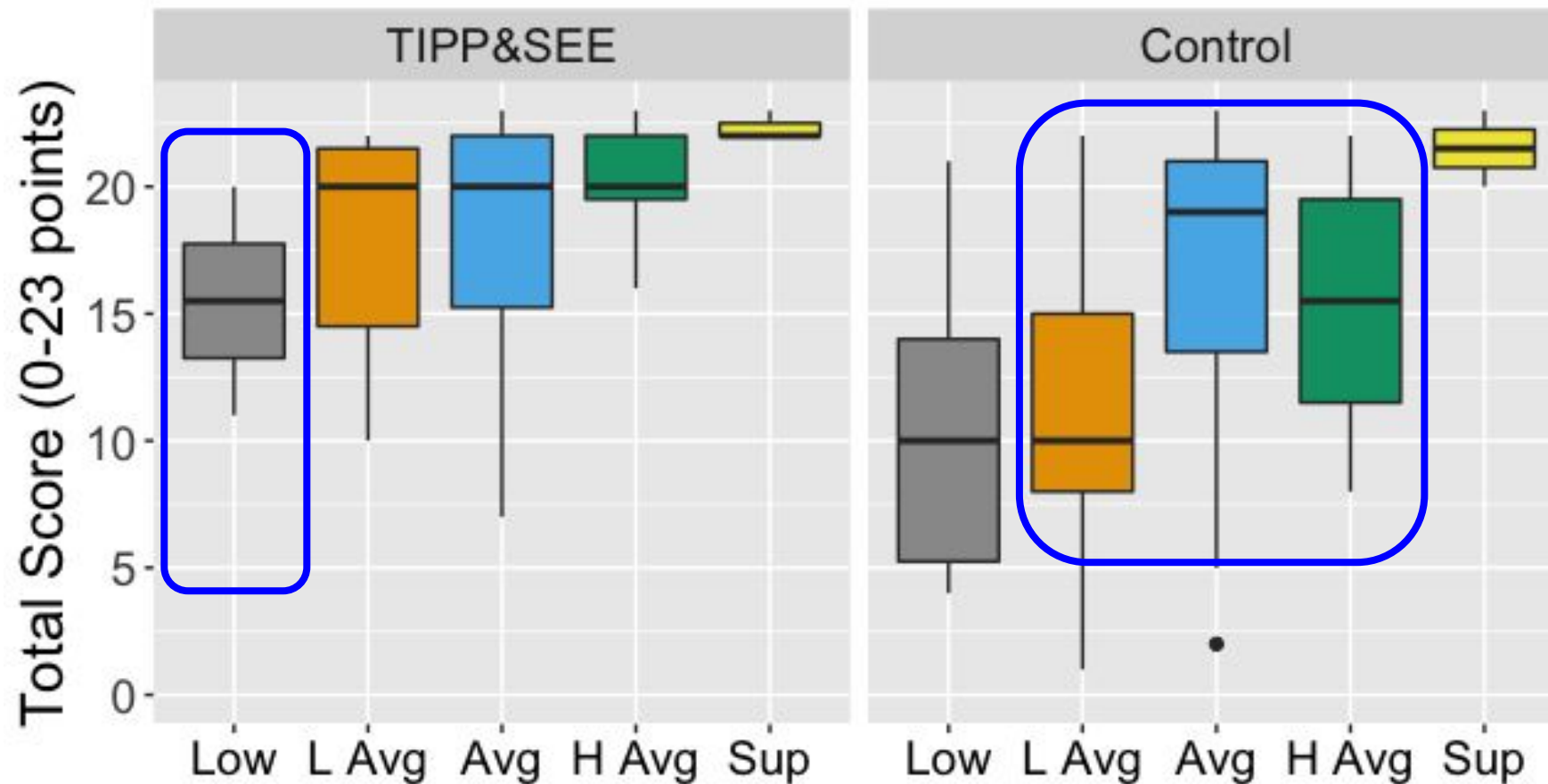
Pair cancellation (pattern recognition measure) had no effect on CT performance



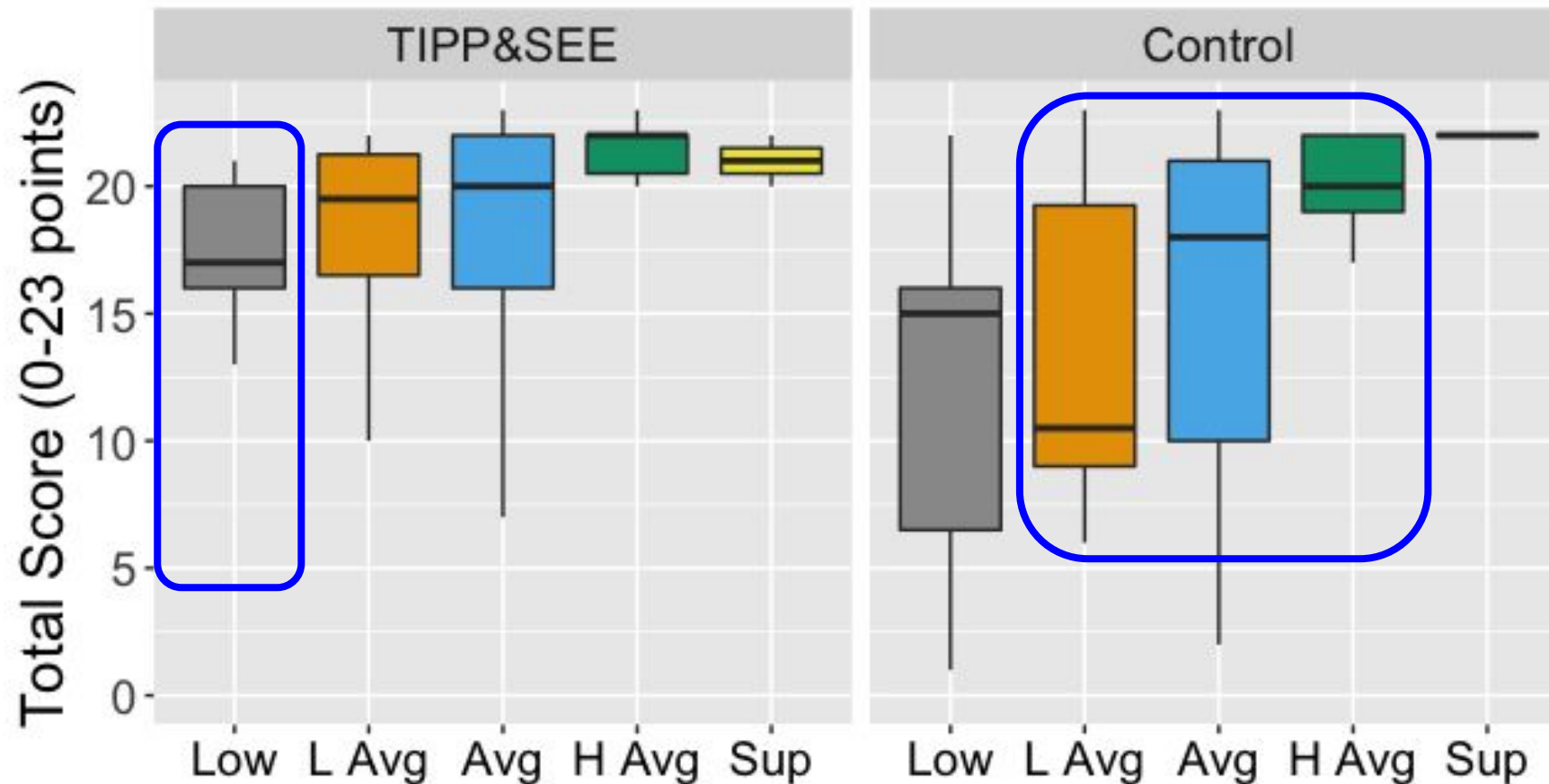
TIPP&SEE students with low scores on Numbers Reversed (working memory measure) performed as well as control students with average scores



TIPP&SEE students with low scores on Verbal Attention (working memory measure) performed as well as control students with average scores



TIPP&SEE students with low scores on Visual-Auditory Learning (long-term retrieval measure) performed as well as control students with average scores





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Key Contributions

- Weak correlations between performance on CT assessments and working memory & long-term retrieval
- Correlations increased with more complex concepts →
More scaffolding beyond TIPP&SEE?
- TIPP&SEE students with below average cognitive test scores performed as well as control students with average scores

RQ1: How do different cognitive abilities relate to CT performance?

1. Separate our data by TIPP&SEE vs Control
2. Ran Spearman correlations between cognitive abilities subtest scores & CT assessment scores
3. Interpreted ρ correlation values:
 - a. $\rho = 0-0.3$: Very weak
 - b. $\rho = 0.3-0.5$: Weak
 - c. $\rho = 0.5-0.7$: Moderate
 - d. $\rho = 0.7-0.9$: Strong
 - e. $\rho = 0.9-1$: Very strong

RQ 2 & 3: How much does TIP&SEE support students with various levels of cognitive ability? In which concepts?

1. Classified student scores from the WJ IV test manual
2. Combined highest and lowest two classifications for sufficient cell size
3. Transformed both aggregate & individual question scores with the Aligned Rank Transform, which enables non-parametric factorial analyses before running an ANOVA F-test
4. Used Type III Sum of Squares for unequal cell sizes & estimated marginal means for post-hoc comparisons

TIPP&SEE has potential to create more equitable CT instruction, but with some limitations

- Weak correlations between CT & cognitive scores, possibly due to scaffolding from TIPP&SEE and Use → Modify → Create
- Correlations increased with concept complexity → Need more scaffolding?
- TIPP&SEE students with low scores in working memory & long-term retrieval performed as well as control students with average scores
- Results on specific concepts are inconclusive