Relations between executive function and social psychological predictors of math achievement among ethnic-racial minoritized middle-school students

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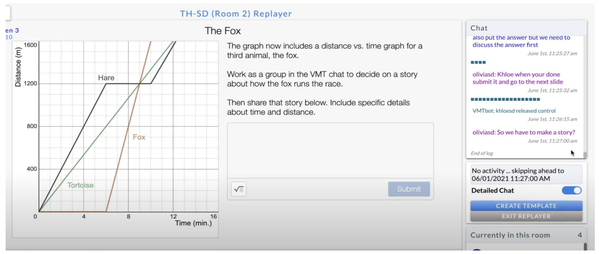
Introduction

While executive functions (EF) and social psychological variables (SPV) have been shown to predict math achievement, far fewer studies have examined relationships between EF and SPV. We investigate this question within the Mathematical Thinkers Like Me project, which aims to:

- help address the mathematics achievement gap that disproportionately targets ethnic-racial minoritized students
- promote online collaborative problem-solving and storytelling context that helps develop student identity and strength as mathematical thinkers (Figure 1)
- integrate a focus on executive functions in practice while developing conceptual understanding and fostering equity

Figure 1: Our online environment, Virtual Math Teams (VMT), allows groups of students to work together in a shared dynamic math space while communicating via text chat.



Methodology

Students (Table 1) completed a bundle of assessments across three domains: mathematics, EF and SPV. Among a battery of math measures primarily focused on rational number understanding, we selected the Calculation subtest of Woodcock-Johnson III as our math achievement outcome measure.

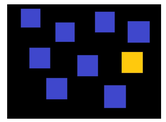
Table 1: Study participants

Middle-school students	n	Sex	Age
Newark Public Schools	13	7 F 5 M 1 Other	13.61 (0.65)
Vista Unified School Districts	102	41 F 52 M 9 Other	13.20 (0.87)

Tasks

Students also completed online EF tasks:

Alternate Uses
(divergent thinking)



Corsi-block tapping
(visual short working memory)

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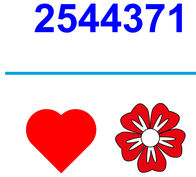
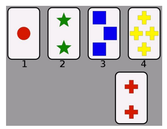
Digit span
(verbal working memory)



Hearts and Flowers
(inhibitory control)



Wisconsin Card Sorting
(cognitive flexibility)

Tower of London
(planning ability)

Finally, students completed a series of online surveys regarding:

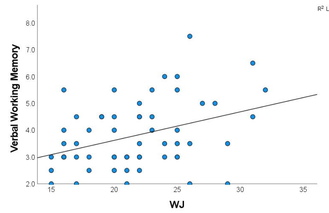
- math anxiety
- math-related SPV (e.g., attitudes towards math, experiences with gender bias)
- and a demographic and background questionnaire (e.g., ethnicity-race, age, sex assigned at birth, gender, and grade)

For the initial analyses in this first phase, we employed Pearson correlations. We intend to use regression analysis for future studies with larger sample sizes.

Results

As with prior studies with EF, SPV, and math, significant correlations (Figures 2 & 3) were noted among these measures and the Woodcock-Johnson III (WJ) math achievement outcome measure.

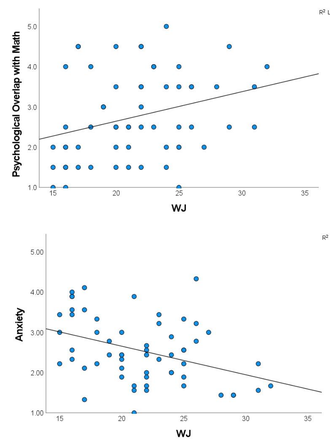
Figure 2: EF correlations (R) with Woodcock-Johnson III math achievement outcome measure.



Verbal Working Memory vs. WJ
Verbal working memory significantly correlated with math achievement
(r=0.373, n=57, p=0.004).

Inhibitory Control vs. WJ
Inhibitory control significantly correlated with math achievement
(r=0.297, n=57, p=0.025).

Figure 3: SPV correlations (R) with Woodcock-Johnson III math achievement outcome measure.



Psychological Overlap with Math vs. WJ
Psychological overlap with math significantly correlated with math achievement
(r=0.299, n=59, p=0.021).

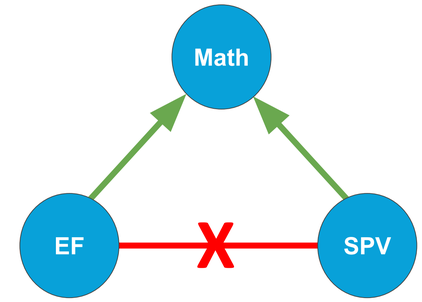
Math anxiety vs. WJ
There was a significant and expected negative correlation between math anxiety and math achievement
(r=-0.389, n=59, p=0.002).

Significant correlations were seen among the two EF measures (r=0.328, n=110, p=<0.001). There were no significant correlations among the SPV, or between the other SPV and EF measures.

Discussion

Our study replicates previous findings and understandings of the correlation between math achievement, math anxiety and psychological overlap with math (e.g. OECD, 2013), verbal working memory (e.g. Swanson, 2017; De Smedt et al., 2009), and inhibitory control (Camerota, 2019). We extend this work by looking at relations between EF and SPV. Surprisingly, there's very little research on this question. Here we find they are independent (Figure 3).

Figure 3: Independent relationship between EF, SPV and Math.



Overall, these results suggest that EF and SPV have distinct contributions to math achievement. The inclusion of other data streams (such as student data within the online collaborative environment and teacher interview data) may help elucidate the independent impact. This research ultimately aims to help inform the building of supportive educational environments.

References

Camerota, M. , Willoughby, M. T. & Blair, C. B. (2019). Speed and Accuracy on the Hearts and Flowers Task Interact to Predict Child Outcomes. *Psychological Assessment, 31* (8), 995-1005. doi: 10.1037/pas0000725.

De Smedt, B., Janssen, R., Bouwens, K., Verschaffel, L., Boets, B., & Ghesquière, P. (2009). Working memory and individual differences in mathematics achievement: A longitudinal study from first grade to second grade. *Journal of Experimental Child Psychology*, 103(2), 186–201. https://doi.org/10.1016/j.jecp.2009.01.004

OECD. (2013). Mathematics Self-Beliefs and Participation in Mathematics-Related Activities. In *PISA 2012 Results* (pp. 87–112). OECD Publishing. https://doi.org/10.1787/9789264201170-8-en.

Swanson, H. L. (2017). Verbal and Visual-Spatial Working Memory. *Developmental Psychology, 53* (5), 971-995. doi: 10.1037/dev0000291.

For more information on this project visit: https://www.21pstem.org/mathematical-thinkers or scan the QR code: