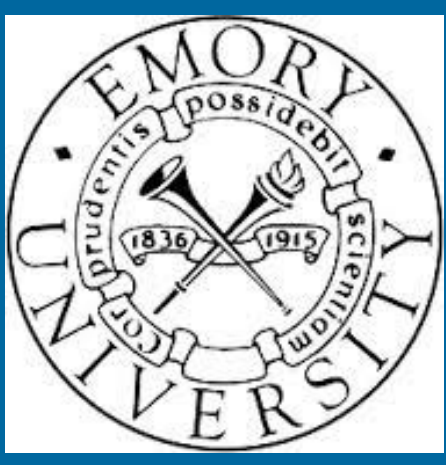


Mathematics Impairments in Children Prenatally Exposed to Alcohol: Investigating the Contribution of Underlying Working Memory and Executive Function Deficits

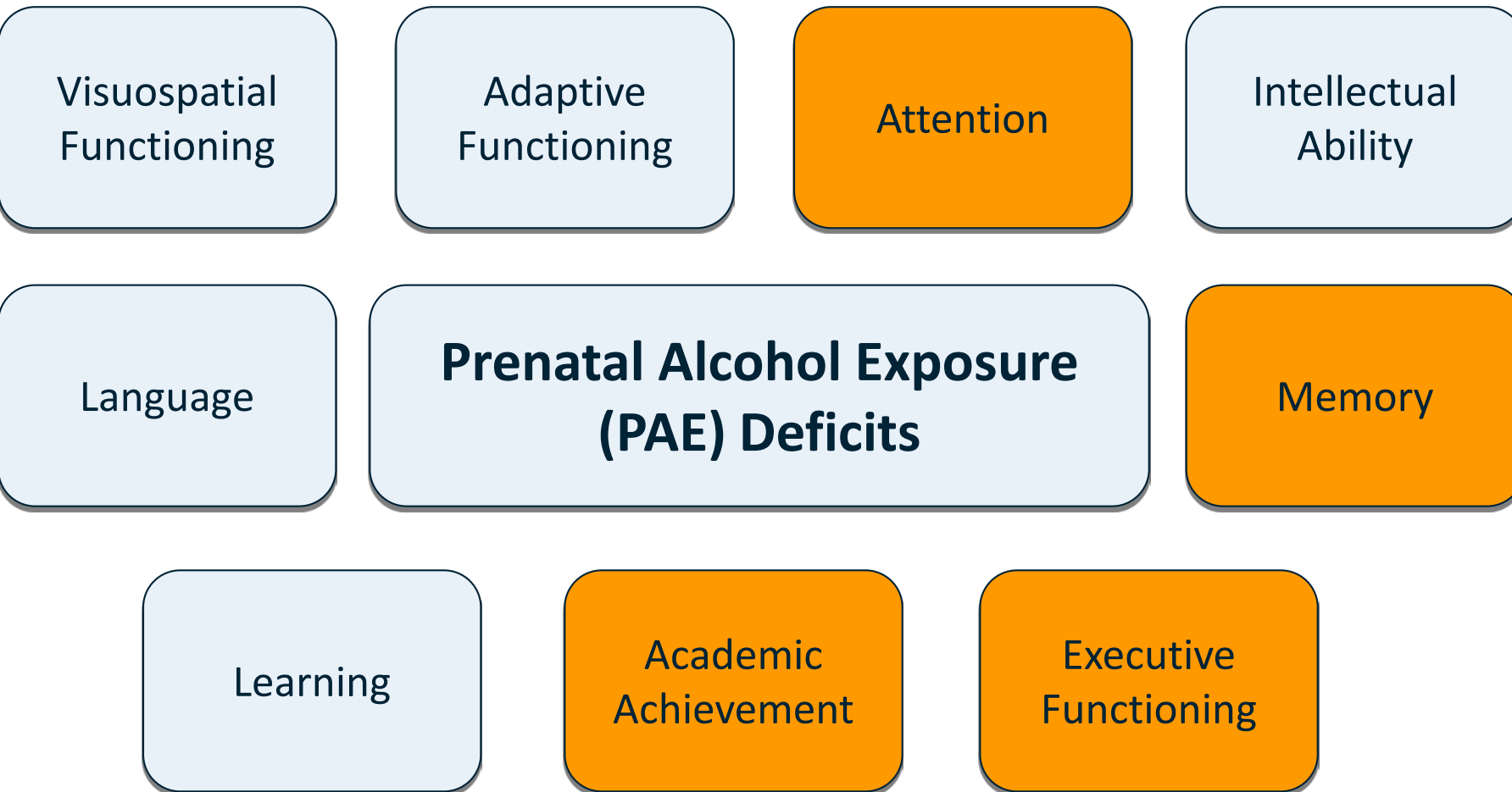


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Background

•Prenatal alcohol exposure (PAE) adversely impacts the developing brain, and can result in a range of global cognitive impairments¹ that interfere with successful academic functioning and independent living²



•Evidence for a **specific deficit in math** is supported by cross-sectional and longitudinal research indicating that math tends to be more negatively affected than other cognitive domains in individuals with PAE^{3,4,5}

•**Executive functions (EF):** Higher order cognitive processes (such as inhibition, cognitive flexibility, planning/strategizing to reach a goal, and concept formation⁶); Core area of deficit associated with PAE⁷

•**Working memory (WM):** Short term storing and manipulating of information in memory⁸; Literature shows an association between PAE and WM deficits⁹. WM is comprised of 3 parts:

1. *Visuospatial Sketchpad* (visual and spatial information)
2. *Phonological Loop*- (verbal information)
3. *Central Executive*- (remembering processing and manipulating information)- associated with EF

•Poor EF ability is connected to poor math achievement in typical and math deficient populations,^{10,11,12,13} but this relationship is relatively unexplored for PAE populations

•The relationship between WM and math has been documented in populations with PAE¹⁴

Research Questions

1. To examine the **mathematical profile** of young children with PAE
2. How does **working memory** performance relate to **math performance**?
3. How does **executive function** relate to **math performance**?

Method

Participants:

•**29 PAE** participants were recruited through the Glenrose FASD diagnostic clinic and schools in Edmonton. **20 healthy controls** (unexposed) were recruited from schools attended by PAE participants to ensure similar socioeconomic status (SES) for a total of **49** participants age 5-10 years.

•Groups did not differ significantly on gender, age or SES. IQ was not tested for control group (assumed to be normal) but PAE group had a mean IQ of 90 (low end of average) *SD* = 15.8.

	PAE group (n = 29)	Healthy controls (n = 20)	p value
Gender	48% Male	50% Male	.906 (n.s.)
Age	M = 7.5 years SD = 17.8	M = 7.6 years SD = 16.4	.679 (n.s.)
SES	M = 40.6 SD = 9.4	M = 38.4 SD = 12.9	.520 (n.s.)

Materials and Procedure:

Participants were tested on:

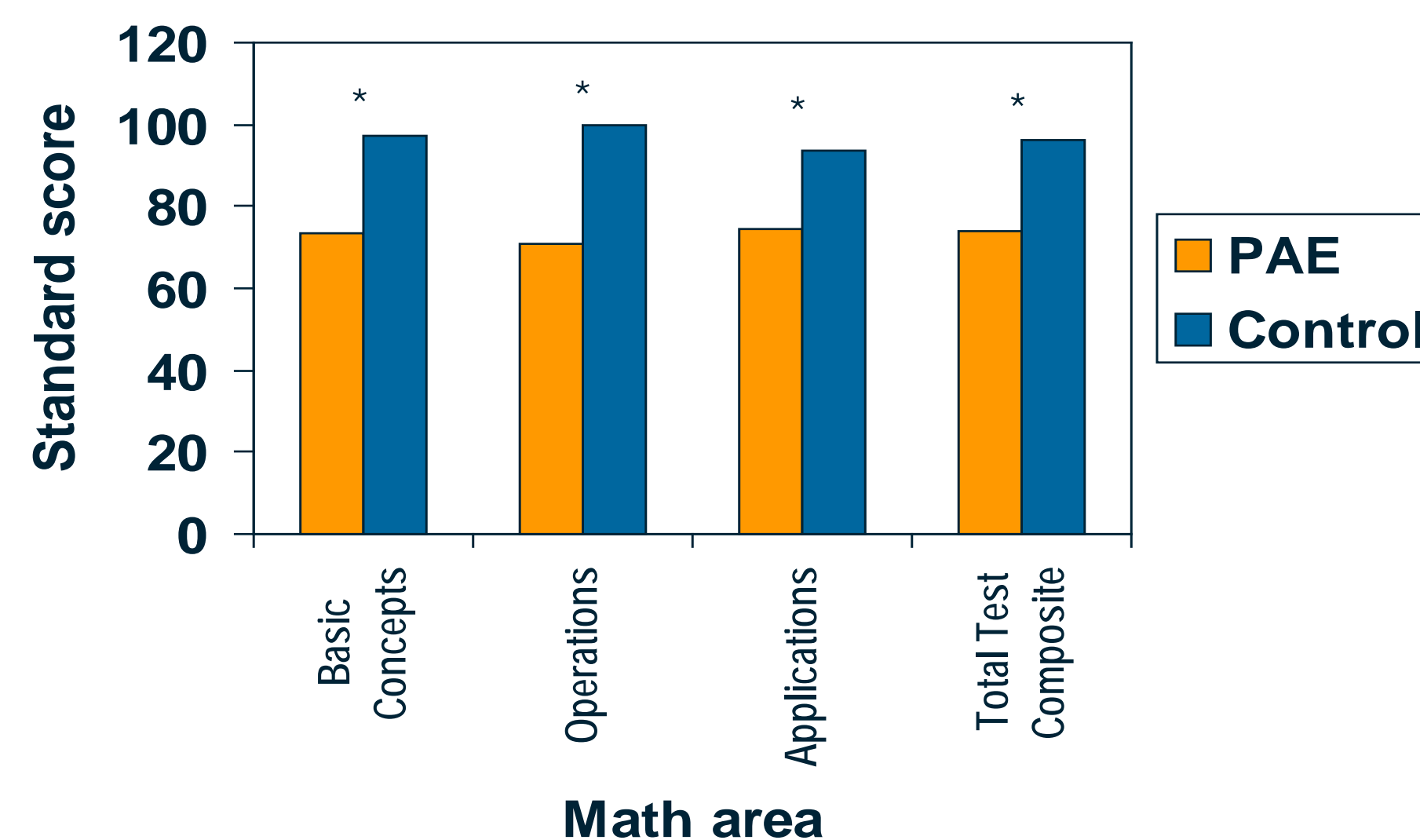
•**Key Math 3- Canadian Edition:** Measures math performance on a full spectrum of math concepts and skills from Grade K-12

•**NEPSY-II:** Selected subtests, Auditory Attention and Response Set, and Design Fluency, are measures of attention and executive functioning

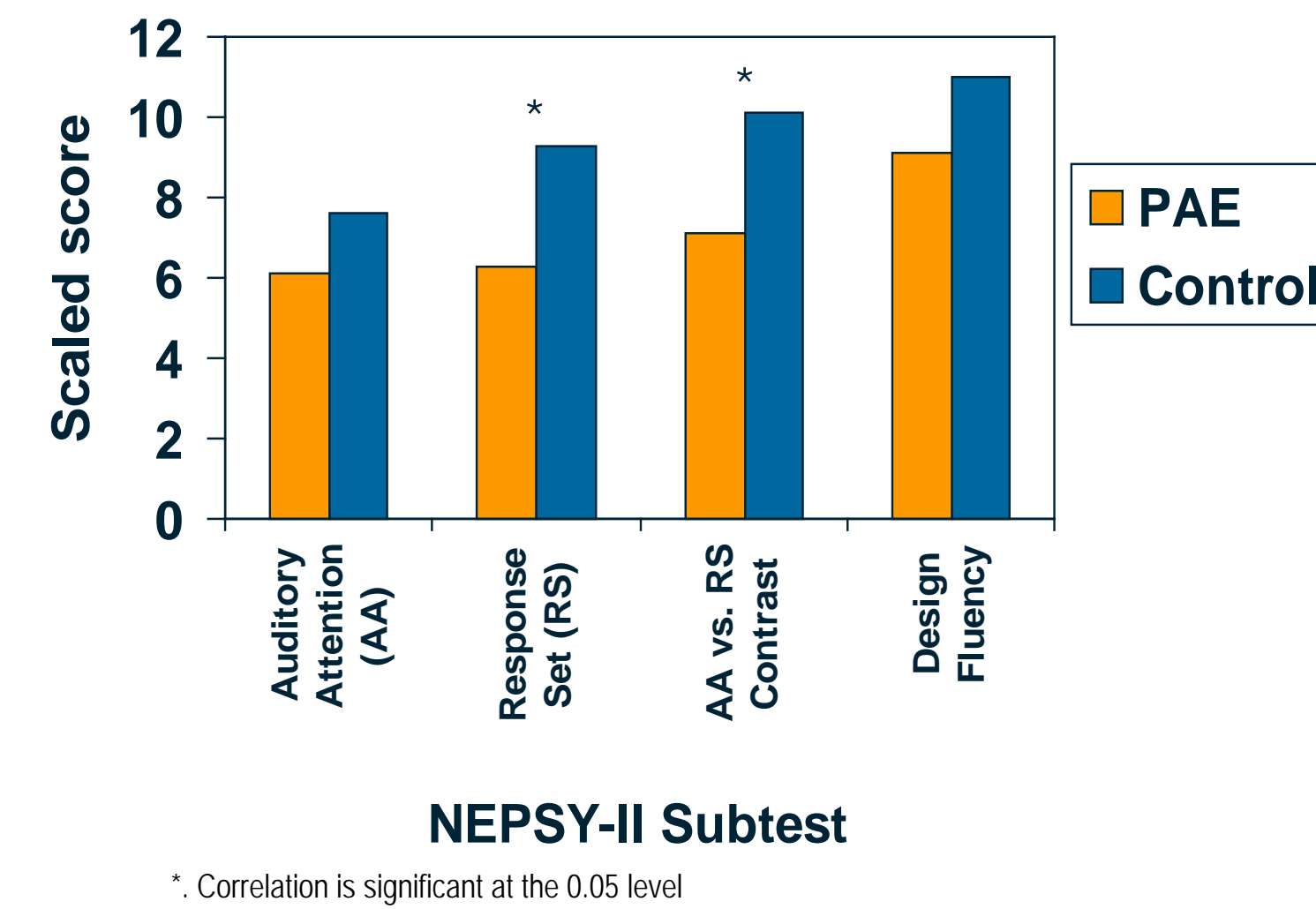
•**Working Memory Test Battery for Children (WMTB-C)** Selected subtests: Digit Recall (measures phonological loop), Block Recall (measures visuospatial sketchpad), Counting Recall and Backward Digit Recall (measure central executive)

Results

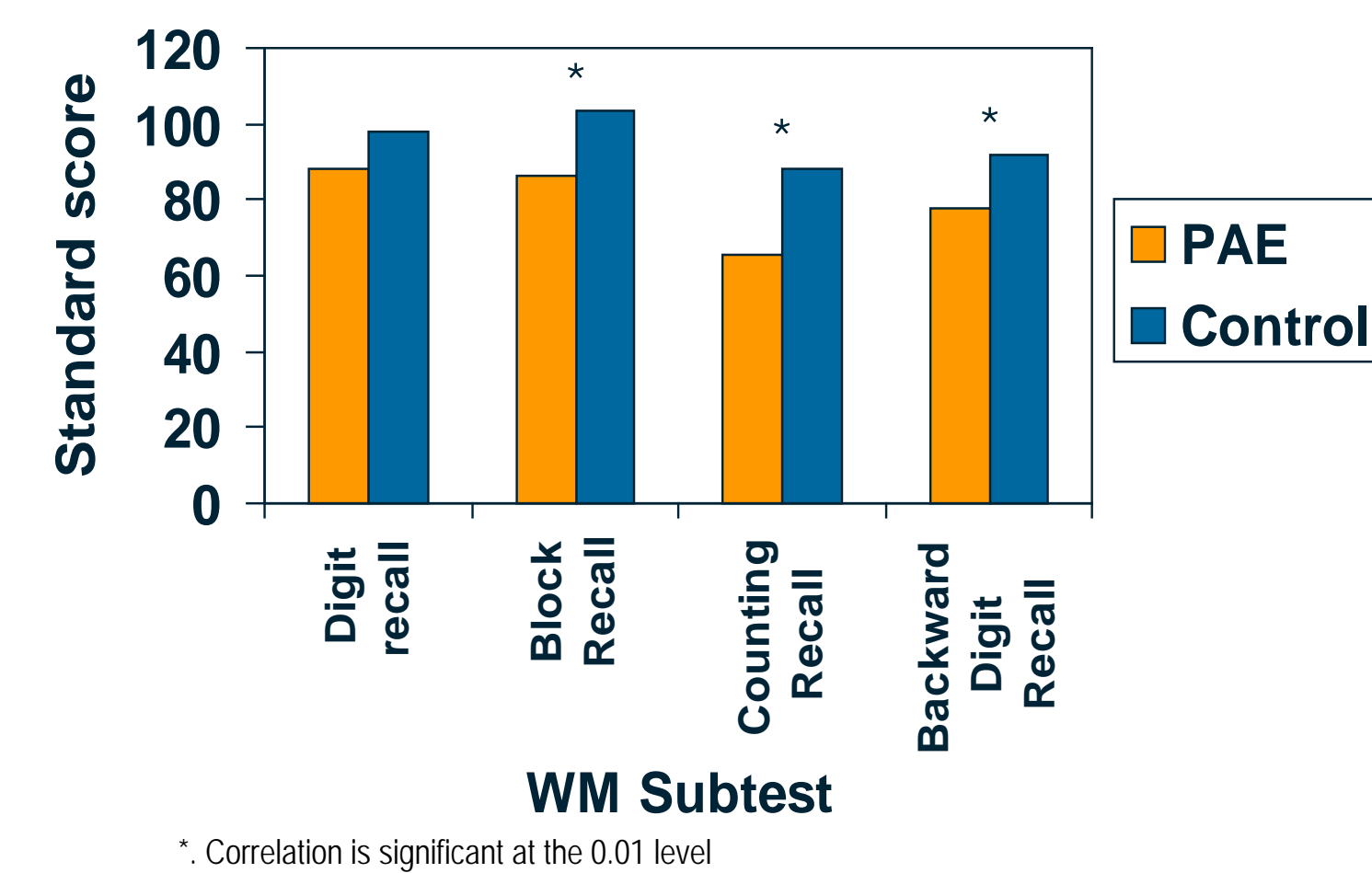
Mean Math Standard Scores



Mean NEPSY-II Scaled Scores



Mean Working Memory (WM) Standard Scores



Correlations between Math and Working Memory/Executive Function

	PAE				Control			
	Math Basic Concepts	Math Operations	Math Applications	Math Total	Math Basic Concepts	Math Operations	Math Applications	Math Total
WMTB Digit Recall	.412*	.511**	.598**	.522**	.694**	.644**	.513*	.680**
WMTB Block Recall	.055	.002	.300	.352	.375	.219	.561*	.429
WMTB Counting Recall	.099	.008	.166	.286	.648**	.622**	.789**	.698**
WMTB Backward Digit Recall	.342	.448*	.648**	.603**	.363	.451*	.318	.403
NEPSY Auditory Attention	.367	.404*	.431*	.461*	.709**	.456*	.590**	.673**
NEPSY Response Set	.456	.506*	.476	.570*	.530	.431	.674*	.599*
NEPSY Design Fluency	.147	.112	.242	.357	.289	.496*	.288	.338

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Significant values highlighted with lighter squares

•Among both groups, math performance correlated with many measures of EF and WM

•For the **PAE group**, both average EF scaled scores and average WM scaled scores **uniquely predicted math scores**, based on regression ($r^2 = 0.21$; $r^2 = 0.15$, respectively)

•For the **control group**, average EF scaled score **uniquely predicted math scores** ($r^2 = 0.13$)

Part Correlations between EF/WM and Math Scores

	Part Correlation	
	PAE	Control
WM	.459**	.207
EF	.387**	.358*

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Discussion

•Lower math, WM and EF scores in the PAE group relative to controls support the wide body of literature on deficits in these areas related to alcohol exposure in utero

•High correlations between both WM and EF and math scores indicate a strong relationship between performance in math and WM and EF

•Interestingly, measures of EF and WM related to visuospatial functioning (design fluency, block recall) showed few significant correlations with math scores in the control group and no significant correlations with math scores in the PAE group. Visuospatial relation to math function is relatively unexplored in populations with PAE, but visuospatial function is linked to math ability in typical and special populations

•Regression findings suggest that the PAE group has more underlying difficulties contributing to their math difficulties, given that WM and EF scores significantly predict math performance in the PAE group, whereas only EF significantly predicts math performance in the control group

•These findings hold implications for future research and practice, suggesting that math is an essential area of intervention for children with PAE, and math interventions for children with PAE should include accommodations for WM and EF

Acknowledgements

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