Examining the Influence of Neurocognitive Constructs on Mathematical Ability

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OBJECTIVE

The purpose of this study was to investigate how specific neurocognitive constructs of the NEPSY-II and Woodcock-Johnson III: Tests of Cognitive Abilities NU (Fluid Reasoning, Visual-Spatial Thinking, and Working Memory) in a mixed clinical sample predict Mathematical Reasoning and Calculation abilities, as measured by the Woodcock-Johnson III: Tests of Academic Achievement.

It was hypothesized that performance on selected subtests of the WJ-III COG NU and NEPSY-II would predict Match Calculation and Math Reasoning domains of the WJ-III ACH NU. The results indicate that the neurocognitive attributes measured by these assessments predict both math calculation and math reasoning skills.

INTRODUCTION

Math reasoning incorporates mathematical knowledge, including problem solving, analysis, reasoning, and vocabulary (Flanagan & Harrison, 2012). Math calculation involves basic mathematical skills, including computational skills and automaticity with basic math facts (Flanagan & Harrison, 2012).

Proctor, Floyd, and Shaver (2005) estimated that approximately 5-7% of the school-age population has difficulty in math achievement. Previous research has indicated that math achievement is influenced by certain cognitive processes (Passolunghi & Lanfranchi, 2012).

The purpose of this study is to evaluate how the cognitive processes of fluid reasoning, visual-spatial thinking, and short-term memory predict math calculation and math reasoning ability in a clinical population.

METHOD

This study incorporated data from the Kids, Inc. School Neuropsychology Post-Graduate Training Program. Participants included 952 individuals ages 6-18 previously identified as having a clinical diagnosis of Learning Disability, Neurological Impairment, Attention-Deficit/Hyperactivity Disorder, or Autism.

Three NEPSY-II subtests were utilized: Arrows, Design Copying, and Memory for Faces. Seven WJ-III-COG subtests were utilized: Auditory-Working Memory, Numbers Reversed, Concept Formation, Analysis-Synthesis, Memory for Words, Planning, and Picture Recognition.

RESULTS

To determine how these subtests predict mathematical ability, two multiple regression analyses were computed.

The first analysis was run using the Enter method, and it was found that the cognitive subtests explain a significant amount of the variance in math reasoning, $F(11, 266) = 4.05$, $p < .05$, $R^2 = .143$. 14.3% of the variance in math reasoning ability can be explained by performance on these cognitive tasks.

The analysis shows that the analysis-synthesis subtest of the WJ-III COG NU significantly predicted math reasoning achievement on the WJ-III ACH, ($\beta = .21$, $t(11,266) = 2.95$, $p < .05$).

The second analysis was run using the Enter method, and it was found that cognitive subtests explain a significant amount of the variance in math calculation, $F(11, 266) = 4.29$, $p < .05$, $R^2 = .151$. 15.1% of the variance in math calculation ability can be explained by performance on these cognitive tasks.

The analysis shows that the auditory working memory subtest of the WJ-III COG NU significantly predicted math calculation achievement on the WJ-III ACH, ($\beta = .2$, t(11, 266 = 2.92, $p < .05$), as did the numbers reversed subtest, ($\beta = .165$, t(11, 266 = 2.27, $p < .05$).

This study supports the hypothesis that performance on these cognitive tasks predicts academic success in math reasoning and math calculation.

DISCUSSION

Specifically, the findings suggest that math reasoning was predicted by the WJ-III COG subtest analysis-synthesis, which requires skills of deduction and algorithmic reasoning.

This suggests that fluid reasoning abilities (problem solving) significantly influence math reasoning skills. Furthermore, the findings suggest that math calculation was predicted by the WJ-III COG subtests auditory-working memory and numbers reversed. This supports the notion that short-term memory significantly contributes to the success of an individual's math calculation ability. Previous research has also noted that short-term memory influences math ability (Floyd, Evas, & McGrew, 2003; Flanagan & Harrison, 2012). Practitioners can utilize these findings to design appropriate interventions bearing in mind the significant influence of memory ability on math achievement.

Table 1: *Math Calculation predicted by WJ-III COG NU and NEPSY-II subtests*

Neurocognitive Subtests	*B*	SE *B*	β	*p*
NPDC	.57	.36	.10	.11
NPAR	.15	.37	.03	.68
NPMF	-.37	.34	-.07	.27
COGAWM	.22	.08	.20	.03
COGNR	.18	.08	.17	.02
COGMW	-.05	.08	-.05	.46
COGPR	.08	.09	.05	.40
COGCF	.00	.07	.00	.95
COGAS	.09	.08	.09	.22
COGPL	-.15	.08	-.11	.06

Table 2: *Math Reasoning predicted by WJ-III COG NU and NEPSY-II subtests*

Neurocognitive Subtests	*B*	SE *B*	β	*p*
NPDC	-3.9	.27	-.95	.14
NPAR	.46	.28	.11	.09
NPMF	.13	.25	.03	.61
COGAWM	.09	.06	.12	.09
COGNR	.00	.06	.00	.97
COGMW	.01	.06	.01	.84
COGPR	.02	.07	.02	.75
COGCF	.05	.06	.07	.32
COGAS	.17	.06	.21	.03
COGPL	.06	.06	.06	.37

References

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