A Cross-Lagged Analysis of Persistent Low Math Achievement

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Introduction

Persistent low mathematics achievement and specific learning disabilities (SLD) in mathematics, including dyscalculia, are associated with normative weaknesses in specific cognitive skills, including fluid intelligence, working memory, processing speed, and numerical skills (Fuchs et al., 2010). However, the causal mechanism for these relations is not entirely clear. This study utilized a cross-lagged panel analysis (Watkins et al., 2007) to examine the causal relationship between fluid intelligence, working memory, processing, and mathematics achievement. Anonymized data from a clinical sample of four hundred students who were referred for a psychoeducational evaluation at time 1 and reevaluated three years later at time 2 was utilized in this study. The investment hypothesis from the theory of fluid and crystallized intelligence (Horn & Cattell, 1966) predicts that fluid intelligence should cause growth in crystallized intelligence, including academic achievement. To test the investment hypothesis in the context of math achievement, students' math calculation at time 2 was regressed on math calculation at time 1, as well as fluid intelligence, working memory, and processing speed using structural equation modeling. The purpose of this study is to inform school psychology practitioners regarding the utility of assessment data when working with students with persistent low achievement in mathematics.

Method

Measures

Fluid intelligence, working memory, and processing speed were assessed using the Woodcock-Johnson Tests of Cognitive Ability, 4th Edition (WJ-IV-COG; McGrew et al., 2014). Math achievement was assessed using the Woodcock-Johnson Tests of Achievement, 4th Edition (WJ-IV-ACH; McGrew et al., 2014). The WJ-IV Cog is a norm referenced, standardized assessment used to measure general intellectual ability, whereas the WJ-IV-ACH is a standardized, norm-referenced measuring achievement levels in reading, mathematics, written language, and specific knowledge (McGrew et al., 2014). Latent variables were assessed using the following subtests:

Fluid Reasoning (Gf)	Concept Formation & Number Series
Working Memory (Gwm)	Numbers Reversed & Verbal Attention
Processing Speed (Gs)	Letter Pattern Matching & Pair Cancellation
Math Achievement	Calculation & Math Facts Fluency

Sample

The sample consisted of 400 students (grades K-8) from a large urban southwestern U.S. school district who were referred for an evaluation (time 1) and a triennial reevaluation (time 2) using the Woodcock Johnson IV Tests of Cognitive Abilities and the Woodcock Johnson IV Tests of Achievement.

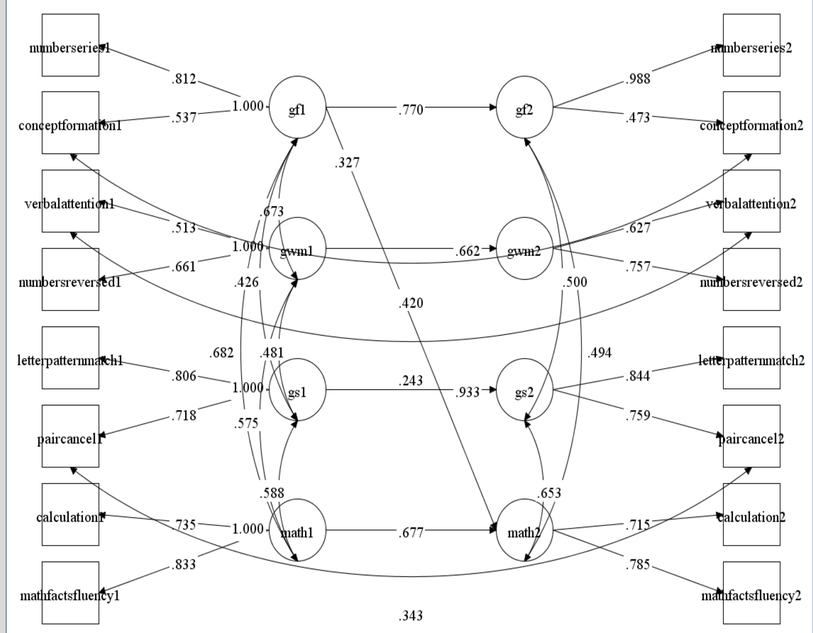
Procedure

School psychologists reviewed report files and placed extracted data into a separate document that included no identifying participant information.

Analysis

A cross-lagged structural equation model (SEM) was used to test the causal relationship between fluid intelligence, working memory, processing, and mathematics achievement. Latent variables at time 2 (3-year reevaluation) were regressed on latent variables at time 1 (initial evaluation).

Results



Cross-lagged structural equation model of mathematics achievement (math) and fluid intelligence (gf), working memory (gwm), and processing speed (gs) at time 1 (initial evaluation) and time 2 (3-year reevaluation). Statistically significant paths at the .05 or lower level are shown. N = 400.

Results indicated that the cross-lagged SEM fit the data well: χ^2 (120) = 1832.888, $p > .00$, CFI=.933; RMSEA=.064; SRMR=.056. As expected, math achievement at time 2 was significantly predicted by math achievement at time 1. In addition, math achievement at time 2 was significantly predicted by fluid intelligence at time 1, supporting the investment hypothesis. Working memory and processing speed at time 1 did not predict math achievement at time 2; conversely, math achievement at time 1 did not predict fluid intelligence, working memory, or processing speed at time 2.

Discussion & Implications

Typical roles and functions of school psychologists consist of conducting psychoeducational evaluations for intervention recommendations and special education eligibility considerations. The results of this study suggest that future math achievement is predicted by both prior math achievement as well as fluid intelligence. The finding that fluid reasoning predicts math achievement supports Horn & Cattell's (1966) investment hypothesis. Targeted math interventions and progress monitoring (i.e., RTI in math) is a critical need for students with persistent low achievement in mathematics. Normative deficits in fluid intelligence constitute a risk factor for persistent low achievement in math and SLD in math. These results also imply the need for:

a) continuing to move the field of school psychology away from discrepancy models as a method for SLD identification
b) continuing to strengthen RTI practices, particularly in math
c) continuing to investigate research-based practices in universal prevention, psychoeducational diagnosis, and individualized interventions.

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