Title	Updating and mathematical performance: Implications for children in lower primary
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Kerry Lee & Rebecca Bull

UPDATING AND MATHEMATICAL PERFORMANCE: IMPLICATIONS FOR CHILDREN IN LOWER PRIMARY

Math Performance in Singapore

- Singapore has performed well in international comparisons of mathematics achievement
  - Trends in International Mathematics and Science Study
  - Programme for International Student Assessment
- A relatively large tail-end compared to other high performing systems
- Around 5.5% of children struggle with math on entry to primary schools

Contributing Variables

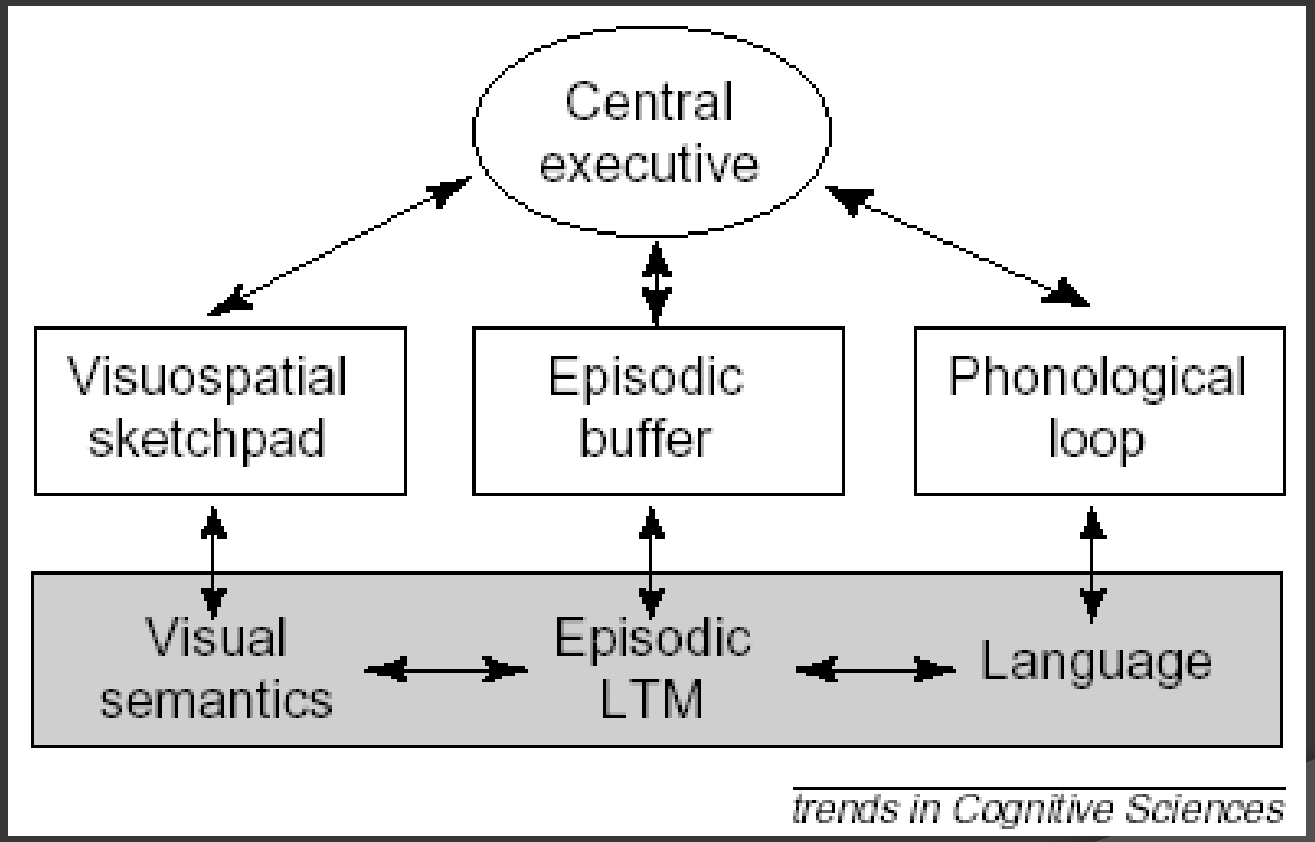
- System
  - Societal expectation
  - Education system
  - Effort and quality of teachers
- Individual
  - Social or motivational (e.g., Ashcraft, Kirk, & Hopko, 1998)
  - Biological (see Geary, 1993, for a review)
  - Cognitive

Working Memory

What is Working Memory?

- 259 + 36 = ?
- 764 / 4 = ?

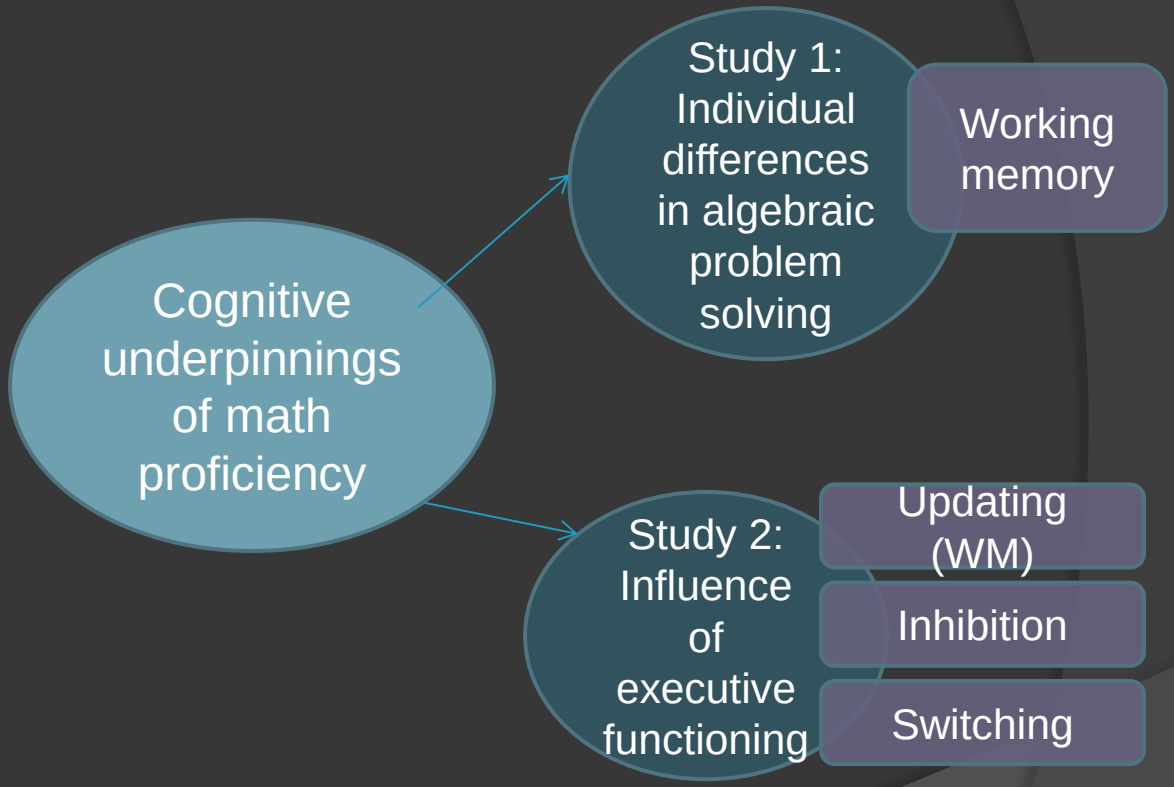
Baddeley (2000)



Working Memory and Mathematical Performance

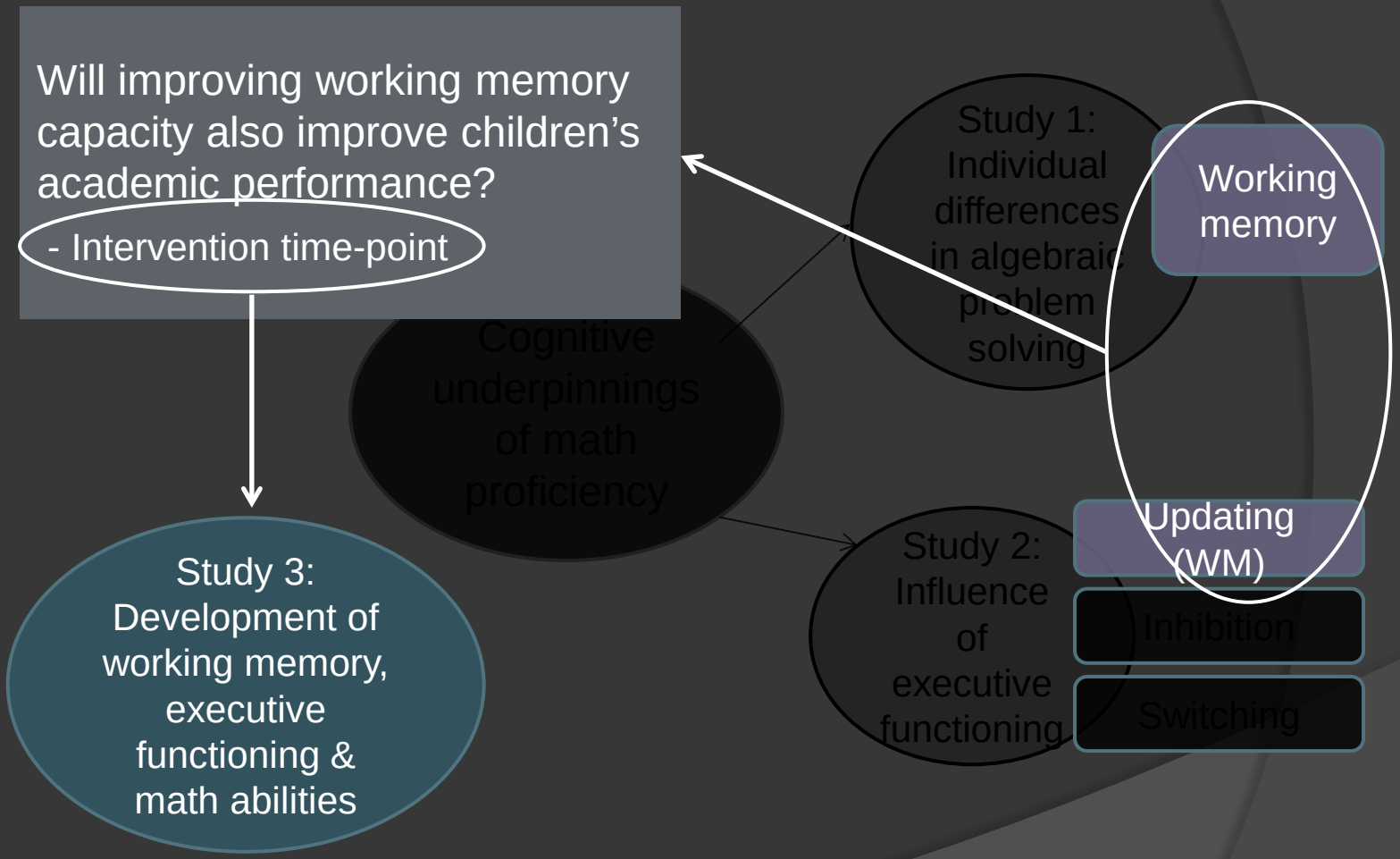
- Central executive measures predicted early mathematical performance
  - Bull, Johnston, and Roy (1999), Bull and Scerif (2001)
- Standardised working memory scores predicted children's academic standing in mathematics with 83% accuracy
  - Gathercole and Pickering (2000)

Cognitive Underpinnings



Lee et al. (2004) *Jn Exp Child Psych*
Lee et al. (2009) *Jn Edu Psych*

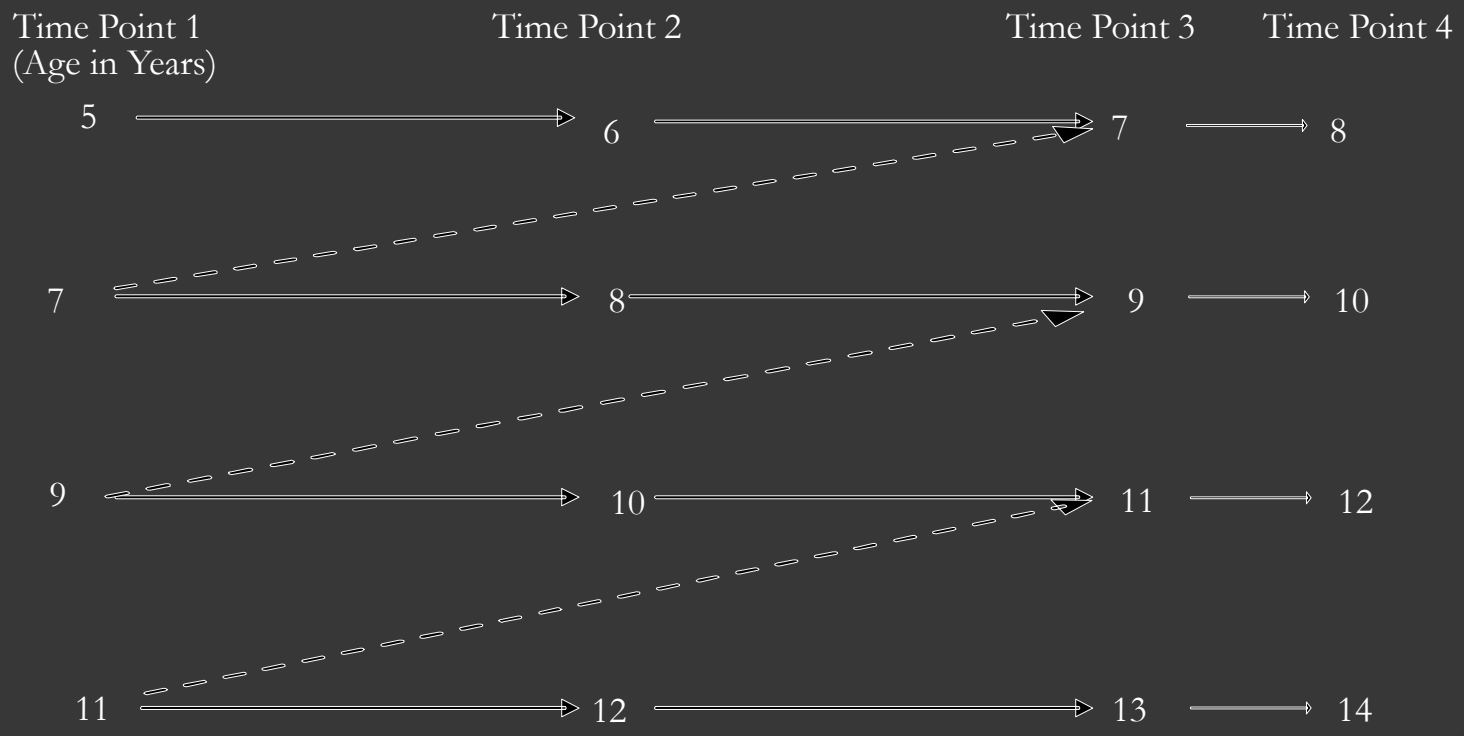
Cognitive Underpinnings



The Present Study

- Examined the relation between working memory/updating (WMU) and mathematical performance
  - Does the relation between WMU and mathematical performance remained the same from Kindergarten to Sec 3?
  - To what extent do earlier capacities in WMU and mathematics contribute to their later development?
  - Does performance in kindergarten affect the rates of growthin WMU and mathematics?

Cohort-Sequential Design

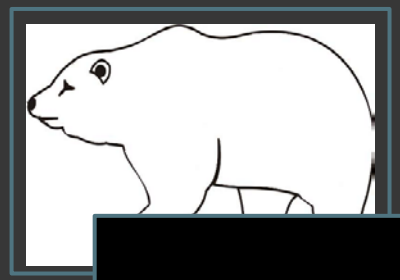


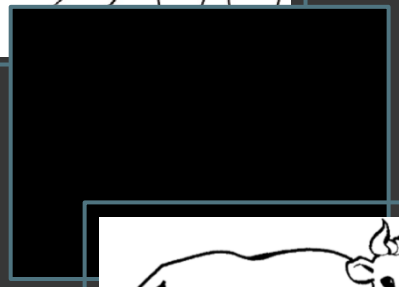
~ 673 children
spread over 4 cohorts,
81 school at Wave 4

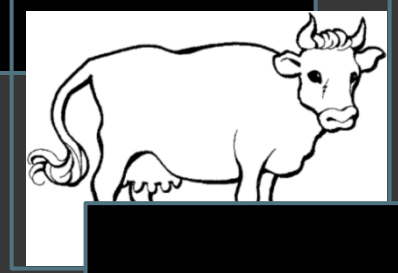
Instruments

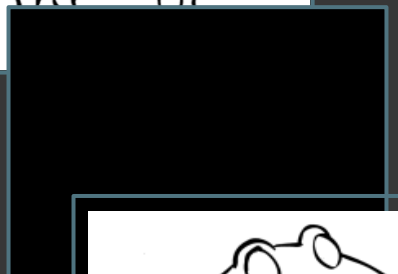
- Executive functioning
  - Inhibitory efficiency
    - Flanker
    - Simon
    - Antisaccade Mickey
  - Switching efficiency
    - Switch conditions from Flanker and Simon
    - Picture–symbol
  - Updating capacity
    - Animal Updating
    - Mr. X
    - Listening Recall
- Standardised mathematical tasks
  - Wechsler Individual Achievement Test
    - Number Operations
    - Mathematical Reasoning
- Curricular based mathematical tasks
  - Growing number patterns
  - Function machines
  - Arithmetic and algebraic word problems

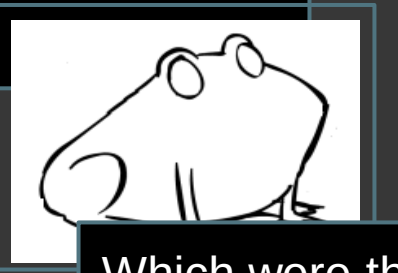
Updating/Working Memory tasks







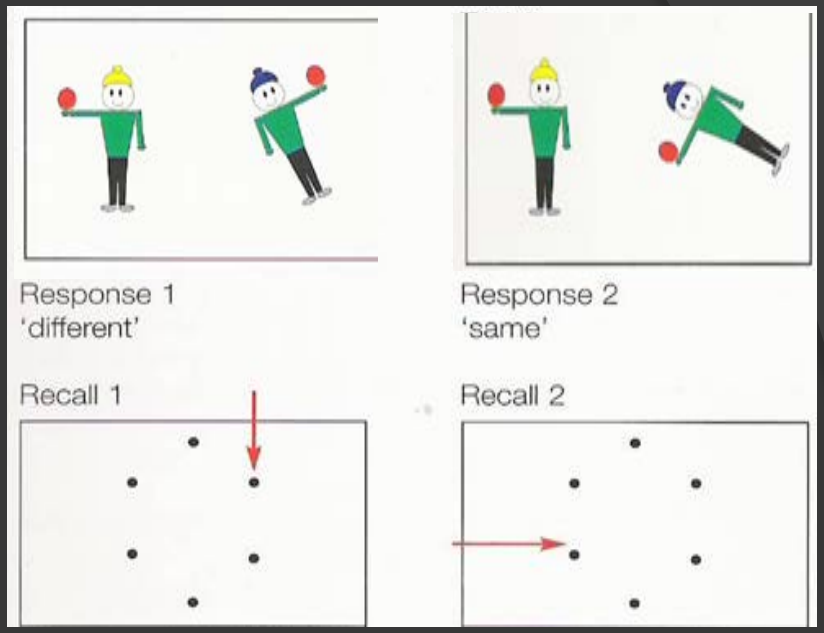




Which were the last two animals that you saw?

Participants were shown an unknown number of animals one at a time. They were then asked to remember the last 2, 3, or 4 animals

- Mr. X (AMWA)



- Listening Span (AMWA)
  - Stimulus
    - Bananas live in water (T/F)
    - Flowers smell *nice* (T/F)
  - Response
    - Remember last words in each statement

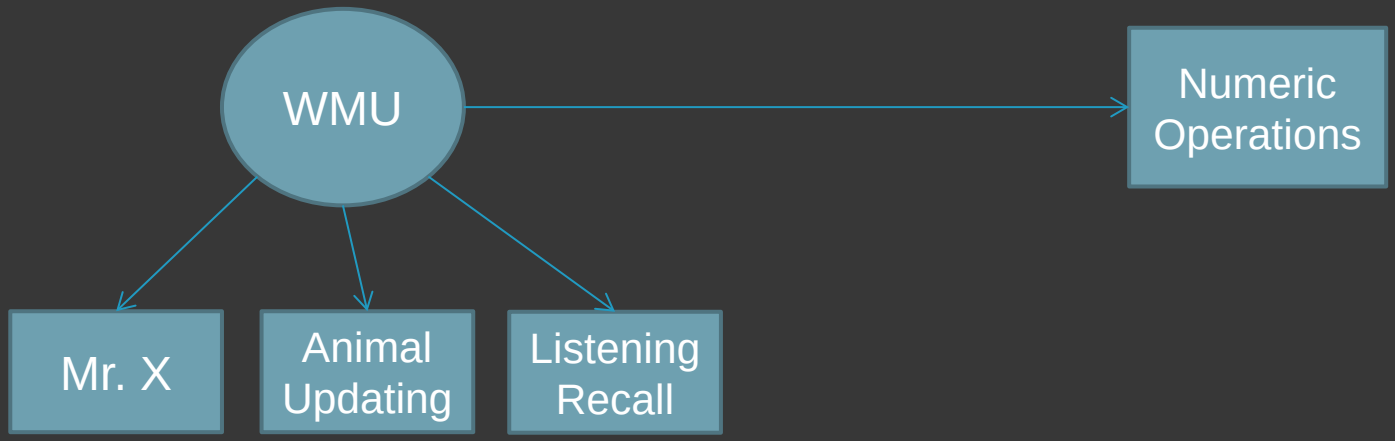
WIAT

Numerical Operations

Grade level	Typical items from the WIAT – Numerical Operations
Kindergarten to Primary 1	1 2 3 _ 5 6 7 8 9
Lower Primary (P1 to P3)	4 + 5 = __ 150 - 25 4 X 3 = __
Upper Primary (P4 to P6)	$7\overline{)861}$ .4 + .6 = __ $\frac{1}{3} - \frac{1}{4} =$ ___
Secondary (S1 and above)	$10^2 =$ ___ -14 + (-16) = __ 200% of 80 = __ 2x - 15 = 3 – x x = __

Results

Concurrent Relations

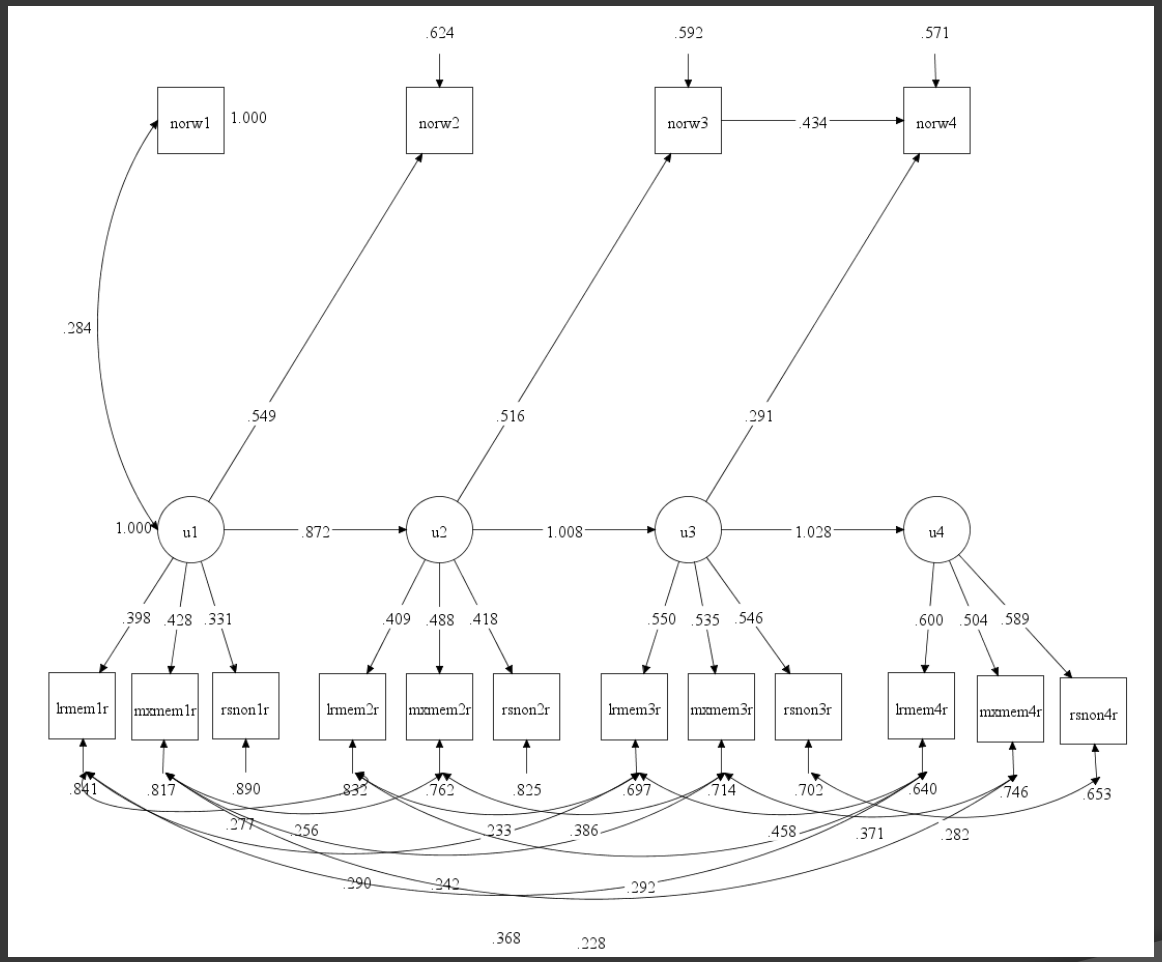


Concurrent Relations

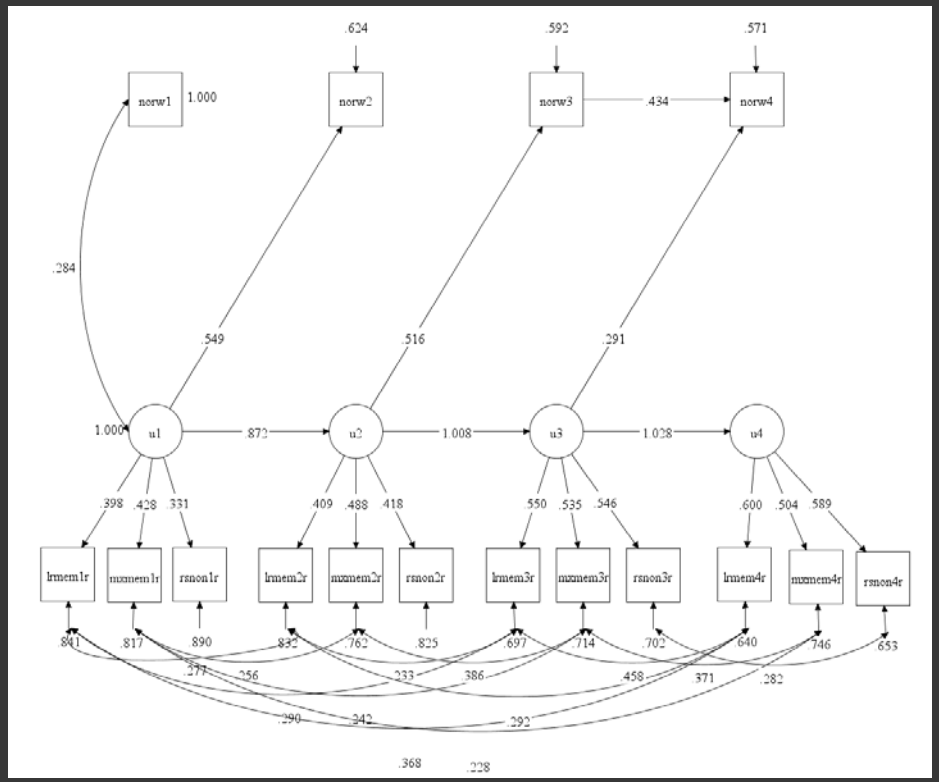
- With the exception of the youngest children, the cross-sectional findings indicate a strong relation between WMU and mathematical performance
- Cross-sectional relations between WMU and mathematics peaked at Grades 1 and 2
  - These findings suggest that, at this age, single to multi-digit addition and subtraction rely heavily on WMU capacity
- Surprising that relation at K1 was relatively small
  - Support the view earlier math skills are more dependent on other fundamental numeric abilities
  - Later math skills, acquired via schooling, being more dependent on general cognitive abilities

Age	K2	P1	P2	P3	P4	P5	P6	S1	S2	S3
Num Op on WMU	0.16	0.66	0.63	0.50	0.47	0.55	0.50	0.49	0.59	0.55

Predictive Relations – K2

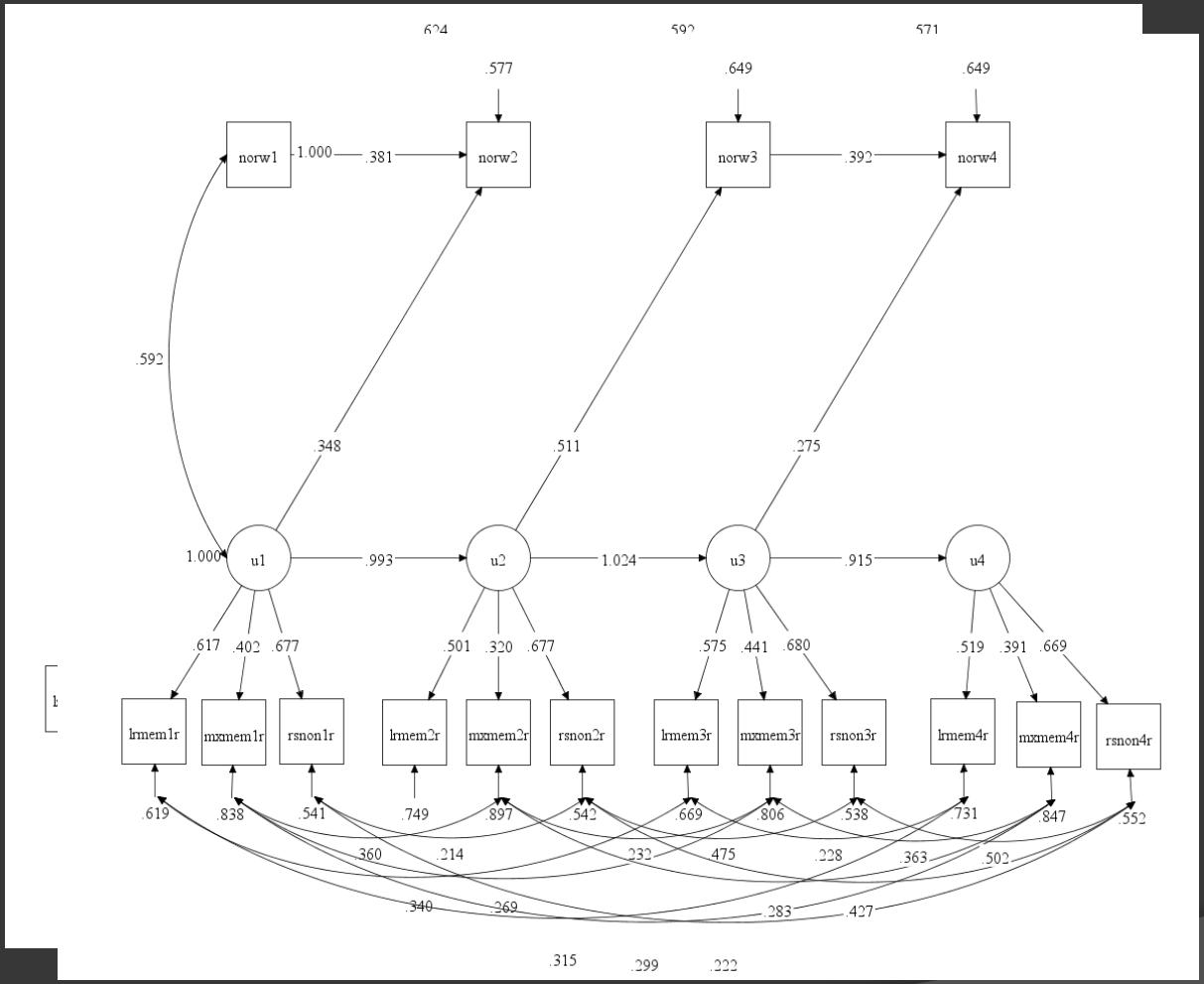


Predictive Relations

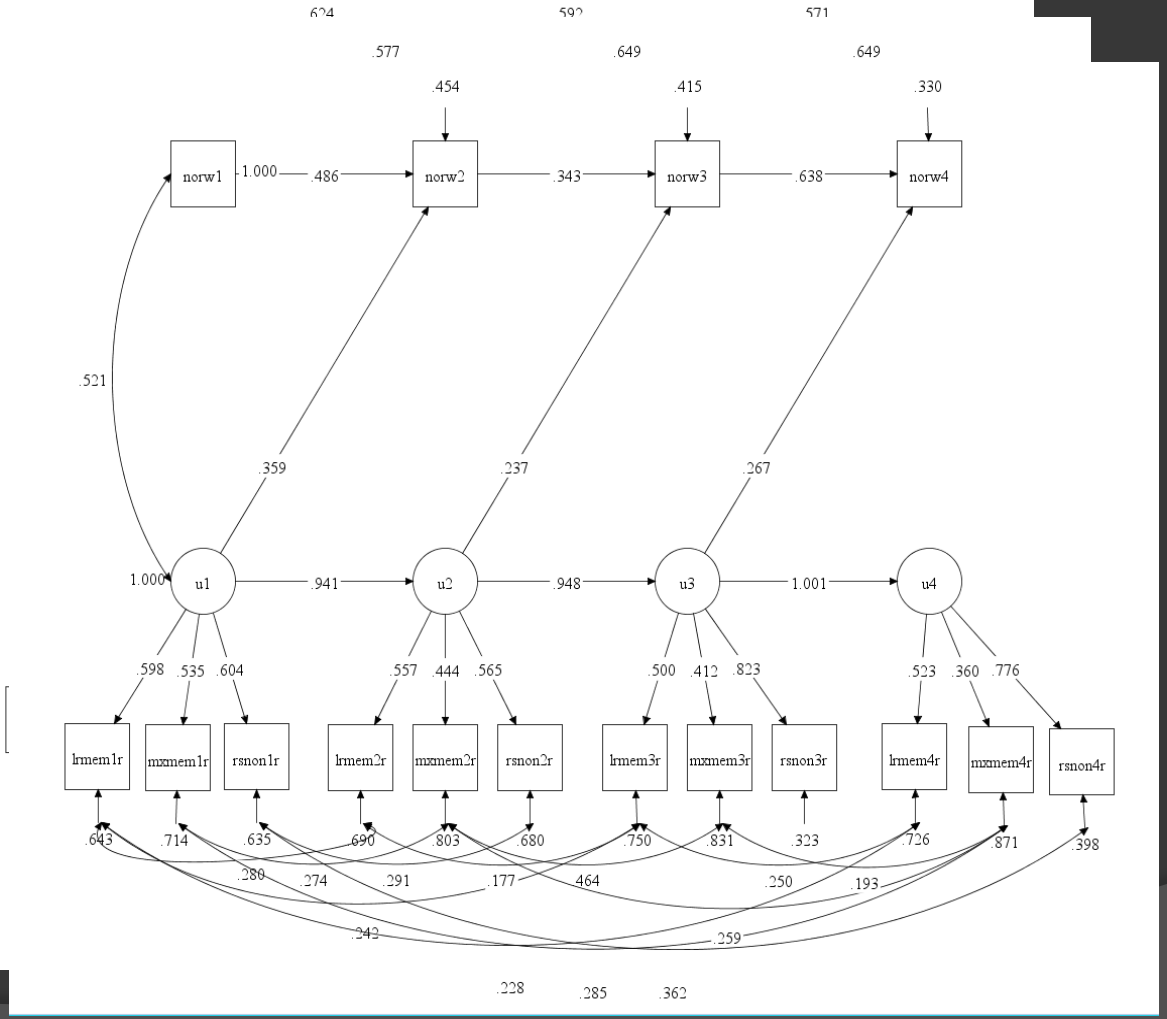


- The predictive findings show that doing well in these early years depends less on what one has learned in mathematics in the previous year, but more on WMU capacity
  - Perhaps indicate that once basic numeracy is mastered, it contributes little to performance in arithmetic computation

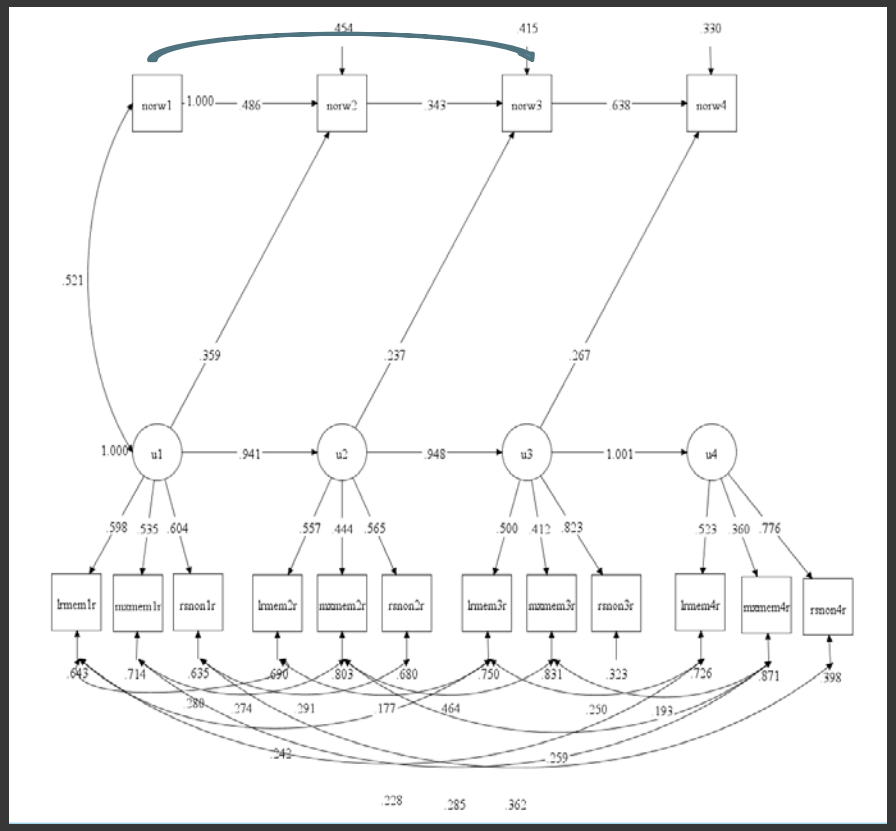
Predictive Relations – P2



Predictive Relations – P4

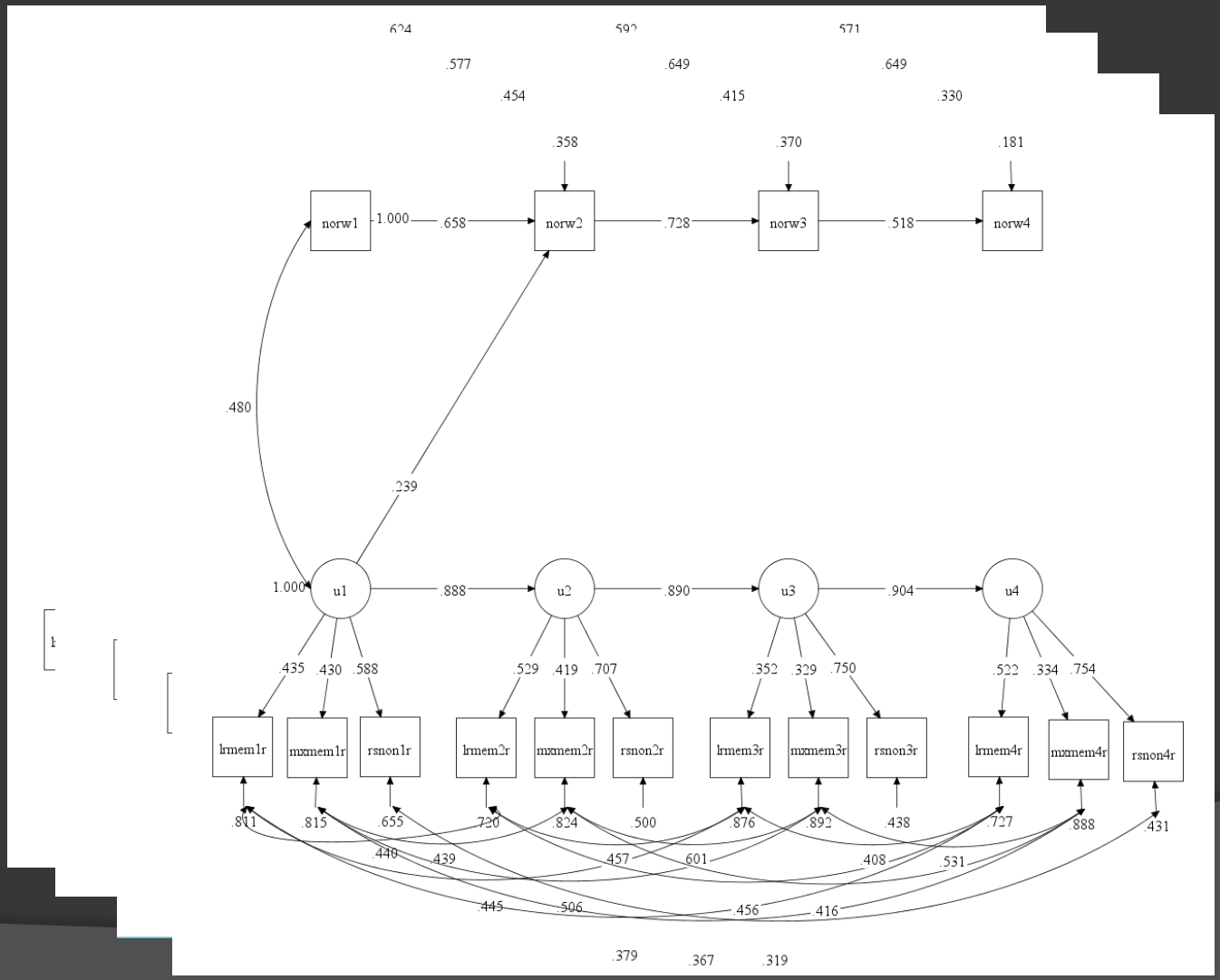


Predictive Relations – P4

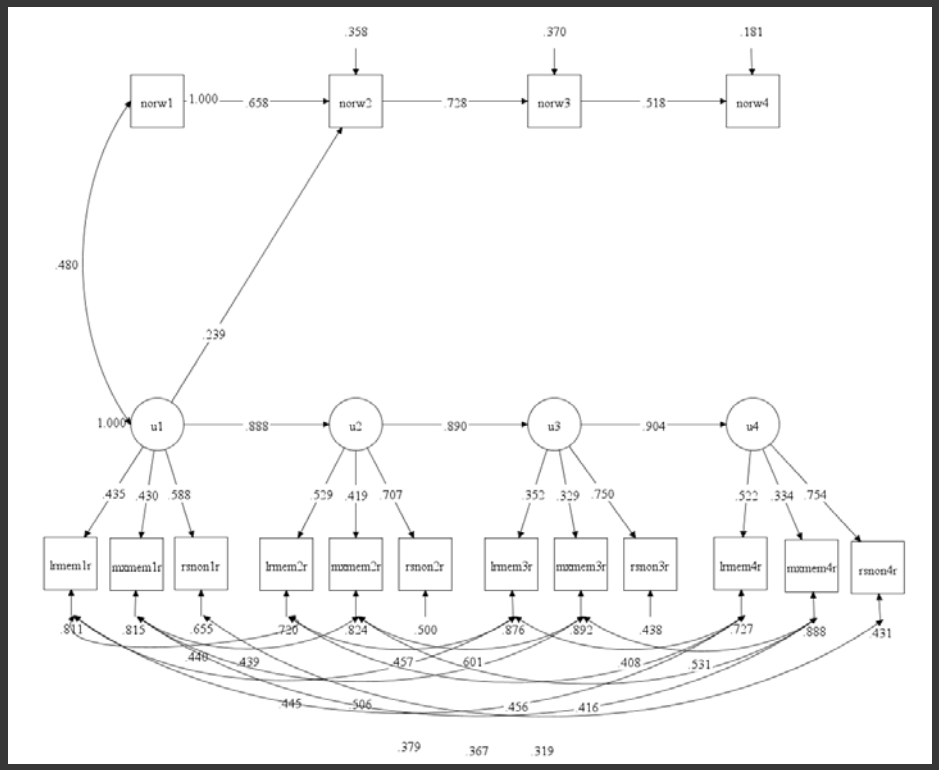


- Math performance at P4 predictive of performances at both P5 and P6
  - simple fraction subtraction and simple addition involving decimals → multi-digit multiplication involving decimals, working with negative integers, and percentages

Predictive Relations – P6

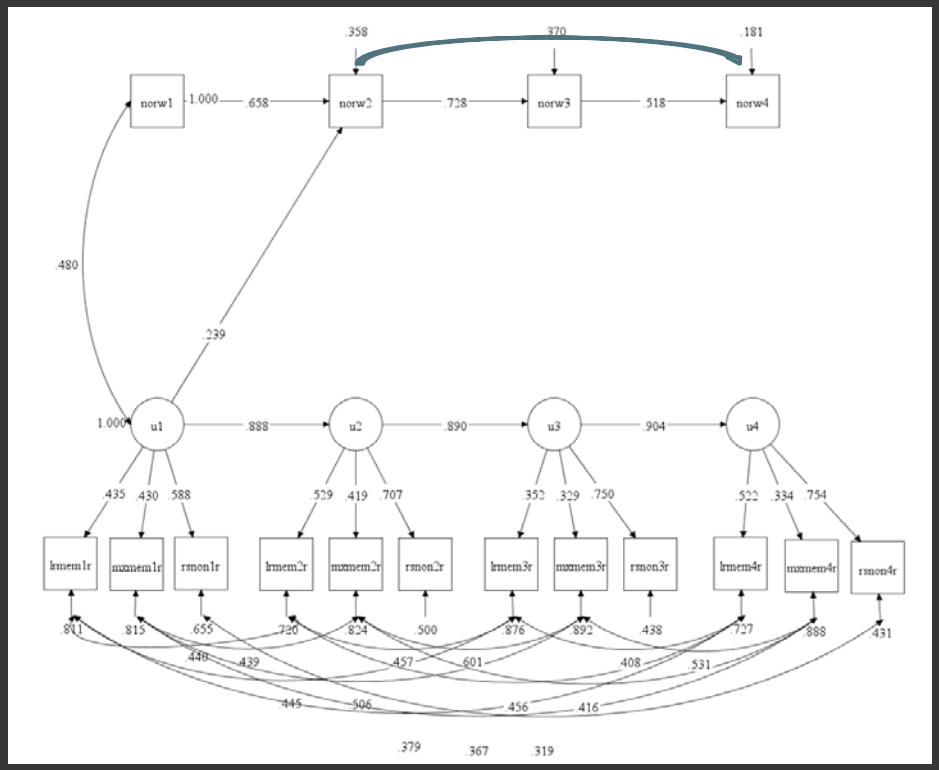


Predictive Relations – P6



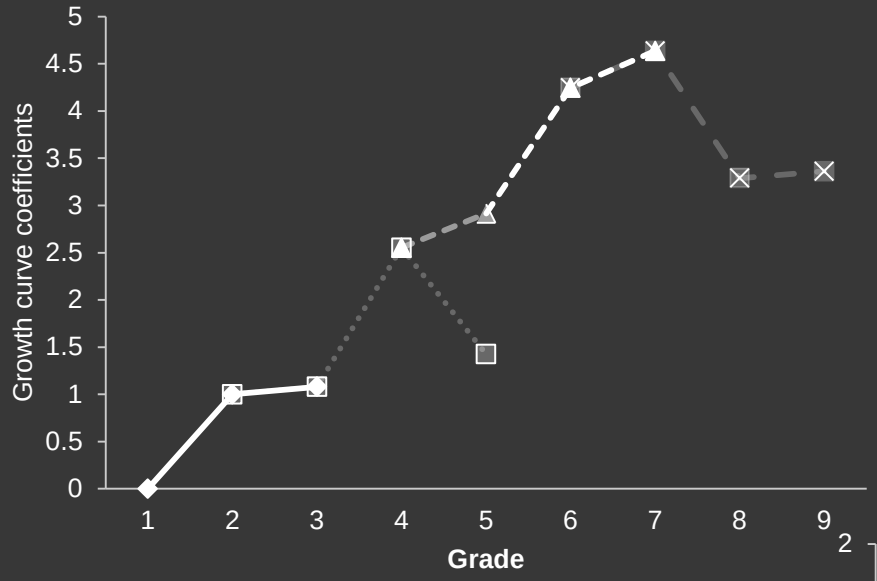
- WMU did not predict subsequent performance in mathematics from S2 to S3
  - With increasing expertise, there is a reduction in reliance on effortful executive processes
  - The increase in complexity places more demands on domain specific knowledge than on WMU capacities

Predictive Relations – P6



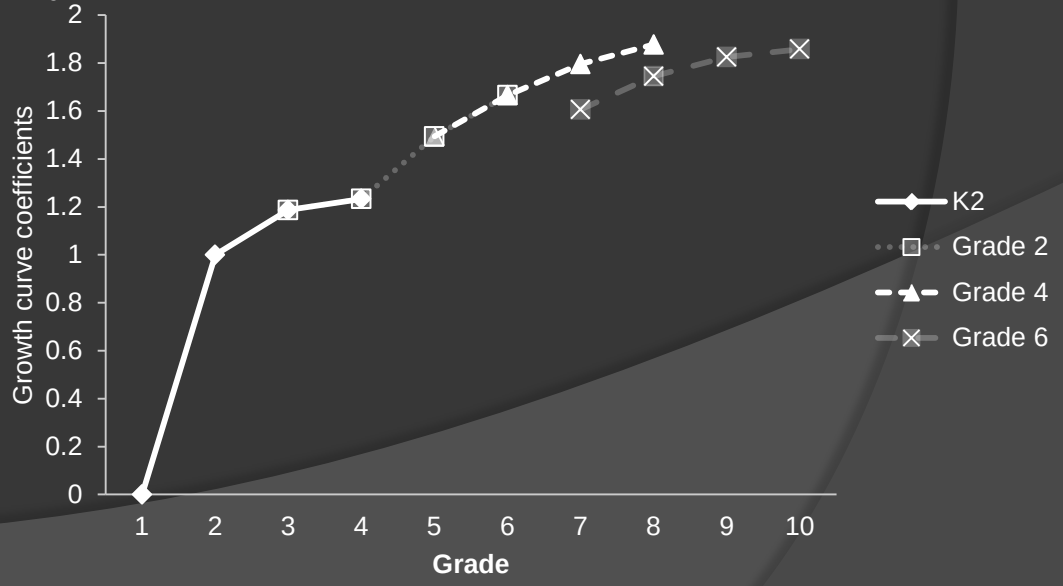
- Math performance at S1 predictive of performances at both S2 and S3
  - simple algebra → questions involving division of fractions and complex exponentials

Patterns of Growth



Estimated slope coefficients for performance on the Numerical Operations task

Estimated slope coefficients for performance on the WMU



Patterns of Growth

- Mathematics
  - Children who had higher scores at kindergarten had lower averaged rates of growth
    - Suggesting that children with lower initial performance do tend to catch up, although not necessarily achieving parity
- Updating
  - Rates of growth did not differ significantly across individuals
- Updating and mathematics
  - Children who entered kindergarten with higher updating capacity improved in their mathematics performance faster than did children with lower updating capacity

Conclusions

- Several important findings
  - Relation between Updating and Math peaked at P1 and P2
  - Children with higher updating capacity improved in their mathematics performance faster
  - Predictive relations between Updating and Math were significant from K2 to S1
  - Performance in math at P1 and P2 not reliant on earlier math performance
- Implications
  - For secondary school students, math content knowledge is more important than underlying cognitive capacity
    - Focus of teaching should be placed on domain specific content
  - For the first years of primary schooling, updating capacity is important
    - Can updating capacity be improved? How?
      - Stay tuned …

Caveat: not all early numeracy capacities were measured – Rebecca's talk

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