The relationship between spatial ability and math performance
The mediating role of number magnitude and Relation to Operands

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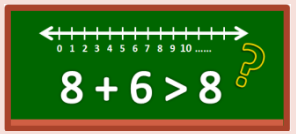


Abstract

The current study aims at investigating the relationship between spatial ability and children's math performance, as well as exploring whether the relationship is mediated by the number magnitude and the understanding of the Relation to Operands principle (A + B > A). A sample of 273 fourth-graders were tested for their spatial ability, number magnitude (NM), understanding of the Relation to Operands (R-to-O) principles and their math performance, as well as a list of control variables (e.g. IQ and working memory). The result showed that children's spatial ability significantly predict math performance, even after controlling for the potential confounding variables. The relation was fully mediated by the NM and the understanding of the R-to-O principle. This finding, in addition to supporting the link between spatial ability and math performance, further indicates that the ability to associate number symbols with magnitude and the ability to detect the Relation to Operands principle may be the mechanism underlying the relation.

Introduction

Spatial ability & math performance

- ✓ Adolescents and adults with higher mental rotation ability perform better in mental arithmetic [1], word problems [2]
- ✓ Mental rotation in grade 1 predict math performance in grade 5. [3]
- ✓ Spatial ability training improve math performance [4]

Spatial ability & NM & math performance

Previous studies found a strong association between

- ✓ Spatial ability and number magnitude [5]
- ✓ Number magnitude and math performance [6]
- ➢ Numerical magnitude meditating the relationship between MRT and math performance [7]

NM & R-to-O & math performance

1. Encoding magnitude is necessary for the acquisition of the R-to-O principle. Students who received relative magnitude training showed greater improvement in their R-to-O knowledge. [8]
2. R-to-O is the marginal significant predictor of math performance. [9]

Objective:

Integrating the above findings by examining whether NM and R-to-O are mediating the relationship between spatial ability and math performance.

Methods

Participants

273 grade 4 students (162 boys, 111 girls) from 9 primary schools in Hong Kong were recruited

Measures

- Spatial ability- MRT (20 items)

- R-to-O understanding
  Evaluation of examples (16 items)

Given that A < B < C < … < I < J, and all letters > 1, the following students answered all the problems incorrectly.

	Zoe	Victor	Which student gives an incorrect but more reasonable answer?
A + C =	B	E	
B + E =	D	H	

- NM
  Number line task in percentage of absolute error
- Mathematics performance
  - Numerical Operation Subscale of WIAT-III
  - Math Problem Solving Subscale of WIAT-III

Control measures:

- Non-verbal intelligence Raven's progressive matrices
- Verbal working memory (VWM) – Backward digit span
- Visuospatial working memory (VSWM) – Corsi block

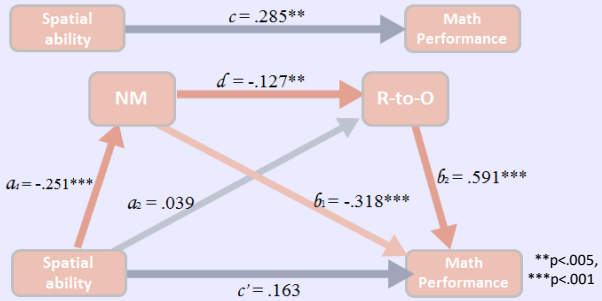
Results

correlation among measures

	VWM	VSWM	Spatial ability	NM	R-to-O
VSWM	.280***				
Spatial ability	.299***	.293***			
NM	-.246***	-.231***	-.383***		
R-to-O	.307***	.387***	.336***	-.341***	
Math performance	.294***	.456***	.435***	-.423***	.558***

1. A bias-corrected bootstrapping was used to test the direct and indirect effect.
   - ✓ Sig. Indirect effect: Point Est. 95% CI
     1) Spatial > NM > math .080 [.029, .145]
     2) Spatial > NM > R-to-O > math .019 [.004, .039]
2. After taking potential mediators into account, spatial ability become insignificant predictor of math performance

→ The relationship between spatial ability and math performance is fully mediated by NM and R-to-O



Summary & Conclusion

The study confirms prior studies that illustrated number magnitude as a potential mediator of the relation between spatial ability and math performance. It also carried out the first empirical investigation which tests the indirect effect from spatial ability →NM → R-to-O → math performance.

Implications and applications

- Spatial training can potentially improve children's mathematic performance, possibly through enhancing the accuracy of their mental number line representation and understanding of R-to-O principle.
- Providing number line as an illustration during class may probably help children to link the NM knowledge to the understanding of R-to-O principle and then benefit their math performance.
- Besides, training programs that combined the numerical magnitude with the acquisition of arithmetic principle may be more efficient to improve children's math performance.

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