Differences by SES and Ethnicity on Pattern and Spatial Skills Among Preschool Children

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BACKGROUND

- Evidence suggests differences exist in children's math skills by socioeconomic status (National Research Council, 2009).
- Students of lower socioeconomic status trail behind their higher-income peers in mathematical skills (Jordan et al., 2009).
- Fryer and Levitt (2004) found that In kindergarten, Black children scored significantly lower than White children on mathematics assessments.
- Less is known about SES and ethnicity differences in other skills that may contribute to the development of math knowledge.
- Pattern skills, which include identifying, extending, and describing sequences of objects or numbers, have been recognized as key skills in mathematical ability and thinking (Charles, 2005; Sarama & Clements, 2004; Steen, 1988), and can uniquely predict math performance in fifth grade (Rittle-Johnson, Fyfe, Hofer, & Farran, 2015).
- Preschoolers' spatial skills, which refer to the ability to cognitively visualize and manipulate spatial images and information (Mix & Cheng, 2012), predict later math knowledge (Verdine, Golinkoff, Hirsh-Pasek, Newcombe, et al., 2014).
- Low-SES 3-year-old children are already beginning to lag behind middle-income peers in their spatial skills (Verdine et al., 2014).
- Patterning skills of low-income 4-year-olds are less advanced than higher-income peers (Rittle-Johnson, Fyfe, Hofer, & Farran, 2015).

QUESTIONS

What is the role of young children's pattern and spatial skills in early math abilities?

- More specifically, how do math abilities differ by SES and ethnicity in pattern and spatial skills?

PARTICIPANTS

77 preschoolers, ages 4.0 to 5.7 months

48.1% boys

54.5% non-White (82.6% Black)

35.2% receive full financial assistance, 15.6% receive some assistance

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PROCEDURES

A team of 5 researchers assessed the children in the fall in two 30-minute sessions. On average, the sessions were 5 days apart. Children were assessed at their own school individually with a researcher in a quiet space with audio/video recording.

Pattern Knowledge Assessments

Research-Based Patterning Assessment
- 9 items that measure children's ability to duplicate, extend, abstract, and identify pattern units using blocks and tangram pieces. Ordered according to difficulty level (Rittle-Johnson, Fyfe, Loehr, and Miller, 2015).

Teacher-Based Patterning Assessment
- Tests patterning skills in extension, abstraction, and identification of the missing unit. It consists of 10 items developed from pre-existing teacher activities online.

Spatial Skills Measures

Form Perception
- Measured by 25-item Position in Space subtest of the *Developmental Test of Visual Perception–Second Edition* (Hammill, Pearson, Voress, 1993) in which children had to identify the image in the same position as the model image.

Spatial Visualization
- Measured by 17-item Block Design, a subtest of the *Wechsler Preschool and Primary Scale of Intelligence–Fourth Edition* (Wechsler, 2012) in which children recreated a picture or a model of a block structure using red and white colored blocks.

Visual Spatial Working Memory
- Assessed with the *Path Span* eCorsi task on the iPad, in which children had to reproduce the frog's path on the lily pad in the same order or backwards.

Other Assessments

Math Knowledge
- Assessed using the REMA Short-Form from the *Research-Based Early Mathematics Assessment* (Weiland et al, 2010)
- 19 items testing children's numeracy knowledge and geometry knowledge

Verbal Intelligence
- Measured by the Picture Vocabulary Test from version 1.6 of the *NIH Toolbox app* on the iPad that assesses children's receptive vocabulary.
- Children had to select one image out of four that corresponds with the orally presented word.
- Scores age-corrected and standardized, centering around a score of 100.

Working Memory
- Assessed using backwards letter span task, based on the backwards digit span task from the *Wechsler Preschool and Primary Scale of Intelligence–Fourth Edition* (Wechsler, 2012).
- Excluded from further analyses due to poor internal consistency in sample.

RESULTS

Mean and Standard Deviations of Performance of Pattern, Spatial, and Math Assessments

	Race		Financial Assistance	
	White	Non-White	None	Full
Pattern	.24 (.93)	-.19 (.81)	.26 (.18)	-.31 (.14)
Spatial	.18 (.81)	-.15 (.79)	.18 (.15)	-.22 (.14)
REMA	11.58 (3.47)	9.90 (3.81)	11.27 (.69)	9.81 (.66)

One-Way ANOVA of Pattern and Spatial Skills According to Race and SES

	Race	Financial Assistance
Pattern	4.80*	3.16*
Spatial	3.41	1.80
REMA	3.99*	1.14

*p<.05

Regression Results for Variables Predicting REMA Performance

Predictors	β
Student Age	.118 (1.081)
Verbal Intelligence	-.001 (.019)
Visual Spatial Memory	.160 (.148)
Spatial Composite Score	.191 (.148)
Pattern Composite Score	.475** (.220)

Standard errors are reported in parentheses.
**p<.01

Correlation Matrix of Pattern Score, Spatial Score, and REMA Score

	Pattern Composite	Spatial Composite	REMA
Pattern Composite	-	.473**	.618**
Spatial Composite		-	.527**
REMA			-

**p<.01

CONCLUSIONS

These findings indicate that math knowledge correlated moderately with spatial skills and strongly with pattern skills.

Furthermore, pattern skills predict math performance over and above spatial tasks.

There is a significant difference in math knowledge between White students and non-White students, but not by financial assistance.

There is a significant relationship between race and pattern skills, with White students performing better than non-White students.

There is a significant relationship between pattern skills and financial assistance, with those receiving no financial assistance performing better than those who receive full assistance.

No differences by race/ethnicity or financial assistance were found for spatial skills.

It is evident that ethnicity and SES level are important to consider in understanding the development of pattern skills, as low SES students and non-White students perform worse than those from higher-income, White families.

These differences may have implications for greater math achievement later on, suggesting that attention must be brought to the development and learning of both math and pattern skills early on among low SES and non-White children, in order to promote greater math achievement.

Future research could investigate the interaction of pattern skills and SES or race in predicting math knowledge.

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