Including Repeating Patterning Skills in Early Mathematics Education

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Word count = 495

The Common Core State Standards (2010) reflect the influence of math development research on educational practice. However, they also reflect limitations in the research at the time the standards were written. The early math standards focus on early numeracy skills, in line with available evidence, but dropped attention to patterning skills that had been included in previous standards for prek and kindergarten (NAEYC, 2014; NCTM, 2006). This was based on recommendations of the National Mathematics Advisory Panel (2008) that "patterns are not a topic of major importance" because of the paucity of evidence available. However, newer evidence indicates that dropping patterning from the content standards was likely a mistake. For example, patterning skills at the end of preschool are predictive of math knowledge years later (Nguyen et al., 2016; Rittle-Johnson, Fyfe, Hofer, & Farran, 2016), and may play a causal role (Papic, Mulligan, & Mitchelmore, 2011). However, little is understood about how patterning skills contribute to early math development or whether their contributions are separable from other related skills, such as spatial or working memory skills. The current research addresses these gaps.

We assessed preschool children's (n = 73) repeating patterning skills, numeracy knowledge and general cognitive skills near the end of the pre-kindergarten year, recruiting children from public and private preschools. The repeating patterning assessment was developed using materials designed for teachers (see Figure 1), with the goal of using a more teacher-friendly and ecologically valid measure than has been used in past research. The measure has good evidence for its reliability and validity. We re-assessed 65 children's math knowledge near the end of kindergarten on a broad math measure (the short form of the Research-Based Early Maths Assessment (*REMA*), which includes a numeracy subscale) and on 2 specific numeracy skills that involve noticing repeating patterns in numbers: (a) the count sequence to 100 and (b)

the successor principle for large numbers.

As shown in Table 1, regression models indicated that children's repeating patterning skills at the end of pre-K were a unique predictor of children's math knowledge at the end of kindergarten for the broad math measure, numeracy subscale and ability to count to 100, but not mastery of the successor principle. Importantly, repeating patterning skills were a unique predictor over and above related skills that have not been controlled for simultaneously in past research, including spatial visualization, visual-spatial working memory (WM), verbal WM and verbal ability.

These findings suggest that repeating patterning skills may help children notice and learn numeracy skills, in part because some numeracy skills involve patterns. Based on these findings, we designed a 5-day intervention focused on improving pre-k children's repeating patterning skills in conjunction with their numeracy skills. We are currently evaluating the impact of the intervention on children's math knowledge compared to active and passive control groups.

Overall, the current study highlights the need to revise the Common Core State Standards (2010) to include repeating patterning skills and to incorporate repeating patterning skills in early math interventions.

Table 1.

Regression Models Predicting End-of-Kindergarten Math Knowledge from End-of-Preschool Skills

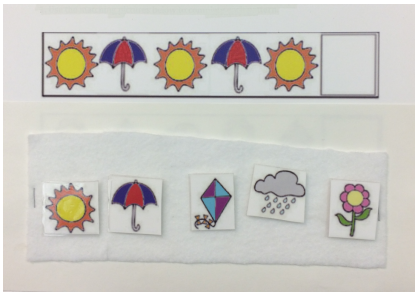
Variable	Broad Math[a]			Numeracy subscale[a]			Count to 100[b]			Successor Principle Mastery[b]		
	B[c]	**β**	***p***	***B***[c]	**β**	***p***	***B***[c]	**Odds Ratio**	***p***	***B***[c]	**Odds Ratio**	***p***
Age	1.26(1.44)	.10	.38	.31(.90)	.04	.73	-1.44(1.71)	.24	.40	.66(1.18)	1.94	.57
Verbal Ability	.02(.03)	.08	.51	.01(.02)	.07	.57	-.01(.03)	.99	.64	-.06(.03)	.94	.02
Verbal WM	.16(.37)	.07	.67	.25(.23)	.17	.27	-.22(.43)	.80	.61	.02(.30)	1.02	.95
Numeracy Knowledge	.61(.24)	.38	.01**	.44(.15)	.44	.00**	-.04(.30)	.96	.90	.17(.20)	1.19	.39
Visual-Spatial WM	-.39(.27)	-.22	.15	-.35(.17)	-.32	.04*	.02(.29)	1.02	.95	-.00(.22)	1.00	.99
Spatial Visualization	.14(.11)	.15	.19	.06(.07)	.10	.39	.12(.12)	1.13	.30	.18(.09)	1.19	.06
Repeating Patterning	.82(.38)	.32	.04*	.50(.24)	.31	.04*	1.49(.62)	4.42	.02*	.06(.32)	1.06	.86

*p<.05, **p<.01.

Notes. [a]From multiple regression model [b]From binary logistic regression model because at least half of children achieved a perfect score, so scores were converted to perfect performance (mastery) vs. not perfect. [c]Unstandardized coefficients with standard errors in parentheses. Verbal ability was age-corrected and standardized score on the Picture Vocabulary Test from the *NIH Toolbox app.* Verbal working memory was trails correct on the backward digit span task from the *Wechsler Intelligence Scale for Children.* Numeracy knowledge was ability estimate for on the numeracy subscale of the REMA Brief. Visual-Spatial WM was trials correct on the forward and backward order of the Corsi Block Tapping Task. Spatial Visualization was score on the Block Design subtest of the *Wechsler Preschool and Primary Scale of Intelligence.*

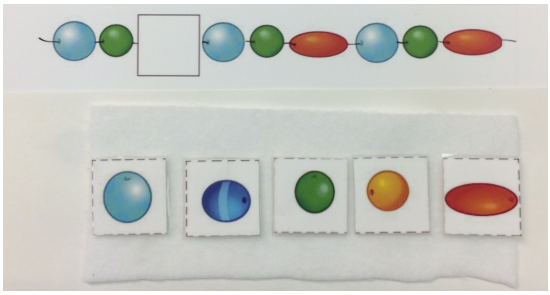
Figure 1. Sample Items on the Teacher-Based Repeating Patterning Assessment

What's Next Pattern AB



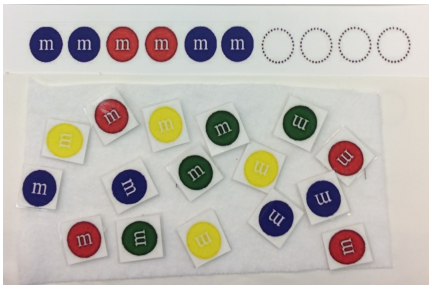
"What comes next in the pattern? Use one of these." [Experimenter gestures to response options.]

Missing Item Pattern ABC



"Find the missing bead [experimenter gestures to response options] to complete the pattern [experimenter gestures across pattern]."

Extend Pattern AABB



"Can you complete the pattern?" [Experimenter gestures to circles on the right of the pattern.]

Match Pattern ABBB

"Can you make the same kind of pattern using your pictures?" [Experimenter gestures to boxes below the model pattern.]