A New Teacher-Based Assessment of Preschoolers' Patterning Skills

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Background

- Children's math knowledge develops rapidly in the preschool years, varies substantially (Starkey, Klein, & Wakeley, 2004), and is strongly predictive of later math achievement (Duncan et al., 2007).
- Theory and research on math development have concentrated primarily on the contributions of number skills (Sarama & Clements, 2004), though children's repeating patterning skills (i.e., linear patterns that have a repeating unit, such as ABABAB) have also been found to predict concurrent and later math knowledge (e.g., Rittle-Johnson, Fyfe, Hofer, & Farran, 2015).
- Repeating patterning skills become systematically more sophisticated in preschool and kindergarten (Clements & Sarama, 2009; Rittle-Johnson, Fyfe, McLean, & McEldoon, 2013; Starkey et al., 2004).
- One of the earliest emerging patterning skills is completing patterns — identifying the missing item in a pattern. A more difficult skill, extending patterns, requires continuing an existing pattern by at least one unit of repeat. An even more difficult patterning skill is abstracting patterns—recreating a model pattern using a different set of materials.
- Children first work with simple alternating AB patterns, and then learn to identify patterns with three and four item units (e.g., ABB/AABB patterns).
- By the end of preschool, many children can complete and extend repeating patterns, and some can even abstract them (Clements & Sarama, 2009; Papic et al., 2011; Rittle-Johnson et al., 2015).

Current Study

Only one valid and reliable instrument currently exists to assess repeating patterning skills in preschoolers (Rittle-Johnson et al., 2015). Our goal was to create a new measure that would be easier for teachers to use, with less difficult items than on the existing measure. Our study employed a single-group longitudinal design with assessments at 2 time points. Children were assessed during the first and final quarter of the preschool year.

Method

Participants: 73 children (54% female) from six preschools in a southern U.S. state (M_{age}= 4 years 6 months, *SD* = 4 months when first assessed).

Pattern Measures

Teacher-based patterning (T1 & T2)- A new patterning assessment developed from worksheets from teacher websites. Included 10-items, worth 1-point each (scored dichotomously), of pictures of model patterns with sets of small, laminated pictures as response options (See Figure 1).

Research-based patterning (T1)- Measures preschoolers' ability to extend and abstract repeating visual patterns with tangram blocks, and consisted of nine items (scored dichotomously) varying in difficulty, described and validated in previous studies (e.g., Miller, Rittle-Johnson, Loehr, & Fyfe, 2016; Rittle-Johnson et al., 2013; Rittle-Johnson et al., 2015). Ability estimates were generated using a Rasch model with a Laplace approximation method (Cho & Rabe-Hesketh, 2011).

Math Knowledge (T1 and T2)- The REMA Short-Form contains 19 items related to numeracy, geometry, and patterning from the Research-Based Early Mathematics Assessment (Weiland et al., 2012). Because four items were polytomous, IRT ability estimates were generated using a partial credit model. To improve the precision of ability estimates for our sample size below 100, we used Empirical Bayes estimation to constrain the item parameters (Baker & Kim, 2004), using WinBUGS 1.4.3 (Spiegelhalter, Thomas, Best, & Lunn, 2003).

Spatial Ability (T1)- Block Design, subtest of the WPPSI-IV (Wechsler, 2012). Raw scores were used.

Verbal Ability (T1)- The Picture Vocabulary Test from version 1.6 of the NIH Toolbox iPad app assessed children's receptive vocabulary. Age-corrected standardized scores were used (Sattler, 2008).

Table 1a: Item Information on Teacher Pattern Assessment Time 1

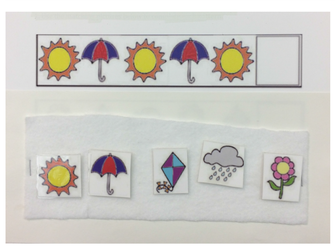
Item number, type, and pattern unit	Proportion correct (SD)	Item-total correlation	Item difficulty (SE) Rasch Model
9. Abstract AB	.57 (.50)	.46	-.60 (.26)
5. Missing ABB	.55 (.50)	.40	-.54 (.26)
3. Missing AB	.51 (.50)	.60	-.38 (.26)
1. What's Next AB	.47 (.50)	.49	-.09 (.26)
2. What's Next ABC	.42 (.50)	.34	-.04 (.26)
4. Missing ABC	.42 (.50)	.40	.08 (.26)
7. Extend AABB	.42 (.50)	.78	.14 (.26)
6. Extend AB	.40 (.49)	.77	.19 (.26)
10. Abstract ABBB	.40 (.49)	.42	.19 (.26)
8. Extend ABC	.25 (.44)	.60	.87 (.27)

Table 1b: Item Information on Teacher Pattern Assessment Time 2

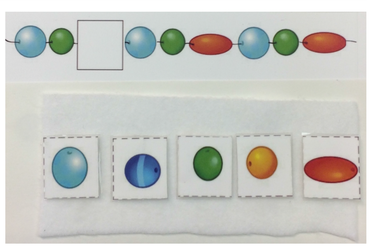
Item order, type, and pattern unit	Proportion correct (SD)	Item-total correlation	Item difficulty (SE) Rasch Model
9. Abstract AB	.74 (.44)	.52	-.65 (.29)
1. What's Next AB	.71 (.45)	.65	-.51 (.29)
6. Extend AB	.70 (.46)	.78	-.44 (.28)
3. Missing AB	.68 (.46)	.73	-.37 (.28)
5. Missing AB	.59 (.49)	.43	.09 (.28)
7. Extend AABB	.58 (.49)	.83	.15 (.28)
10. Abstract ABBB	.56 (.50)	.62	.22 (.28)
2. What's Next ABC	.49 (.50)	.66	.53 (.27)
4. Missing ABC	.48 (.50)	.51	.59 (.27)
8. Extend ABC	.47 (.49)	.64	.65 (.27)

Notes. Items in Tables 1a and 1b are listed in order of item difficulty. Negative item difficulty values = easier items.

Figure 1: Sample Items from Teacher Patterning Assessment



What Comes Next AB



Missing Item Pattern ABC

Extend Pattern AABB

Abstract Pattern ABBB

Reliability & Validity of Teacher Patterning Assessment

Reliability

Internal consistency- Time 1 Cronbach's α = .83 and Time 2 Cronbach's α = .87

Test-retest- Correlation between student performance at the two time points was high $r(73)= .61$, $p < .01$.

Validity

Convergent- Time 1 Teacher-based patterning correlated with Research-based patterning scores $r(73) = .575$, $p < .01$.

Concurrent & predictive- Teacher-Based patterning at T1 correlated with math knowledge at T1 and T2, $r_{mathT1}(73)= .654$, $p < .01$, $r_{mathT2}(73)= .657$, $p < .01$.

Discriminant- Moderate correlations between Teacher patterning measure and verbal and spatial ability $r_{verbal}(73)= .320$, $p < .01$, $r_{spatial}(73)= .361$, $p < .01$.

Construct- Examining item difficulties at Time 1 (See Table 1a), pattern completion tasks—what's next and missing—were often easier than extend tasks. Difficulty on the final task type – abstracting patterns – was more variable. As with past research, AB patterns were generally easier than those with larger units. At T2 especially, item difficulty seemed to depend significantly on the type of pattern unit, with AABB patterns being systematically easier than ABC patterns (See Table 1b).

Conclusion

The new teacher-based patterning measure has been demonstrated to be both reliable and valid. For example, it relates to strongly valid measures of patterning and mathematics, but only moderately to measures of more distant constructs.

More research is needed to understand why item type seemed to drive T1 teacher-pattern performance, while unit size appeared to drive T2 performance.

The teacher-based patterning measure is easy to administer and has strong psychometric properties. Teachers should be encouraged to use it to assess patterning knowledge in their preschool classrooms, with the option of dropping abstract items given their variability in difficulty, and extended administration time.