Measuring Preschoolers' and Kindergarteners' Understanding of Different Types of Patterns

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Background

- Children's early math knowledge predicts later math and overall academic achievement (Duncan et al., 2007).
- Though most research and theory have focused on the contributions of numeracy skills, patterning skills are also theorized to be important for early and later math development (Sarama & Clements, 2004).
- Children's early repeating and growing patterning skills play an important role in their math development (Wijns et al., 2019; Zippert et al., 2020).
- However, there is not an established, commonly used measure of early patterning skills, nor a good understanding of how varying pattern types, rules, and tasks influence children's patterning performance (e.g., Rittle-Johnson et al., 2013).

Study Purpose

1. Advance development of a short and easy to administer, teacher- and researcher-friendly, patterning instrument that reliably assesses the repeating and growing patterning knowledge of both preschool and kindergarten students.
2. Provide evidence for the reliability of the assessment when administered virtually.
3. Expand our understanding of how the difficulty of repeating and growing patterns vary by pattern task and rules.

Methods

Participants

- Ninety-six 4- to 6-year-olds (M_{age} = 5.1 years, *SD* = .65, 51% female)
- Recruited from departmental research database and local schools in the Nashville area
- 88% were White; 94% spoke only English in the home; 3% received financial assistance to attend school

Measures and Design

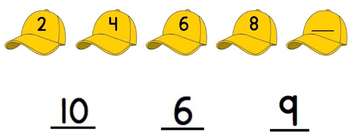
Patterning Knowledge:

- Repeating and growing patterning knowledge were assessed in the Fall of 2020 using the Early Patterning Assessment - Online (Rittle-Johnson et al., 2020; see Figure 1).
- All sessions occurred via a synchronous Zoom session.
- Repeating Pattern Subscale had four task types for a total of 16 items: four completion ("What is missing in the pattern?"), four extension ("What comes next in the pattern?"), four abstraction ("Which pattern makes the same kind of pattern as the model pattern, but with different items?"), and four pattern identification (i.e., "Is this a pattern?").
- Growing Pattern Subscale had four task types for a total of 18 items: five completion, five extension, six pattern identification, and two pattern unit identification (i.e., "How does this pattern grow?").
- Items in each subscale were developed based on items from past patterning assessments as well as kindergarten curricula.
- All participants completed the Repeating Pattern Subscale before the Growing Pattern Subscale.
- Both subscales used model patterns with various pattern rules.
  - Repeating Pattern Unit Rules: Number of overall elements (e.g., ABC has 3 overall elements, ABCC has 4 overall elements); and Number of distinct elements (e.g., ABC and ABCC both have 3 distinct elements).
  - Growing Pattern Unit Rules: Objects vs. Numerals, Increasing vs. Decreasing, Unit change of 1 vs. Unit Change of 2.

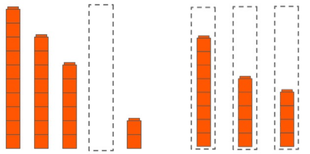
Methods

Figure 1: Sample Items from the Early Patterning Assessment (EPA-Online)

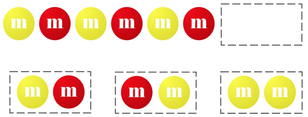
Growing Extend Add 2 Numerals



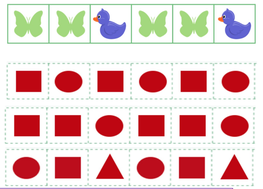
Growing Missing Subtract 2 Objects



Repeating Extend AB Pattern Unit



Repeating Abstract AAB Pattern Unit



Results

Table 1: Descriptive Statistics of Entire Measure and Subscales

	Growing (11 items)	Repeating (12 items)	Total (23 items)
Mean (SD)	.49 (.13)	.67 (.20)	.57 (.14)
Median	.50	.69	.56
Minimum	.22	.19	.33
Maximum	.83	1.00	.88
Cronbach's Alpha	.48	.73	.74

Notes. Numbers reflect analyses after dropping 4 growing pattern items and 2 repeating pattern items with poor item fit; and combining pattern identification items.

- Children's repeating and growing patterning knowledge were positively correlated, $r(95)$ = .40, $p < .001$.
- Children were significantly better at completing repeating patterns compared to growing patterns, $t(85) = 11.41$, $p < .001$

References

Duncan, G. J., Claessens, A., Magnuson, K., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. Developmental Psychology, 43(6), 1428–1446. https://doi.org/10.1037/0012-1649.43.6.1428

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Sarama, J., & Clements, D. H. (2004). Building Blocks for early childhood mathematics. Early Childhood Research Quarterly, 19(1), 181–189. https://doi.org/10.1016/j.ecresq.2004.01.014

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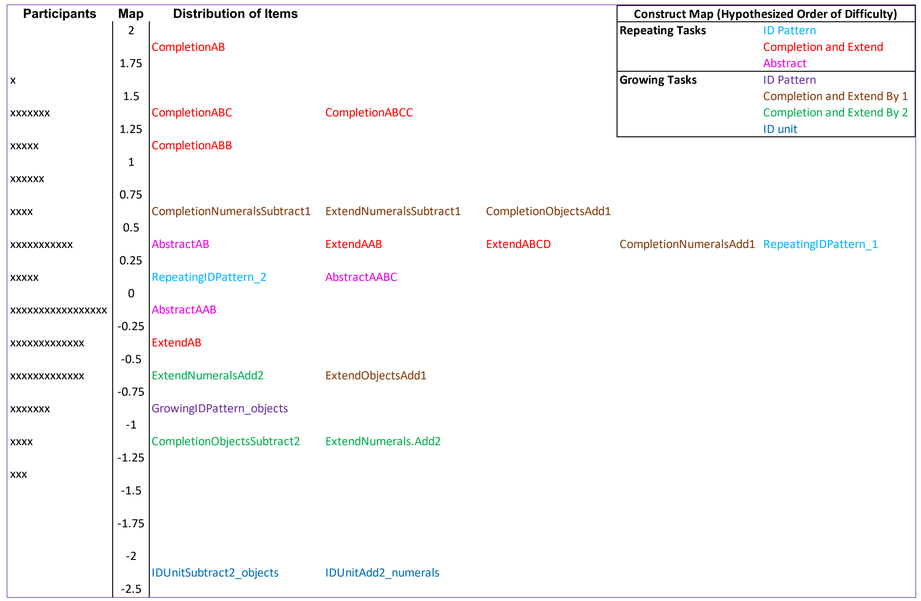
Results

Figure 2: Wright Map examining children's patterning knowledge estimates relative to item difficulty estimates



Notes. Items listed in order of difficulty (easiest at top). Participants listed in order of patterning knowledge (lowest at top).

- Suggests the easiest task was completing repeating patterns while the most difficult was identifying the pattern rule of growing patterns.
- Pattern difficulty did not increase as the number of overall or distinct elements in the pattern increased; repeating patterns with two, three, and four overall and distinct elements had similar IRT difficulty estimates.
- Growing patterns with a change-by-2 pattern rule were more difficult than ones with a change-by-1 rule; and performance was similar for increasing vs. decreasing patterns.
- Preschoolers did not do better on growing patterns composed of objects (M = 1.06, SD = .92) compared to numerals (M = 1.54, SD = .91), $F(1,52)$ = .189, p = .666.

Conclusions

- Our online Early Patterning Assessment provided reliable estimates of White, middle-class preschool and kindergarten children's overall and repeating patterning knowledge.
- Revisions are needed to improve the reliability of our growing patterning subscale and the assessment needs to be administered to a more representative range of children.
- Pattern difficulty does not appear to increase based on the length of the pattern unit, or if the pattern is composed of numerals compared to objects; it does increase when the unit change is two rather than one for growing patterns.
- Our hope is that teachers will use the assessment as a quick and reliable tool to identify students who may benefit from additional patterning instruction, with the goal of improving these students' math achievement later on.