Abstract Title Page

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

Authors: Jake Kaufman, Ashli-Ann Douglas, Camille Msall, Serkan Özel, Bethany Rittle-Johnson

Abstract Body

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Background

Children's early math knowledge predicts later math and overall academic achievement (Duncan et al., 2007). One important, but often overlooked, skill related to early math development is patterning (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 performance (e.g., Rittle-Johnson et al., 2013).

Purpose

The purpose of the current study was to 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. A repeating pattern is made up of elements that repeat over and over (e.g., ABABAB), while a growing pattern is a sequence that increases or decreases by a consistent rule (e.g., add 1). Past research on early patterning knowledge has primarily focused on repeating patterns. This study focuses on a new online version of an Early Patterning Assessment (Rittle-Johnson et al., 2020) administered virtually across the full target age range for the assessment (i.e., preschool and kindergarten children; see Figure 1 for sample items). Our initial study of the Early Patterning Assessment involved kindergarten students with a print version of the assessment given in-person (Douglas et al., 2021; see Table 1 for overview of subscales). The current study provides evidence for the reliability of the assessment when administered virtually and expands our understanding of how the difficulty of repeating and growing patterns vary by pattern task and rules among preschool and kindergarten children.

Based on our previous work (Douglas et al., 2021; Zippert & Rittle-Johnson, 2019; Rittle-Johnson et al., 2013), for repeating patterns, we predicted that identifying patterns will be easiest, followed by similar performance completing and extending patterns, and lastly, that abstracting patterns will be most difficult. We also hypothesized that repeating pattern difficulty will increase as the number of overall elements (e.g., 2 – AB versus 3 – AAB) and distinct elements (e.g., 2 – AAB versus 3 - AABC) in the pattern increase. For growing patterns, we predicted that identifying patterns will be easiest, followed by completion and extend items that change by 1, then completion and extend items that change by 2, and finally, that pattern unit identification items will be most difficult. Lastly, we predicted preschoolers will do better on growing patterns composed of objects compared to numerals, as preschoolers will have had limited experience with numerals.

Setting

All sessions occurred via a synchronous Zoom session, with a parent or guardian present with the child.

Participants

Participants were recruited from a departmental research database and local schools. Children (n = 96) were assessed in Fall 2020. Participants were between the ages of 4 and 6 (M = 5.1 years, SD = .65 years), with 57 participants in preschool, 36 in kindergarten, and 3 not attending school. Based on parental self-report, 51% of participants were girls, 88% identified as White, 94% spoke only English in the home, and only 3% received financial assistance to attend school.

Design

The assessment has two subscales: repeating patterns and growing patterns (see Table 1 for overview). The items in each subscale were developed based on items from past patterning assessments as well as kindergarten curricula. Items identified as having poor fit from the initial round of data collection were revised for the current study.

Repeating patterns varied by the number of elements that made up the repeating pattern unit. Each task was a three-option forced-choice question, except for pattern identification that required a "yes/no" response. Growing patterns differed in the unit they changed by (i.e., change by 1 or change by 2 items), and whether the pattern was composed of objects or numerals. All items were forced-choice except for the pattern unit identification task, which was an open-ended verbal response.

Results

Children demonstrated some patterning knowledge (see Table 2). Children's repeating and growing patterning knowledge were positively correlated, $r(95) = .40$, $p < .001$, and children were significantly better at completing repeating patterns compared to growing patterns, $t(85) = 11.41$, $p < .001$. The online assessment reliably measured children's overall patterning knowledge and repeating patterning knowledge; however, the growing subscale was not a reliable measure.

A Rasch model with a Laplace approximation and empirical Bayesian prediction method (Cho & Rabe-Hesketh, 2011) was conducted to examine item difficulty and children's patterning knowledge on the same scale (see Figure 2). Contrary to our prediction, completing repeating items were the easiest, followed by extension, identification, and abstraction items – which all had similar difficulty levels. Furthermore, pattern difficulty did not increase as the number of overall or distinct elements in the pattern increased; patterns with two, three, and four overall and distinct elements had similar IRT difficulty estimates. For the growing patterning subscale, pattern identification items were not found to be easiest; however, pattern unit identification items were the most difficult; and patterns with a unit change of 1 were easier than items with a

unit change of 2. Lastly, 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. However, 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.

Children demonstrated greater knowledge of repeating patterns than growing patterns, with the easiest items being those that only require the child to identify what is missing from the pattern, while the most challenging are items which require the child to verbally explain the pattern unit. Lastly, 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.

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Table 1

Number of Items and Pattern Types by Subscale and Task

Subscale	Task	Number of items	Pattern Types
Repeating Patterning	Pattern Identification ("Is this a pattern?")	4	AABB, ABB, 2 non-patterns
	Completion ("What is missing in the pattern?")	4	AB, ABB, ABC, ABCC
	Extend ("What comes next in the pattern?")	4	AB, AAB, ABC, ABCD
	Abstract ("Which pattern makes the same kind of pattern as the model pattern, but with different items?")	4	AB, AAB, AABC, ABCD
Growing Patterning	Pattern Identification	6	Add 1 Objects, Subtract 2 Numerals, 4 non-patterns
	Completion	5	Add 1 Objects, Subtract 1 Numerals (x 2), Add 2 Numerals, Subtract 2 Objects
	Extend	5	Add 1 Objects, Subtract 1 Numerals, Add 2 Numerals (x 2), Subtract 2 Objects
	Pattern Unit Identification ("Tell me how the pattern grows.")	2	Subtract 2 Objects, Add 2 Numerals

Table 2

Descriptive Statistics of Entire Measure and Subscales

	Growing	Repeating	Total
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

Note. Values are proportions of items that children answered correctly

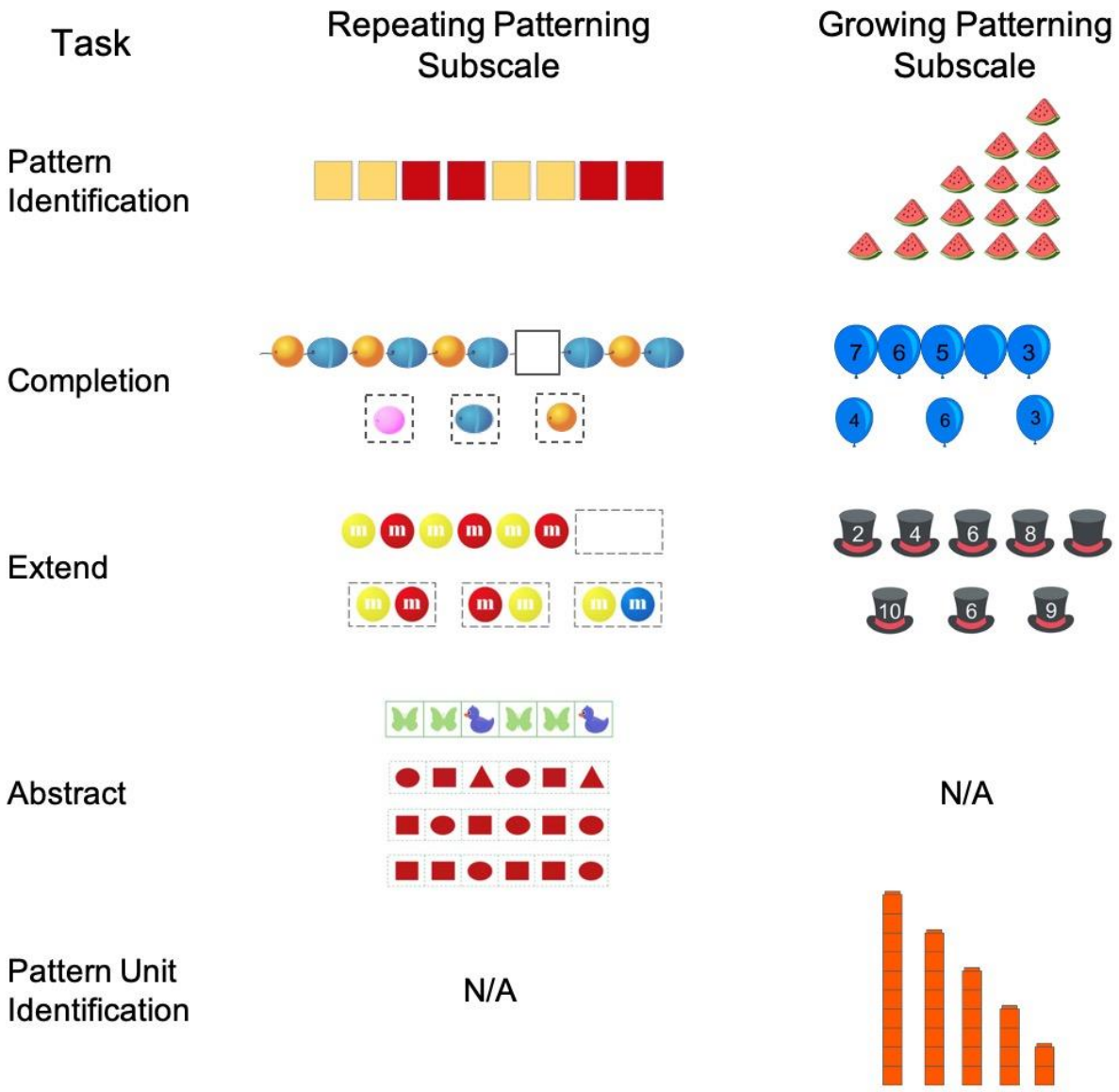

Figure 1. Example items for each task. Response options for completion, extend and abstract items are shown underneath the model pattern.

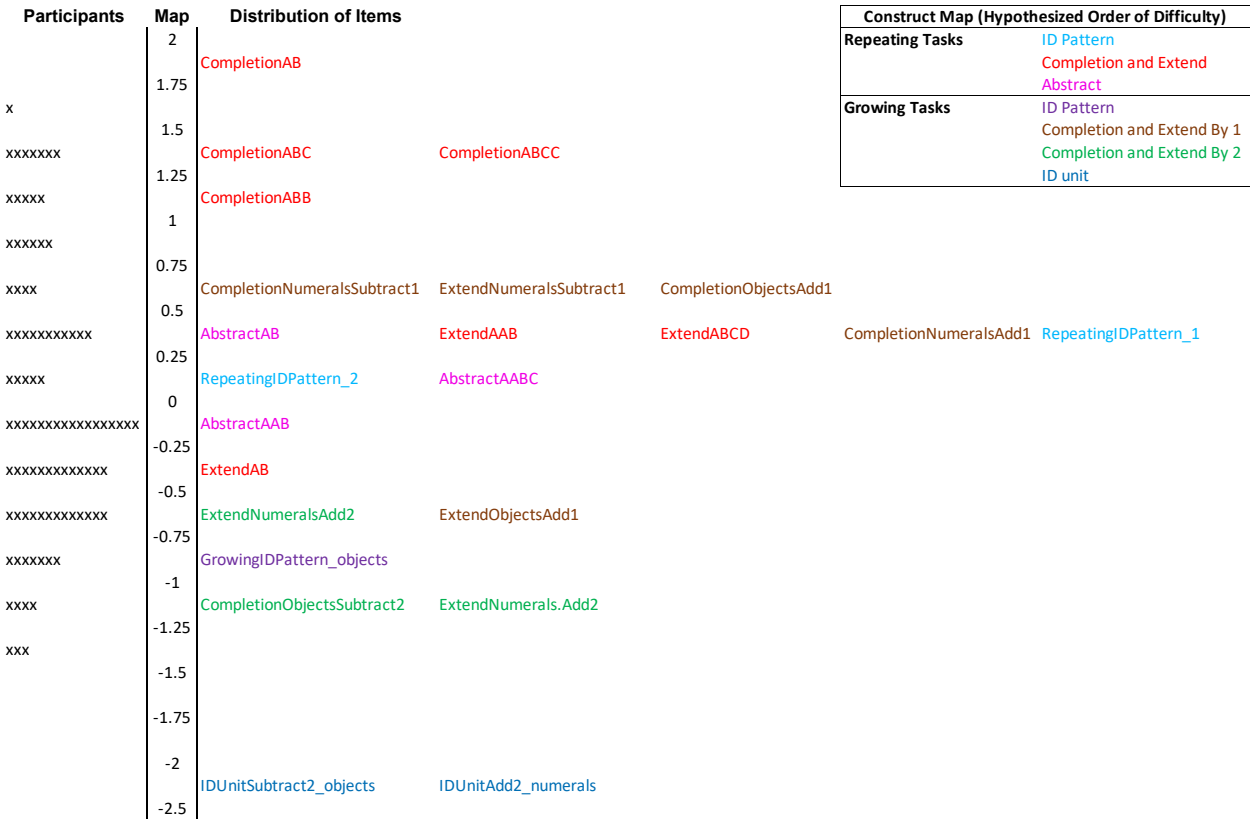

Figure 2. Wright Map showing the distribution of children's patterning knowledge estimates relative to the item difficulty estimates.

Note. Items are listed in order of difficulty from easiest (at the top) to most difficult (at the bottom). Participants listed in order of patterning knowledge from lowest (at the top) to highest (at the bottom).