

Kindergarteners' Understanding of Different Types of Patterns

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Introduction

- Math knowledge develops early and predicts later math and reading achievement (Geary et al., 2012). Thus, it is important to determine foundational skills that support this development.
- Though some research and theory have focused on the contributions of counting skills, patterning skills are also theorized to be important for early and later math development (Domene & Clements, 2016).
- Children's early repeating and growing patterning skills play an important role in their math development (Kaufman et al., 2019).

Study Aims & Hypotheses

Aims

- The current study aimed to expand our understanding of:
 - the relation between kindergarteners' knowledge of repeating and growing patterns
 - how the difficulty of repeating and growing patterns vary by:
 - pattern size
 - task type

Hypotheses

- The relation between kindergarteners' knowledge of repeating and growing

Method

Participants

- Fifty seven 5- to 7-year olds (Mean = 5.90 years, SD = .62, 52% female, 72% white)
- Recruited from 5 private kindergartens in the Nashville area
- 52% received no formal instruction, 32% received some formal instruction, and 17% received full formal instruction.

Measures and Design

- Repeating and growing patterning knowledge were assessed in the Fall of 2018 using the Early Patterning Assessment (EPA-2018) which was designed for the study (see Fig. 2).

Results

	Correct	Incorrect	Not
	(n = 25)	(n = 17)	(n = 15)
Male girls	16	14	10
Female	11	16	10
White	16	14	10
Nonwhite/Hispanic	11	16	10

- As predicted, children's repeating and growing patterning knowledge were positively correlated ($r = .28, p < .01$).
- 5 female children were significantly

Results

The predictions about item difficulty based on task type were only partially supported (see Fig. 2).

- As we predicted, the easiest repeating patterning task was identifying patterns. However, we predicted that identifying patterns units would be harder than abstracting patterns but these items were harder to identify.
- As we predicted, the easiest growing patterning task was completing and extending patterns but task 1 was the most difficult was identifying the

Figure 1: Sample Items from the Early Patterning Assessment (EPA-2019)

Growing Extend ABC2 Numerals

Model Pattern:

Answer Choices:

10 6 9

Repeating Extend AB Pattern Unit

Model Pattern:

Growing Completion Abstract 2 Objects

Answer Choices:

More Pattern Less Pattern Unit

Repeating Abstract AB Pattern Unit

Model Pattern:

Conclusion

- The Early Patterning Assessment (EPA-2018) had good reliability and multi-informant EPA-2018 growing and EPA-2018 repeating had acceptable reliability. Having the study was done at a single private kindergarten with predominantly white and upper-income families, so additional research is needed to evaluate whether the findings reflect the general population.
- The study might be children's necessary supports that the assessment will be suitable for repeating kindergarteners.

[ABSTRACT](#) [REFERENCES](#) [CONTACT AUTHOR](#)

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INTRODUCTION

- Math knowledge develops early and predicts later math and reading achievement (Duncan et al., 2007). Thus, it is important to determine foundational skills that support this development.
- 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, little is understood about the developmental trajectory of patterning skills in relation to varying pattern rules and patterning tasks (e.g., Rittle-Johnson et al., 2013).

STUDY AIMS & HYPOTHESES

Aims

- The current study aimed to expand our understanding of:
 - the relation between kindergarteners' knowledge of repeating and growing patterns
 - how the difficulty of repeating and growing patterns vary by:
 - pattern rule
 - task type

Hypotheses

- The relation between kindergarteners' knowledge of repeating and growing patterns:
 - We predicted that kindergarteners' knowledge of repeating and growing patterns would be positively correlated. We also predicted that kindergarteners would be more accurate at completing repeating patterning tasks than growing patterning tasks.
- The difficulty of patterns by pattern rule:
 - For **repeating patterns**, we predicted that the difficulty of the pattern units would increase as the number of unique elements in the pattern unit increased. For example, patterns with an ABCD pattern unit would be harder than patterns with an ABC pattern unit which would be harder than AB and ABB.
 - For **growing patterns**, we predicted that patterns with a unit change of 2 would be more difficult than patterns with a unit change of 1. We also predicted that patterns that utilized numerals would be more difficult than patterns that utilized objects.
- The difficulty of patterns by task type (see construct map, Fig. 2)

METHOD

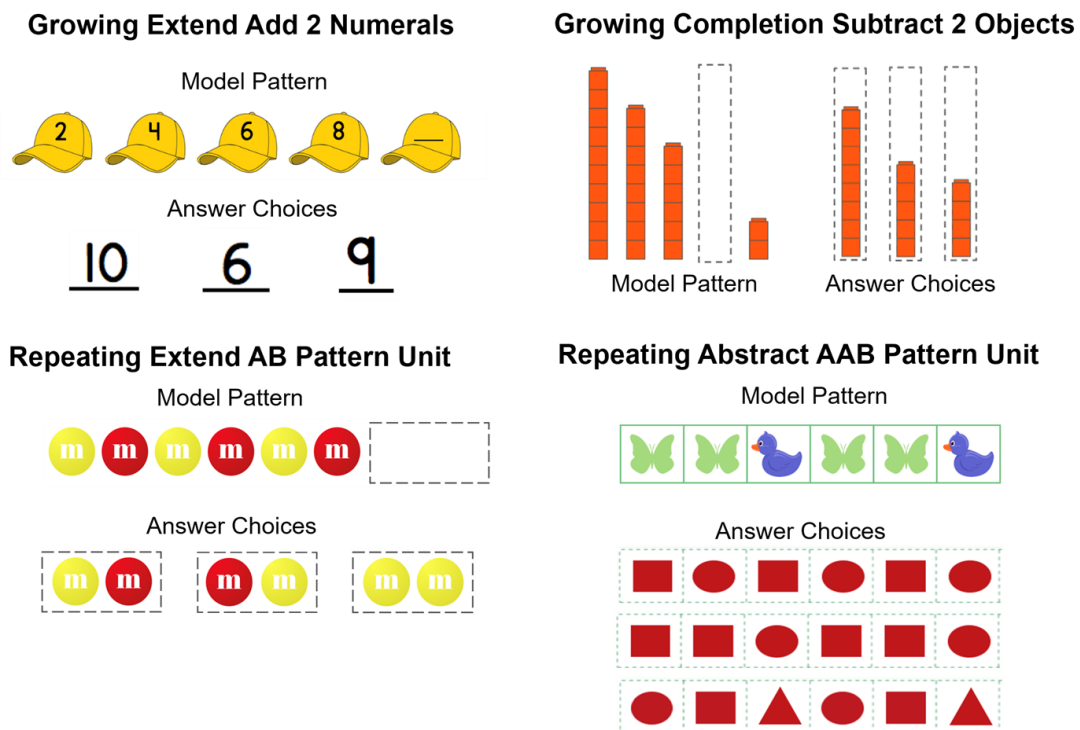
Participants:

- Forty-seven 5- to 7-year-olds ($Mage = 5.90$ years, $SD = .40$, 53% female, 72% white)
- Recruited from 1 private kindergarten in the Nashville area
- 66% received no financial assistance, 32% received some financial assistance, and <1% received full financial assistance.

Measure and Design

- Repeating and growing patterning knowledge were assessed in the Fall of 2019 using the Early Patterning Assessment (EPA-2019) which was designed for the study (see Fig.1).
- Items were primarily forced-choice, usually with 3 response options.

Figure 1: Sample Items from the Early Patterning Assessment (EPA-2019)



- The order of the assessment was counterbalanced.
- Repeating Pattern Subscale had five task types for a total of 20 items
 - completion
 - extension
 - abstraction
 - pattern identification (i.e., "Is this a pattern?")
 - pattern unit identification (i.e., "Identify the part of the pattern that repeats.")
- Growing Pattern Subscale had three task types for a total of 14 items
 - completion
 - extension
 - pattern unit identification
- Both subscales used model patterns with various pattern rules.
 - Repeating Pattern Units: AB; AAB, ABB, AABB; ABC, ABCC; ABCD.
 - Growing Pattern Rules: unit change of 1 or unit change of 2 (increasing or decreasing)
 - used objects or numerals

RESULTS

Table 1: Descriptive Statistics of Entire Measure and Subscales

	Growing (14 items)	Repeating (20 items)	Total (34 items)
Mean (SD)	.50 (.22)	.75 (.17)	.64 (.16)
Median	.50	.75	.67
Minimum	.07	.35	.32
Maximum	.93	1.00	.97
Cronbach's Alpha	.74	.76	.81

Note. Values are proportions of items that children answered correctly.

- As predicted, children's repeating and growing patterning knowledge were positively correlated, $r(45) = .39$, $p < .01$.
- Likewise, children were significantly better at completing repeating than growing patterning tasks, $t(46) = 7.79$, $p < .001$, as predicted.
- Notably, accuracy was higher among children who completed repeating patterns first than among children who completed growing patterns first (15% higher on growing items and 7% higher on repeating items).

RESULTS

Our predictions about item difficulty based on **task type** were only partially supported (see Fig. 2).

- As we predicted, the easiest repeating patterning task was identifying patterns. However, we predicted that identifying pattern units would be harder than abstracting patterns but these items were similar in difficulty.
- As we predicted, the easiest growing patterning task was completing and extending patterns that had a rule of 1 while the most difficult was identifying the pattern rule.

Our predictions about item difficulty based on **pattern unit** were also only partially supported.

- As we predicted, repeating pattern units increased in difficulty as the number of unique elements increased (e.g. ABC more difficult than ABB and AB), except that repeating pattern units with 3 and 4 unique elements (i.e., ABCD and ABC) had similar IRT difficulty estimates.
- As we predicted, growing patterns with a change-by-2 pattern rule were more difficult than growing patterns with a change-by-1 rule, though this was only true for completion and extend items (but not for identify pattern rule items).
- Our prediction that growing pattern items that utilized numerals would be more difficult than growing pattern items that utilized objects was not supported (these items were similar in difficulty).

Figure 1: Sample Items from the Early Patterning Assessment (EPA-2019)

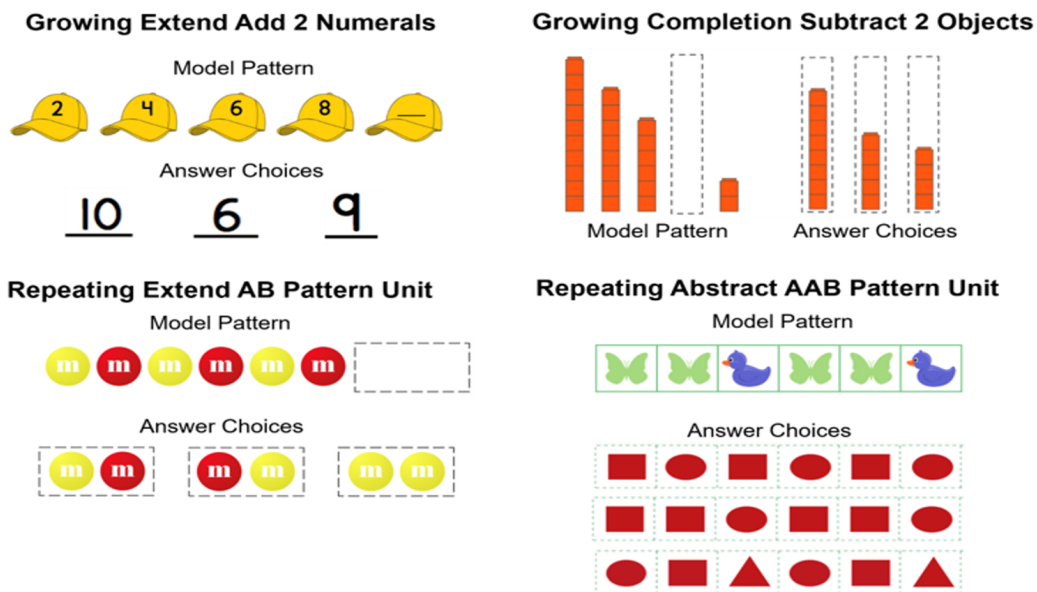
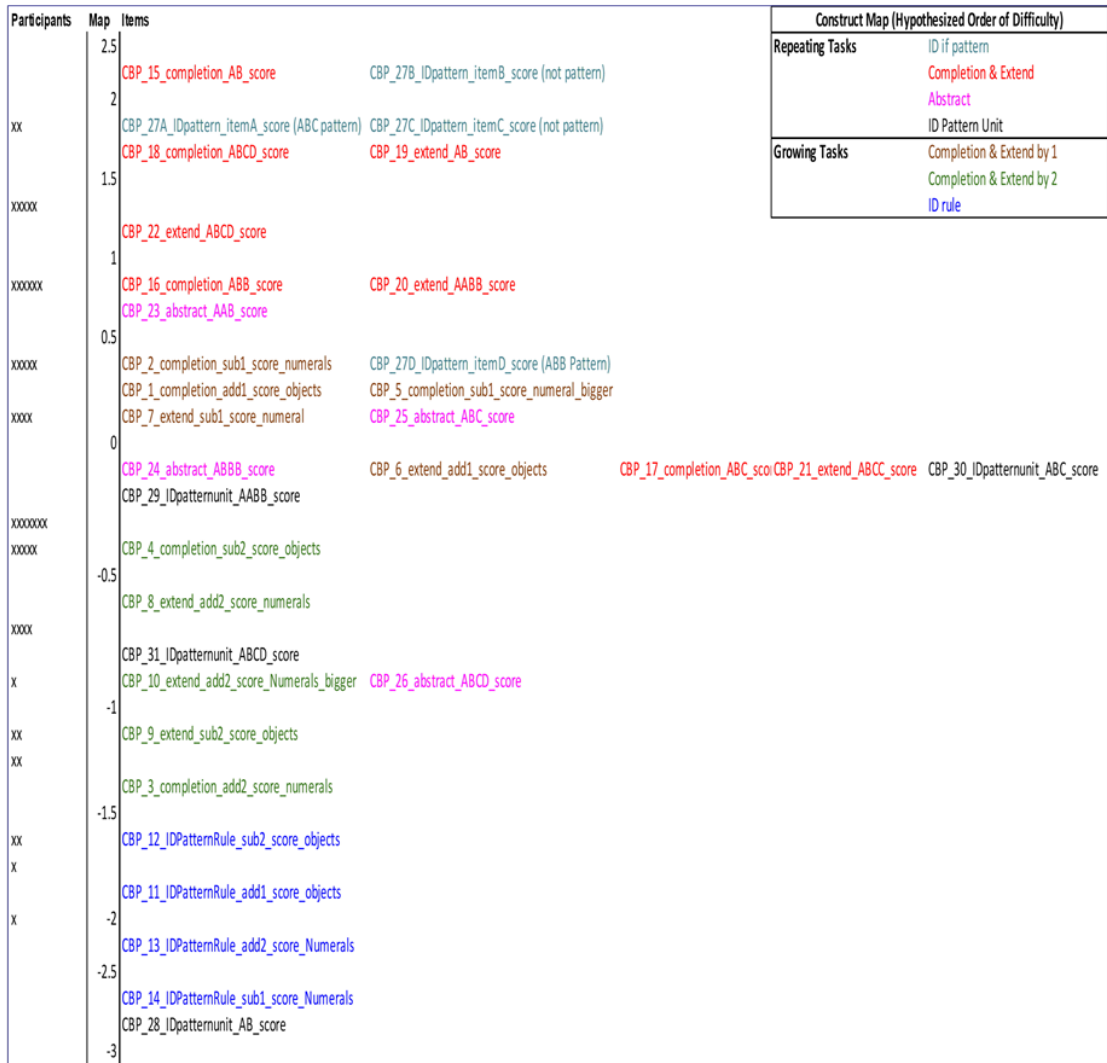


Figure 2: Wright Map examining children’s patterning knowledge estimates relative to item difficulty estimates



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

CONCLUSION

- The Early Patterning Assessment (EPA-2019) had good reliability and each subscale (EPA-2019-growing and EPA-2019-repeating) had acceptable reliability. Notably, the study was done at a single private kindergarten with predominantly white and upper-income families, so additional research is needed to evaluate whether the findings reflect the general population.
- The wide range in children's accuracy suggests that the assessment will be suitable for assessing kindergarteners' knowledge of various pattern types and rules.
- Our findings suggest that knowledge of repeating patterns may serve as a foundation for the development of more complex patterning skills (e.g., growing patterns).
- Finally, our results provide insight into the developmental trajectory of patterning knowledge in relation to varying pattern rules and tasks, though additional research is needed.
- Notably, we have revised the measure based on item characteristics such as item-total correlation and to allow for virtual use and have examined its reliability with both preschoolers and kindergarteners (EPA-2020; measure and additional information available via the Vanderbilt Children's Learning Lab website (https://peabody.vanderbilt.edu/departments/psych/research/research_labs/childrens_learning_lab/IESprojects-and-materials.php)).

ABSTRACT

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, little is understood about the developmental trajectory of patterning skills in relation to varying pattern rules and patterning tasks (e.g. Rittle-Johnson et al., 2013). The current study aimed to expand our understanding of how the difficulty of repeating and growing patterns vary by task types and pattern rules.

We assessed 47 kindergarteners individually during the Fall of their kindergarten year using a patterning assessment that we developed. The assessment consisted of a repeating patterning and a growing patterning subscale that measured children's ability to complete various patterning tasks (e.g. extend patterns). Both subscales used model patterns with several pattern rules (classified as easiest to hardest a priori). The order in which the subscales were administered was counterbalanced.

Children had high patterning knowledge on average, though there was wide variability (see Table 1). Children's repeating and growing patterning knowledge were positively correlated, $r(45) = .39$, $p < .01$, and they were significantly better at completing repeating than growing patterning tasks, $t(46) = 7.79$, $p < .001$. Notably, accuracy was higher among children who completed repeating patterns first than among children who completed growing patterns first (15% higher on growing items and 7% higher on repeating items).

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 1). It suggested that the easiest task was identifying repeating patterns while the most difficult was identifying the pattern rule of growing patterns. The analysis only partially supported our hypotheses about the difficulty of repeating and growing patterns based on their pattern rules. For example, we hypothesized that the difficulty of repeating pattern units would increase with the number of unique elements. However, pattern units with three and four unique elements (i.e. ABCD and ABC) had similar IRT difficulty estimates. We also predicted that growing patterns with a change-by-2 pattern rule would be harder than ones with a change-by-1 rule. However, this was only true for two of three patterning tasks. Additionally, we predicted that growing patterns created with objects would be easier to complete than those created with numerals. Contrary to this prediction, accuracy was similar for these two item types though children's errors differed based on whether the patterns used objects or numerals.

The findings have several implications for future research. First, the wide range in accuracy suggests that the assessment will be suitable for kindergarteners of varying patterning knowledge. Second, the results suggest that repeating pattern understanding may serve as a foundation for the development of more complex patterning skills (e.g. growing patterns).

Finally, our results provide insight into the developmental trajectory of pattern understanding in relation to varying pattern rules. Further research is required to better understand the sequence in which children develop proficiency with repeating and growing patterns of different pattern rules and tasks.

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