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Orientation of Letter and Number Patterns

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Abstract

Teaching children to understand simple patterns is ubiquitous in the elementary schools of English-speaking countries, but without any continuity or universal system. In the present study, the orientations of 24 patterns of letters or numbers were varied systematically, with the middle item missing in each sequence. Thirty-nine first grade students were asked to select the missing letter number or object from one of four alternatives. There was no overall difference between in the children's accuracy with letter or number patterns, but there was a small, statistically significant overall difference due to pattern orientations. The interaction between type of pattern and orientation. Letter patterns presented vertically were twice as difficult as letter patterns presented horizontally; number patterns were three times as difficult when presented horizontally as when presented vertically. Making patterns more difficult by increasing the number of skips within a pattern (e.g. J,M,?,S,V versus K,M,?,O,Q) had larger effects when patterns were presented in favorable orientations (i.e. horizontal for letters, vertical for numbers). These data suggest that teachers should begin patterning lessons with patterns in the orientations that most favor children's success. and developmental psychologists should continue systematic investigations of the parameters of young children's pattern comprehension.

Keywords: Patterning, Education, Mathematics, Sequencing

Patterns surface in myriad disciplines and skill sets, in processes embedded in daily activities (e.g. anticipating the order of events or incoming information), and in the mental acrobatics of associative reasoning and abstraction. Moreover, the cognitive demands of patterning, which requires abstract and symbolic reasoning, mirrors those of quantitative math problems. In fact, mathematics has been referred to as the "science of patterns" (Schoenfeld, 1992, p. 3).

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In order to reach a higher plateau of mathematical comprehension, one must first break problems down to their core. Patterning instruction serves as the foundation for this systematic sense-making and knowledge-acquisition process. By applying an instructional technique known as *patterning*, educators in English-speaking countries have sought for more than half a century to guide young children in understanding patterns. The manner in which this instruction is provided has been described in numerous educational resource manuals (Burton, 1982; Jarboe & Sadler, 2003; Rivera, 2013).

Patterning is a common component of early elementary program curricula in the United States (U.S.) and abroad (Ebel & Labahn, 2010; Econoupolous, 1998; Papic, 2007; Threlfall, 2004). In the U.S., teaching patterns to children has garnered the endorsement of national organizations – e.g. the National Council of Teachers of Mathematics, or NCTM (1993), and the National Association for Education of Young Children and NAEYC (2002; 2010**),** as evidenced in their joint position statement. Educational policymakers have underscored the importance of patterning instruction as early as kindergarten in the Common Core State Standards (CCSS; 2010), the educational standards that have been implemented in 45 states and the District of Columbia (Achieve, 2013). These standards regulate curricula design and set nationwide progress goals for kindergarten through 12th grade students. In the kindergarten years, CCSS math proficiency expectations include the ability to identify mathematical patterns and structure; in high school, these achievement goals extend to more complex algebraic and geometric reasoning, yet pattern detection and creation remains an integral part of problem-solving strategies (Common Core State Standards Initiative, 2012).

The most traditional and rudimentary types of sequences employed in patterning instruction are sequences of alternating colors or shapes. In kindergarten and first grade, children generally encounter simple alternations (e.g. red, blue, red, blue) and double alternations (e.g. circle, circle, square, square, circle, circle).

More recently, Australian researchers (Warren & Cooper, 2008; Papic, Mulligan, & Mitchelmore 2011) have given attention to growing patterns (geometric figures which can be extended). Some American researchers have employed a large variety of patterns. Hendricks, Trueblood, and Pasnak (2006) used shapes, animal stickers, clock faces, letters, numbers, and shapes in patterns ranging from ranging from multidimensional sequences presented in matrices to simple unidimensional linear orderings.

These varied number of missing items, number of items, and in length, as well as in the number of dimensions. Kidd (2013; in press) examined the impact of teaching children patterns of rotating figures, symmetrical sequences, and progressive sequences with increasing numbers of elements, sizes, or values and random yet repeated sequences of otherwise unrelated items.

Despite the prevalence of patterning instruction in schools, its continued inclusion in elementary curricula, and its integration into national educational standards, empirical investigation of patterning is limited, particularly regarding which types of patterns young children find most challenging. Access to this information would allow educators, administrators, researchers, and policymakers to design challenging yet developmentally-appropriate materials to effectively target focus areas for academic skill-building. Progressively more difficult patterning problems would complement higher-level elementary school math courses.

To assess how the characteristics of items within a pattern affect first-grade children's ability to detect that pattern, Gadzichowski (2010; 2012a) analyzed the impact of differing item features. She found that variations in the dimensions in which patterns were presented - colors, shapes, numbers, letters, rotation, and orientation (vertical or horizontal) did not affect the performance of six-year-olds. However, this observation may be attributed to the noise generated by the large number of dimensions varied, with correspondingly few examples of each dimension. Our investigation extends Gadzichowski's (2012b) hypothesis that an observable effect for dimension might be detected if only letters and numbers were presented to the students and other dimensions were excluded. Moreover, we examined Gadzichowski's (2012b) hypothesis that students comprehend number patterns presented vertically and letter patterns when presented horizontally with the greatest ease.

Lastly, we sought to replicate Gadzichowski's (2012b) finding that patterns with fewer skipped items (e.g. a skip of one letter, such as A, C, E) can be more easily detected by first grade students than patterns with a greater number of skips (e.g. a three letter skip, such as A, E, I).

Method

Participants

Parental consent was obtained for 39 first-grade students (20 males, 19 females) from two public elementary schools. Of these students, 11 were African-American, 6 were Hispanic/Latino, 12 were Middle Eastern, 8 were Caucasian, and 2 were of mixed ethnicity. Parental consent, child assent were obtained for participation, as was approval through the Internal Review Board of George Mason University.

Materials and Procedure

Twenty-four patterns were presented to the children via a flipbook. Twelve were letter patterns, six presented vertically and six horizontally, and twelve were number patterns, six presented vertically and six horizontally. Each pattern consisted of four items with a missing fifth item in the center, indicated by a question mark. Additionally, each pattern involved skips of one, two, or three items. Presentation order was counterbalanced, as randomization would have inevitably resulted in some types of patterns being presented sooner, on average, than others, Children were asked to select one of four possible solutions presented on the opposite half of the same page for the missing item, and were given as much time as needed.

Results

Analyses were conducted with a three factor ANOVA for correlated factors. Factors analyzed were dimension (letters or numbers), orientation (presented vertically or horizontally), and number of items skipped. There was no major difference in the children's accuracy with number and letter patterns, $F(1,38) = .16$, $p > .05$. Overall, orientation made a small but statistically significant difference, $F(1,38) = 4.47$, $p < .05$, with scores for vertically presented patterns approximately 16% higher than scores for horizontally presented problems (see Table 2). Results supported Gadzichowski's (2012b) hypothesis that a significant interaction between dimension and orientation exists, $F(1,38) = 110.71$, $p < .001$. Scores for letter patterns presented horizontally were twice as high as scores for letter patterns presented vertically. Moreover, scores for number patterns presented vertically were three times as high as scores for number patterns presented horizontally.

The number of skips between the items in a pattern was also a significant factor, $F(2,76) = 175.51$, $p < .001$. Bonferroni tests revealed significant differences ($p < .01$) between one, two, and three skips (see Table 2.) Unexpectedly, a significant interaction between dimension, orientation and number of items skipped was discovered, $F(2,76) = 39.98$, $p < .001$. The number of skipped items had a greater effect on vertically presented number problems, and on horizontally presented letter problems, than on other combinations of dimension and orientation.

Table1: Descriptive Statistics for Dimension, Orientation and Skip

Dimension	Orientation	Skip	M	SD
Letters	Vertical	1	.7949	.76707
Letters	Vertical	2	.3590	.66835
Letters	Vertical	3	.1538	.36552
Letters	Horizontal	1	1.6410	.66835
Letters	Horizontal	2	.7692	.77668
Letters	Horizontal	3	.1795	.45142
Numbers	Vertical	1	.1.7949	.40907
Numbers	Vertical	2	.8462	.67037
Numbers	Vertical	3	.1795	.45142
Numbers	Horizontal	1	.6254	.78188
Numbers	Horizontal	2	.2564	.54858
Numbers	Horizontal	3	.0769	.26995

Table 2: Estimated Marginal Means

Dimension	M	Standard Error
Letters	.650	.039
Numbers	.628	.039
Orientation	M	Standard Error
Vertical	.688	.039
Horizontal	.590	.039
Skip	M	Standard Error
1	1.212	.048
2	.588	.048
3	.147	.048

Discussion

As letters in English words are typically presented horizontally, it is follows that letter patterns would be easier for children to understand if presented in this corresponding manner (rather than vertically). The order in which numbers are presented, however, is less consistent. But particularly in addition – a staple of kindergarten and first grade work in the school system – and subtraction – encountered in the first grade – numbers are most commonly presented in a vertical orientation. In any event, the data show that number patterns are more easily understood in a vertical orientation and letter patterns are better understood in a horizontal orientation.

It may be evident to the reader that a pattern like 31, 33, ?, 37, 39 is easier to grasp than one such as 2, 6, ?, 10, 14. Children ordinarily deal with number or letter sequences that do not involve any skips, and increased skips clearly layer the pattern with greater levels of difficulty.

What is more difficult to interpret is the three-way interaction between dimension, orientation, and number of skipped items. The nature of the interaction is that the effect of skips is more than halved when either letters or numbers are presented in an unfavorable orientation. Hence, it appears that adding complexity to a pattern by increasing the amount of the skips from one item to three has more effect when the pattern is easy than when it is already relatively difficult.

This research represents an early step in an effort to determine which aspects of patterns impact children's ability to understand the patterns. One implication is that educators might make a more conscious effort to present number patterns and letter patterns in orientations that are easy in the beginning of lessons, and in the more difficult orientations, as children's mastery progresses. Most important, however, is the need for cognitive and developmental psychologists, few of whom have heard of patterning, to investigate the parameters of this phenomenon so prevalent in our elementary schools.

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