

**Abstract Title Page**  
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**Title:** Cognitive Underpinnings of Preschool Literacy and Numeracy

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## **Abstract Body**

*Limit 5 pages single spaced.*

### **Background/context:**

*Description of prior research, its intellectual context and its policy context.*

➤ Insert text here.

Abstraction of relationships, and generalization of these abstractions, is a crucial difference between more mature and less mature learners in a variety of domains (Son, Smith, & Goldstone, 2008). Young children are highly variable in the extent to which they have developed their abstractive abilities. There is what has sometimes been termed a *relational shift* (Gentner, 1988; Gentner & Ratterman, 1991) from attending to specific attributes of objects to relations between them. This shift occurs sooner with some children than others, and is certainly not complete even at the end of elementary school (Sternberg & Downing, 1982). Of interest in the present study are two forms of abstraction: oddity and seriation.

Probably the earliest purely abstract relation that children understand is the oddity principle, i.e., what makes one object in a group “odd” or different than the rest. If a child has three oval beads and a fourth square bead, the square bead is odd, but if three beads are square and one oval, the oval bead is odd. Understanding such relationships emerges at about age four.

At about the same time as children begin to understand the oddity principle, they begin to *seriate*. They understand that objects can be ordered along a dimension from smallest to largest. First accomplishing this by what Inhelder and Piaget (1964/1959) called the *method of extremum*, they next develop the ability to insert an object in its proper place within the order, relating the new object to the objects just larger and just smaller in the series.

### **Purpose / objective / research question / focus of study:**

*Description of what the research focused on and why.*

➤ Insert text here.

Pasnak, Maccubbun, and Ferral-Like (2007) used a form of structured play to teach oddity to preschoolers who had not yet developed an understanding of it. Their method improved the children’s understanding of the oddity principle and numeracy. The present research represents a test of the effect of adding seriation instruction to oddity instruction produce an advantage in both forms of abstraction. Pasnak et al. (2007) and Kidd, Pasnak, Gadzichowski, Ferral-Like, & Gallington (2008) have shown that at risk kindergartners profit academically from instruction in both oddity and seriation. This study extends this work into the preschool classroom, testing whether oddity and seriation instruction benefits at risk preschoolers in both literacy and numeracy.

### **Setting:**

*Description of where the research took place.*

➤ Insert text here.

The research was conducted in seven Head Start preschools in Alexandria, Virginia, an urban

community just south of Washington DC.

### **Population / Participants / Subjects:**

*Description of participants in the study: who (or what) how many, key features (or characteristics).*

➤ Insert text here.

All children enrolled in these preschools who were 4 years old as of October 1 were screened with a 22 problem oddity test to determine how well they understood the oddity principle. The 72 who scored lowest (16 correct or less) participated. There were 35 girls and 37 boys. All were from families that met federal poverty guidelines. They were ethnically and culturally diverse: 38% African American, 16% Hispanic/Latino, 31% Mideast Asian, 8% West African, and 8% other.

### **Research Design:**

*Description of research design (e.g., qualitative case study, quasi-experimental design, secondary analysis, analytic essay, randomized field trial).*

➤ Insert text here.

A randomized field experiment was conducted. The 72 children who scored worst on the screening test were formed into quartets in each classroom. One child in each quartet was randomly assigned to receive the experimental “cognitive” instruction on oddity and seriation, another to receive control instruction on literacy, a third to receive control instruction in numeracy, and the fourth to receive control instruction in art. In this way the effects of instructors and classrooms were neutralized for the children in the four conditions. All children in a quartet received the same number of experimental instructional sessions from the same instructor.

### **Intervention / Program / Practice:**

*Description of the intervention, program or practice, including details of administration and duration.*

➤ Insert text here.

: The instruction was conducted three times per week from the middle of September until the end of April.

*Cognitive Intervention: Oddity Instruction.* Children in the cognitive intervention group were shown four objects which differed only in form and asked to identify the object which had the odd form. The instructor used an “errorless” training method for this and all subsequent instruction, giving the child many extra cues to the correct choice, such as placing it closer to the child, pointing at it, and (if necessary) blocking the child’s effort to select an incorrect choice. As the child learned which object was “odd” the extra cuing was gradually reduced until it was no longer needed. In this way, learning of form oddity was accelerated. When all 20 form oddity problems could be solved easily without any extra cues, instruction on size oddity problems began. Problems wherein the odd object was bigger than three otherwise identical objects were alternated with problems in which the odd object was the smallest. When size oddity was mastered, instruction on orientation oddity problems began. These initially involved

three identical objects in horizontal orientations, and one in a vertical orientation, or vice versa. Or, three might be right side up and one upside down. When these were mastered 20 problems were presented with three of the objects slanting 45 degrees in one direction and the other 45 degrees in the opposite direction. Finally, 20 orientation oddity problems were presented again, with 3 objects facing left and one right, or vice versa.

*Cognitive Intervention: Seriation Instruction.* First the children were helped to solve 15 problems that had three objects varying in size. The errorless instructional method was used as needed to make this fun and easy. When a child was good at this 20 four-object problems were introduced, one at a time, and each child's animal was taught to align the objects from smallest to largest. When this was easy, the instructor repeated the same 20 problems, but would give the child only three of the objects, holding back the fourth. After the child seriated the three objects the instructor would deliver the fourth object to the child to place it in its proper place in the series. The same procedure was involved when teaching a child to form a series of four objects and insert a fifth, or to form a series of five, six, or seven objects and insert an additional object.

*Literacy Control Instruction.* First, using foam alphabet letters, children were taught to identify and recognize the letters of the alphabet. The errorless method was used as needed to make this fun and easy. Once children had mastered identification and recognition of letters, they were taught the sounds that the letters make using letter bags. The instructor presented the child with the a picture of the letter that corresponded with the letter bag, and then asked the child to select specific items from the bag that began with the target letter. Once the child had successfully identified the object, the instructor would say the name of the object while emphasizing the sound of the first letter, and then would ask the child to do the same. Once the children had mastered the letter sounds, they were asked to sort the objects from two different letter bags based on the letter that the objects began with.

*Numeracy Control Instruction.* Using foam numbers, children were taught to identify and recognize numbers from zero through 20. Then the instructor taught them to count by 5's and 10's. They were also taught to complete simple patterns using objects that come in multiple colors. Finally, they were taught to tell time using small clocks.

*Art(Control Instruction.* The children who received art instruction would work with the instructor on creating an art project of their choice. They were given the option to draw, color or paint a picture, use stickers, paste cut-outs on construction paper, fingerpaint, or use clay to make objects of their choice.

## **Data Collection and Analysis:**

*Description of the methods for collecting and analyzing data.*

➤ Insert text here.

**Data collection and Analysis:** In early May, experimentally “blind” testers administered the 22-problem oddity test, a 10-problem seriation test, the Applied Problems (quantitative scale from the Woodcock-Johnson III, and the Letters and Words scale from the SESAT-2 to the children. Because multiple children were in the same school, hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) was conducted using HLM 6.0 software. Our final models can be represented by the following equations:

Level-1 Model

$$Y_{ij} = \beta_0 + \beta_1(\text{GENDER}) + \beta_2(\text{AGE}) + \beta_3(\text{ODDITY PRETEST}) + \beta_4(\text{COGNITIVE}) + \beta_5(\text{LITERACY}) + \beta_6(\text{NUMERACY}) + r$$

Level-2 Model

$$\beta_0 = \gamma_{00} + u_0$$

The Level-1 equation models within-school variance based on children's characteristics. Thus, for child  $i$  in school  $j$ , the expected outcome,  $Y$ , is equal to the school average for that outcome,  $\beta_0$ , plus an effect for being male,  $\beta_1$ , plus an effect for age (in months),  $\beta_2$ , plus an effect for their oddity pretest score,  $\beta_3$ , plus an effect for being in the cognitive group,  $\beta_4$ , plus an effect for being in the literacy group,  $\beta_5$ , plus an effect for the being in the numeracy group,  $\beta_6$ , plus error,  $r$ . The Level-2 equation states the school average,  $\beta_0$ , is equal to a grand average,  $\gamma_{00}$ , plus error,  $u_0$ .

## Findings / Results:

*Description of main findings with specific details.*

➤ Insert text here

: Descriptive statistics and correlations for all variables included in the analyses are presented in Table 1. Significant negative correlations existed between group membership categories because being assigned to one group was by definition related to not being assigned to another group. These simple correlations also revealed associations between cognitive group membership and three of the four outcomes. The four outcomes correlated from .27 - .42.

Table 2 presents results from the HLM analyses. Unconditional models indicated there were large disparities in the amount of variance attributable to the school. Between 0 and 31% of the variance in the outcomes was due to the school in which children were enrolled. Intraclass Correlation Coefficients (ICC)s were only significant for the SESAT (.31) and seriation (.12). We conducted HLM for all outcomes for the sake of consistency. Results from non-nested models were nearly identical.

Results from the final models (with the Art group being the comparison group) indicated that gender was not related to the outcomes, that age predicted W-J III scores ( $t = 2.43, p < .05$ ), and that oddity pretest scores predicted SESAT scores ( $t = 2.21, p < .05$ ). Notably, oddity pretest scores were not a significant predictor of oddity posttest scores. This, however, is not surprising given that a quarter of the children received an intervention which changed their oddity posttest scores from what the oddity pretest scores would predict.

Table 2 only indicates whether or not scores based on group membership were significantly different than scores for the art group. In order to evaluate our hypotheses, multiple comparisons were conducted whereby the reference group was systematically changed. Table 3 presents the results of the multiple comparisons tests. In this table, the mean for each group is presented for each outcome. Superscripts denote which of the groups are statistically different from one another for a given outcome. It is immediately evident that the cognitive group had the highest mean across all four outcomes, although differences were not always statistically significant. For the oddity and seriation measures, the cognitive group performed significantly better than the remaining three groups. For the W-J III, the cognitive and numeracy groups both scored significantly higher than the literacy and art groups but did not differ appreciably from each other. For the SESAT, the means for the cognitive and literacy groups were substantially higher than those for the numeracy and art groups; the difference between the cognitive and numeracy groups on this literacy test was statistically significant.

The scores of both the cognitive and numeracy groups on the W-J III were appropriate for 5-year-olds in the first or second month of kindergarten, i.e., between K-1 and K-2. This is an excellent outcome for economically disadvantaged children. In contrast, the children in the literacy and art groups scored at the prekindergarten level – about the same as an average child at the age of 4.4 years. The picture is similar on the SESAT, which provides norms in terms of percentiles rather than age equivalents. The children in the cognitive and literacy groups scored at the K-1 level – the 46<sup>th</sup> and 42<sup>nd</sup> percentiles, respectively, for kindergartners tested in the fall of the kindergarten year. Those in the numeracy and art groups scored at the prekindergarten level (the 29<sup>th</sup> and 25<sup>th</sup> percentiles).

### **Conclusions:**

*Description of conclusions and recommendations based on findings and overall study.*

> Insert text here.

That the literacy and numeracy control lessons were effective is shown by the high scores the children in those groups made in the specific domain in which they were instructed. However, the children who received the literacy or art instruction scored below national norms on numeracy, and the children taught numeracy or art likewise scored below norms on literacy, despite the enrichment offered by their Head Start program. Such outcomes are likely when children have been raised in impoverished homes. Lacking the cognitive enrichment that would be found in many middle-class homes, they were probably functioning closer to the floor provided by their inherent abilities than to the ceiling. At least, that is one of the assumptions on which this research was based. Lagging in normal cognitive development, they would be less apt to understand and profit from preschool activities aimed at fostering literacy and numeracy.

That the cognitive group matched the numeracy group in numeracy, and the literacy group in literacy, testifies to the importance of the advantages in abstraction that group had gained. These advantages appear to have enabled it to better understand the normal preschool curriculum, which offered plenty of chances to improve on literacy and numeracy. Preschool learning activities assume that children can detect relevant differences and understand the relations between big, medium, small, and so forth. When children are deficient in these abstractions, many of the instructional activities are over their heads. We conclude that strengthening children's understanding of differences on one dimension and unidimensional ordering enables them to gain more from learning opportunities in the preschool classroom.

## Appendices

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### Appendix A. References

*References are to be in APA version 6 format.*

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