1978

Sensitivity to structural information: a developmental perspective

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Iowa State University

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Sensitivity to structural information:
A developmental perspective

by

Mary Ann Catherine Skowronski

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ABSTRACT

The simultaneous presentation of two or more objects results in the formation of an array. Two experiments investigated the role of array structure on information processing of young children. Experiment 1, using reproduction and copying tasks, indicated that 4- and 5-year-olds more accurately reproduced symmetrical than asymmetrical arrangements but no differences between these pattern types were observed in the copying task. This suggests that the effect of pattern structure is probably at a stage of processing later than perception. The conclusion was confirmed by reaction times; preschoolers did not use more time in copying asymmetrical than symmetrical patterns, but did require longer times for reconstructing the asymmetrical arrays in the reproduction task. Experiment 2, exploratory and descriptive in nature, was concerned with the preschooler's ability to decode the arrangement when there were differences between the elements forming the model and those comprising the choice stimuli. That investigation suggested that before 59 months, the structure of the configuration appears to have little influence on the processing of information. Thereafter, the preschooler's decoding ability seems to be related to the type of organization in the model stimulus. That is, when the structure of the model reflects Garner and Clement's "good" level of pattern structure, the child decodes the arrangement. However, when the organization of the model reflects the "poor" level of pattern goodness, the 59-month-old child tends to be influenced more by the
characteristics of the individual elements than the overall structure of the array. In the final section, the author reviews a pilot study with 3-year-old subjects in reproduction and copying tasks similar to those used in the first experiment. Unlike the 4- and 5-year-olds, those subjects showed no performance differences for the symmetrical and asymmetrical patterns in either task. Through a series of arguments, the absence of task differences is attributed to a lag between perception and performance. Specifically, the author contends that the failure of pattern structure to influence 3-year-old performance is due to a cognitive process that develops around the age of 3.
INTRODUCTION AND LITERATURE REVIEW

An Array

When two or more objects are simultaneously presented, their presentation results in the formation of an "array". "Form" and the near synonym "pattern" have also been used to denote the arrangement, order or relationship of a set of elements. The nature of the components (elements) may vary considerably from one equivalent pattern to another, but the essence of the array concept is the global or overall structure imposed on the parts that may or may not themselves convey any meaning. Thus, it can be said that the structural properties of the array are derived from the spatial interrelationships among the components rather than from the characteristics of the individual elements.

What is already known about the psychological processes involved in the preschooler's perception of "arrays", "patterns" or "configurations"? The literature contains at least two relevant components that shall be reviewed in turn: first, the historical importance of structural information; and second, the already existing data from grammar school children.
Importance of Structural Information

The Gestalt psychologists were the first to recognize the importance of the arrangement of the elements (Boring, 1950). Based on numerous investigations, these researchers formulated a set of principles designed to describe how the spatial arrangement or organization of the elements influences the perception of the entire array. The central theme of these organizational principles is that external stimuli mobilize internal processes, which, depending on the properties of the array, can range from well organized to chaotic processes. Koffka (1935) further suggested that the "traces of chaotic processes (less organized) have a much lower 'survival value' than traces of well organized processes" (p. 501). The notion that the degree of organization present in the stimulus array affects the perception of that stimulus is also reflected in the Law of Pragnanz. According to this principle, certain figures, forms, arrangements or patterns are particularly "good" in that they possess a highly organized structure.

Unfortunately, the Gestalt approach to figural goodness was not amenable to experimental investigation because the level of goodness of an array was dependent upon the subjective assessment of the observer. Not until Garner and Clement (1963) provided an operational criterion for determining one type of array goodness did the concept become amenable to experimental investigation. The authors found that the rated goodness of patterns formed by placing dots in 5 of the 9 cells of an imaginary 3 x 3 matrix was inversely related to the size of a subset
of patterns which could be produced by rotating a pattern in 90° steps and/or reflecting it along its vertical, horizontal or diagonal axis. Using subset size as an operational criterion of goodness, arrays which produced small subsets were rated highest in goodness, while those with the largest number of subsets were rated lowest in goodness.

To date, the Garner and Clement dot patterns have not been used to index the effects of stimulus structure (arrangement) on young children's visual information processing. However, a review of the developmental literature indicates that the symmetry-asymmetry concept has been equated with the Garner and Clement level of pattern goodness distinction. Where employed, these studies have shown that reproduction accuracy is better for symmetrical forms (relatively high in pattern goodness) than for asymmetrical displays (relatively low in pattern goodness) (e.g., Attneave, 1954, 1955).

Stimulus Structure Affects Processing: Evidence

In addition to recognizing the importance of the arrangement of the elements on the processing of that information, the Gestaltists maintained that the ability to detect various properties (e.g., symmetry, proximity) of the array is an innate characteristic of the perceptual system (Kohler, 1939). Although current views hold that all behavior is necessarily an interactive process, there is some empirical evidence that supports the notion that the structure of the stimulus influences the processing of the presented information very
early in the life of the organism. Two lines of evidence show this effect: (1) part-whole studies and (2) research concerned with the processing of symmetrical and asymmetrical displays.

**Part-whole perception**

When the child is exposed to an arrangement of stimuli, the question of what and how the child perceives becomes important. For instance, it has frequently been stated that children "perceive in a diffuse and global manner; that is, they look at the whole configuration of a stimulus pattern, without much attention to its detail" (Reese & Lipsitt, 1970). According to this view, attention to detail appears only later, in middle childhood, and is, in turn, followed by an integrative mode of perception in which the parts and the whole are perceived simultaneously and in relation to one another. The early work of Claparède (1908), one of the pioneers in the field of child psychology in Europe, and more particularly, the work of Werner (1940) emphasized this view of the changes in children's part-whole perception with age.

Evidence for this three-phase sequence was, in fact, obtained from developmental studies of responses to inkblots of the Rorschach test. In several studies utilizing these materials, there was up to the age of six years, a marked predominance of responses that appeared to be based on an undifferentiated perception of the whole blot; these gradually declined, in favor of responses based on small details, and sub-
sequently of responses indicating an attempt to encompass the parts of the blot within a single, meaningful whole (Ames, Learned, Metraux & Walker, 1953; Dworetzki, 1939; Hemmendinger, 1953). The following responses illustrate these stages with respect to the blot shown in Figure 1: "A Christmas tree" (age 4); "Cocks, ears, stones and holes" (age 8); "A bat" (adult).

In interpreting such responses, however, it must be remembered that the unstructured stimulus configuration represented by a Rorschach inkblot does not correspond to any identifiable object or thing known to the child, or to anyone else, for that matter. Thus, the responses reveal more about the kinds of images an individual conjures up on the basis of ambiguous stimulus information of indeterminate meaning, than about his perception of meaningful stimuli, such as pictorially represented objects.

Recognizing this limitation of the Rorschach blots, Dworetzki (1939) approached this question more directly, by constructing stimulus figures made up of meaningful parts, which together made a meaningful whole (Figure 2 A). Faced with this type of material, 3- to 5-year-old children respond predominantly to the whole figure when asked to describe what they see. As this tendency diminishes, responses to individual parts increase, at first at the expense of the whole, but subsequently in conjunction with a recognition of the whole figure.

Later, Elkind, Koegler and Co (1964) tried to replicate the Dworetzki study with certain modifications. Elkind et al. felt that
Figure 1. Card 1 of the Rorschach Test.
Dworetzki's figures were drawn so as to detract from the component parts, as in the lower picture in Figure 2 A, in which it is admittedly difficult to recognize the arms and back of the chair as animals and a man on all fours, respectively. The stimuli used by Elkind et al. illustrated in Figure 2 B, were designed to bring the component parts into sharper relief. The data from that investigation showed that responses exclusively to parts did indeed predominate at the youngest age level (5½ years) included in this study; while they exceeded the percentage of exclusively whole responses at all ages, these responses decreased rather than increased.

What can be concluded from these contradictory results? First, a comparison of the sample stimuli shown in Figure 2 suggests that in their efforts to accentuate the parts more clearly, Elkind and colleagues inevitably detracted from the recognizability of the whole. Second, and more to the point, the question of whether young children focus on the part as opposed to the whole appears unanswerable in any absolute sense; it must rather be considered as depending on the nature of the stimuli presented to the child. The situation fits nicely into a formulation proposed by Meili (cited in Reese & Lipsitt, 1970) to handle similarly contradictory findings from previous studies of part versus whole perception in children. According to Meili, the young child will respond to details in a stimulus configuration if the whole is complex or weakly structured, but he will favor the whole if the whole is simple or well-organized. Admittedly, the usefulness of this form-
Figure 2. Sample stimuli used in studies of children's part-whole perception. A. From Dworetzki (1939, Figures 1 and 2, p. 260). B. From Elkind, Koegler and Go (1964, Figure 1, Items 4 and 6, p. 84).
ulation depends on the prior specification of criteria defining the complexity or degree of structure of a stimulus.

**Processing symmetrical-asymmetrical displays**

Another line of evidence that supports the notion that structural information influences the processing of the presented information very early in the organism's life comes from investigations which have shown that the information processing of young children is facilitated if the material is presented in a symmetrical arrangement (e.g., Boswell, 1976; Deregowski, 1971; Munsinger & Forsman, 1966; Paraskevopoulos, 1968; Spitz, 1966).

The role of structural symmetry on information processing has been assessed in two tasks: the recognition procedure and the reproduction task. In the earliest study (Munsinger & Forsman, 1966), a recognition procedure was used. First, third and sixth grade, and college students were presented random shapes for tachistoscopic recognition on four successive days. The sets of stimuli differed in amount of variability (5, 10 or 20 turns) as well as form (symmetrical versus asymmetrical). Several results of this investigation are pertinent to the present research. (1) Recognition accuracy improved as a linear function of age. (2) Stimulus variability influenced recognition accuracy for random shapes with accuracy scores being a decreasing linear function of the logarithm of number of turns. Consequently, identification was best for 5 turn figures, intermediate for 10 turn forms and
poorest for 20 turn shapes. (3) The form by stimulus variability interaction implied that recognition was facilitated by the addition of symmetry to the random shapes, however, this was only true for 5 and 10 turn figures.

Besides recognition, researchers have also investigated the effect of structural symmetry on reproduction. Three studies have used this mode of investigation. Paraskevopoulos (1968) presented dot patterns for 1.5 sec to children 5½ to 12 years. Six dots were placed in a 5 x 5 grid and were arranged into 4 types of configurations: asymmetrical, horizontal symmetry, vertical symmetry and double symmetry (Figure 3). The results indicated that children demonstrated increasing accuracy for reproducing the patterns with age. Additionally, Paraskevopoulos obtained a statistically reliable age by pattern type interaction. Multiple comparisons indicated that 5-year-olds performed equally on all pattern types. The 6-year-olds showed significantly greater reporting ability for the double symmetry patterns than for any other type of symmetry, which did not reliably differ from each other. The 7-, 8- and 9-year-olds also performed best on double symmetry patterns and second best on vertical symmetry arrangements. No differences in performance were shown between the asymmetrical and horizontally symmetrical figures. For 11-year-old children, the mean differences between all of the patterns were significant. These were ordered: double symmetry, vertical symmetry, horizontal symmetry and asymmetrical with the highest performance on the double symmetry arrays. On the
Figure 3. Examples of Paraskevopoulos' four pattern types.
basis of his results, Paraskevopoulos argued that children develop the ability to organize various symmetrical relations between the ages of 6 and 12. Specifically, he proposed that double symmetry is not decoded until the child is 6, that vertical symmetry is not decoded until 7 or 8, and that horizontal symmetry is not decoded until age 11.

Also utilizing a reproduction procedure, Deregowski (1971) examined the effect of spatial organization on the child's perception of that stimulus by presenting X patterns for 2 seconds to children 7-10 years. Eight X's were placed in a 4 x 4 grid to form 5 pattern types: vertically symmetrical, vertically repeated, horizontally symmetrical, horizontally repeated and random (Figure 4). Like Paraskevopoulos', Deregowski's study revealed higher accuracy scores for symmetrical arrangements than for random patterns. Furthermore, the data indicated that when the patterns were symmetrical about the horizontal axis or repeated about this axis, there were no differences disclosed in reproduction scores. However, symmetrical patterns were produced more accurately than repeated patterns when the vertical axis was the target. These findings were typical of all age groups.

If the conclusions from Paraskevopoulos' research could be accepted without further investigation, one would have expected the Deregowski study to likewise reveal an age-related difference in the reproduction accuracy for the various patterns. However, the later investigation indicated no such age-related results. Several procedural differences may have contributed to the observed findings. These include differ-
Figure 4. Examples of Deregowski's five types of stimulus patterns.
ences in the number of stimuli forming the array, ages of the subjects, as well as the size of the visual angle subtended by the stimuli and the distance from the screen.

In view of the theoretical importance in determining children's abilities to detect various structural relationships, Boswell (1976) recently investigated the processing of asymmetrical and symmetrical patterns with kindergarten, 2nd grade and 4th grade children. Presenting 6 dots arranged in 1 of 4 configurations (asymmetry, horizontal, vertical and double symmetry) (Figure 5) for 200 msec she observed that all subjects reproduced symmetrical patterns more accurately than asymmetrical configurations. Furthermore, the reproduction accuracy for all the children for the symmetrical arrays was ordered as follows: accuracy was best for the double symmetry displays, intermediate for those configurations marked by vertical symmetry and poorest for those arrangements characterized by horizontal symmetry. On the basis of these results, Boswell argues that the ability to process information about the stimulus structure evolves early in perceptual development but there are no age-related differences in the subjects' abilities to use this information in constructing their responses.

This finding contradicts Paraskevopoulos' assertion that the ability to detect symmetry developed systematically between the ages of 6 and 12. In the Boswell study, even the kindergarten children's reproduction abilities were helped if the dots were presented in horizontally symmetrical displays, an effect which, according to Paraskevopoulos, does not appear until the child is 11-years-old.
Figure 5. Examples of Boswell's (1976) four stimulus patterns.
Although the Boswell data did not support Paraskevopoulos' claim that the ability to detect symmetry develops systematically, the data did confirm his finding regarding the relative difficulty on the four pattern types. Subjects showed highest performance on double symmetry patterns, followed by vertical, horizontal and asymmetrical displays.

The investigations reviewed thus far reveal several points concerning the role of stimulus structure in information processing. First, the structural arrangement influences the processing of the stimulus information. That symmetry affects information processing has been evidenced in recognition and reproduction tasks. Second, structural information influences the perceptions of subjects as young as 6 years old. Third, the facilitative effects of symmetry depend on the type employed with reproduction accuracy best for patterns characterized by double symmetry, intermediate for those arrays marked by vertical symmetry and poorest for those arrangements characterized by horizontal symmetry. Fourth, these effects of symmetry are not age-related.

Focus of the Present Research

The research to be reported herein consists of two independent but related experiments designed to provide a better understanding of the role of stimulus structure on various information processing tasks with young children.
EXPERIMENT 1

As noted earlier, the structure or organization of a stimulus influences the processing of that information. That is, information presented in a symmetrical pattern is more accurately reproduced than that identical stimulus presented in an asymmetrical configuration. This finding has been repeatedly observed by Boswell (1976), Deregowski (1971) and Paraskevopoulos (1968). However, in all of these studies, the child was asked to reproduce one asymmetrical array for every three symmetrical designs (a double, a vertical and a horizontal) per block of trials. Possibly then, the higher reproduction scores for the symmetrical patterns might be a function of increased practice with these designs and not a result of the arrangement of the stimulus. Equating the child's experience with these two types of arrays should provide a better test of the hypothesis that structural symmetry facilitates processing more than structural asymmetry.

Second, it appears that structural information operates quite early in the life of an organism—at least by 6-year-olds. But can organizational information influence visual processing prior to that age? Perhaps the 6 year age limit observed in the previous studies reflects the inability of the experimenter to devise a sufficiently sensitive task that can be used with very young children. That is, in all of the reproduction studies mentioned thus far, the child was shown one pattern for a specified time and at offset of the stimulus configuration, the subject was asked to draw the circles or X's on a
5 x 5 ruled answer sheet in the positions he or she saw them. Since the task is basically a motoric performance measure, it is plausible that the absence of performance differences with younger subjects may be a function of the difficulty of the task. Admittedly, the assumption here is that younger subjects are less capable of producing the motoric responses required in the traditional reproduction task. This assumption seems plausible in light of the data on motor development which indicates strong differences in small muscle tasks with subjects of the preschool-kindergarten age (Gardner, 1978).

Third, given that the differential reproduction accuracy for the various patterns is replicable, what is the locus of this performance difference? That is, what stage of visual processing does structural information affect? If the higher accuracy for the symmetrical patterns is due to an effect of structural arrangement on a later stage of processing (e.g., retrieval), then it might be said that the image of the asymmetrical design fades faster than that of the symmetrical displays. Consequently, the picture of the asymmetrical configuration degenerates before the child has the opportunity to place all of the circles in their correct positions. However, if the locus for the higher accuracy scores for the symmetrical arrays is partly a function of differences at the perception stage, then it can be suggested that the image formation process of the asymmetrical configuration might be less defined, less formed than that of the symmetrical patterns.

Since all of the existing research used a task where memory differences between subjects are likely to influence the observed results,
no comments can be made regarding the locus of the observed performance differences. In the present study, two types of tasks were used: a reproduction (memory) task and a copying (perception) procedure. If the various arrays are no more accurately "copied" than "reproduced", then the results indicate that the effect of structural information is at the image-formation or perception stage. However, if the typically improved performance for the symmetrical configurations over the asymmetrical arrangements is not observed in the copying task (where memory differences between subjects are minimized), then the locus of the better reproduction scores for the symmetrical arrays appears to be at the image-recall (retrieval) stage of processing.

This result would be further supported if the time taken by the child to construct the various arrays in the copying task did not differ from each other, while the reaction time to these same patterns varied in the reproduction task.

Method

Subjects

Sixty-four 4- and 5-year-olds served as subjects in the first experiment. These children attend one of the seven preschool/daycare centers located in the Ames, Iowa area.
Materials

The form board was a black 10½ inch square wooden board with 25 1 inch x 1 inch holes cut 3/8 inch into the surface so as to make 5 rows and 5 columns of equally spaced holes into which 1 inch x 1 inch x 3/4 inch white wooden squares can be placed to make a pattern.

The advantage of this piece of equipment over that employed in the reproduction task used to date, is that the child can more easily observe the correspondence between the model presented and the board on which he/she will be attempting their reproduction. This is for two reasons. First, in the preceding studies, the model was a picture projected on a screen and the subject was required to "reproduce" it by drawing circles in the appropriate squares of a 5 x 5 ruled answer sheet. In the present study, the model was of the same concrete nature as the stimulus (form board) the child used to copy or reproduce the pattern. Second, for the previous research, the model was presented above the place where the child would make his copy, while in the present study, the model was first set over the child's form board and then placed either to the child's left or removed from his/her view, depending on the condition. Although Braine (1978) has recently reviewed a number of studies that have shown that children as young as three are competent at matching orientations of stimuli under certain test conditions, the data from a pilot study did not indicate any performance differences for the various orientations when the model is placed either to the left of the child's board or above the child's
board. Hence, the position of the to-be-copied model was not manipulated in this experiment and was always placed to the left of the child's board in the copying task.

For any single trial, two such form boards were used; on one, the experimenter constructed the pattern (the model); on the second, the child attempted to copy or reconstruct a pattern identical to the one displayed by the experimenter with another 6 squares.

On each trial, six of the squares were arranged to form one of the four pattern types used in the Paraskevopoulos (1968) and Boswell (1976) studies. Examples of the four pattern types are presented in Figures 3 and 5. These patterns were constructed as follows:

<table>
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<th>Pattern Type</th>
<th>Description</th>
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<td>Asymmetry</td>
<td>Six of the 25 spaces in the form board were randomly selected for element placement. Any symmetrical pattern which was generated was discarded and replaced by a new asymmetrical arrangement. Fifty such patterns were constructed and on any trial, selection from these patterns was random.</td>
</tr>
<tr>
<td>Vertical Symmetry</td>
<td>Three positions in the left 5 x 3 portion of the form board were randomly selected, with the remaining positions chosen to represent a mirror image of that pattern. Fifty vertically symmetrical arrays were formed and patterns were randomly selected for the trials.</td>
</tr>
<tr>
<td>Horizontal Symmetry</td>
<td>Each vertical pattern was rotated 90° in order to produce a horizontal array. Fifty such displays were constructed and randomly selected for use in the study.</td>
</tr>
</tbody>
</table>
Double Symmetry Twenty double symmetry (vertical and horizontal) pattern were generated and randomly selected for the use in the experiment.

Design

The experiment contained the following factors: pattern type (double, vertical and horizontal symmetry and asymmetry), type of task (copying and reproduction), order of tasks (reproduction followed by copying or vice versa) and age (4- and 5-year-olds), with the first factor being a between-subjects manipulation.

Each subject participated in 10 trials with one pattern type. On five of these trials, the child was asked to copy the picture (copying task) while on the remaining trials, that subject was asked to reproduce the arrangement (reproduction task) without the model stimulus. The order of these two tasks was randomized and balanced across all subjects.

Procedure

One week prior to testing, a permission letter (Appendix A) was sent to the parents of the 4- and 5-year-olds. Subjects in the experiment were selected from those who returned the permission slips. Before the individual testing procedures began, each child was asked if they "would like to play a game". Only those children who agreed were participants in the experiment. Of the seven centers included in this study, 98% of the children returned the completed permission forms.
Of that percentage, only two children declined to play the game when asked by the experimenter.

**Warm-up**

On entering the experimental room, the child was seated at a small table to the right of the experimenter, given a form board and six squares and asked to place the blocks into the holes in the board. (This indicated whether the child had any difficulty inserting the blocks into the spaces.) After the six blocks had been inserted, the experimenter asked the child to take them out. Then the experimenter told the child that they will play a game. "In this game, I will make a picture with some blocks and then give you a chance to make a picture just like mine". The experimenter then constructed a pattern on her form board without letting the child see what she was making. The child was told: "I don't want you to watch me make my picture. Look out the window. I'll tell you when it is ok to look. Now, don't peek!" She then displayed the pattern by putting her form board directly in front of the child, thus, covering the child's board. The experimenter said: "See the picture that I made? Can you make a picture just like that?" (Some children responded to this last question. Generally the 4- and 5-year-olds said that they could or would try. A few subjects replied "no" or "I'm not sure". These children were verbally encouraged to try. From the 64 subjects tested in this study, no child refused to try even after the verbal urging.) The child was then requested to touch each of the blocks (to insure that he/she was visually attending to the pattern). The experimenter then placed her form board either to the left of the child's (copying task) or removed it from view.
(reproduction task) and pointing to the child's form board said: "Here is your form board. See if you can make a picture just like mine. Tell me when you are finished." The child was given a one minute time limit to construct the pattern. Both pilot data and the subjects in the study showed that no 4- and 5-year-olds worked beyond 45 seconds on any one trial. During that time, the experimenter recorded the proportion of that one minute the child actually used in constructing his/her pattern. The child's pattern was recorded on a 5 x 5 ruled answer sheet. For every trial the child was told "good", "fine" or "ok" and then asked to remove his/her blocks.

The warm-up patterns that the child was asked to copy or reproduce included one symmetrical and one asymmetrical design. For all children, in all conditions, the patterns were always presented in the same order with the symmetrical array first. This procedure was based on the following reasoning. If the data from the previous studies and the pilot was accurate, then children should have differential success constructing these patterns, especially when the model is not present (reproduction task). Thus it was believed that failure in constructing the asymmetrical array on the first trial may influence the preschooler's willingness or motivation to continue on the subsequent test trials, even if the child was not given any "correct" feedback concerning the accuracy of his/her pattern.
Test trials

Test patterns were presented in 2 blocks of 5 patterns each, with 5 exemplars of one pattern type in the copying task and another 5 exemplars of the same pattern type in the reproduction task. Between tasks, the subjects were given a 2 minute rest for either a stretching game, a drink of water or a trip to the bathroom. Upon resuming the second block of trials, the instructions and necessary modifications were given to the child. For example, if the child first copied 5 patterns, before beginning the second block of trials, the subject was told: "This time we will play the game another way. I will show you my picture. Then I will hide my picture under the table. I want you to try to make a picture just like mine, without peeking at my picture. Do you think you can do that?" Again, if the child exhibited some hesitation, he/she was verbally encouraged to try. As in the copying task, two practice trials preceded the test trials.

Results and Discussion

Two dependent measures were recorded for each subject on every trial. As in the preceding studies concerned with the effects of structural information on visual processing, one dependent measure was the number of elements (blocks) placed in the exact position. The second dependent measure was reaction time, the portion of the 1 minute the child used in constructing or copying the pattern. The scores used for the analysis for each subject were obtained by computing the means
(number of blocks in the exact position and reaction time) of the 5 responses for the pattern type in each task. The data were entered into a pattern type (4) by age (2) by order (2) by task (2) analysis of variance.

The mean number of elements placed in the exact positions obtained under the various conditions of Experiment 1 revealed significant main effects of pattern type, $F(3, 48) = 7.95, p < .0004$, and task, $F(1, 48) = 373.58, p < .0001$. That is, the accuracy of block placement was higher for the symmetrical arrays ($\bar{X} = 3.83$) than the asymmetrical designs ($\bar{X} = 3.19$) and performance was better in the copying task ($\bar{X} = 5.00$) than in the reproduction task ($\bar{X} = 2.34$).

More importantly, as depicted in Figure 6, a comparison of the means for the interaction of pattern type and task was informative, $F(3, 48) = 5.21, p < .003$. While the average number of elements correctly placed in the 3 types of symmetrical patterns ($\bar{X} = 5.01$) did not differ in accuracy from placement in the asymmetrical arrays ($\bar{X} = 4.97$) in the copying task, this dependent measure indicated performance differences for these array types in the reproduction task (Asymmetrical $\bar{X} = 1.41$; Symmetrical $\bar{X} = 2.65$). A Scheffe's test between the symmetrical and asymmetrical means in the reproduction task indicated differences at the .01 level of significance.

Analysis of the mean response latencies obtained under the various conditions of Experiment 1 revealed significant main effects of age, $F(1, 48) = 7.52, p < .008$, pattern type, $F(3, 48) = 36.80, p < .0001$, 
Figure 6. Mean number of elements placed in the exact positions as a function of task and pattern type from Experiment 1.
and task, $F(1, 48) = 1015.10, p < .0001$. In general, response latencies were (1) shorter for the 5-year-olds ($\bar{X} = 23.98$) than for the 4-year-olds ($\bar{X} = 24.64$); (2) shorter for the symmetrical arrays ($\bar{X} = 23.61$) than the asymmetrical displays ($\bar{X} = 26.42$); and (3) shorter for the reproduction task ($\bar{X} = 20.56$) than the copying task ($\bar{X} = 28.06$).

More importantly, as shown in Figure 7, the interaction of pattern type and task, $F(3, 48) = 36.12, p < .0001$, indicated that the duration of response latencies for the various pattern types depended on the task. That is, while the average RT for copying the symmetrical ($\bar{X} = 28.05$) and asymmetrical designs ($\bar{X} = 28.08$) did not differ, the response latencies for the asymmetrical displays ($\bar{X} = 24.75$) were longer than those for the symmetrical patterns ($\bar{X} = 19.17$) in the reproduction task. A Scheffe's comparison between the response latencies for the symmetrical and asymmetrical patterns in the reproduction task indicated differences at the .01 level of significance.

The results of Experiment 1 present impressive evidence for the importance of the variable of pattern structure in visual information processing tasks. It appears that the ability to process information about stimulus structure evolves early in perceptual development—at least by 4-year-olds. Although the results from this study, as Boswell's (1976) findings, counter Paraskevopoulos' (1968) assertion that sensitivity to symmetrical information develops systematically with age, the data from the reproduction task did confirm his finding regarding the relative difficulty of the 4 pattern types. Subjects again showed
Figure 7. Mean response latencies obtained as a function of task and pattern type from Experiment 1.
highest performance on double symmetry patterns, followed by vertical, horizontal and asymmetrical designs.

Furthermore, the results of this investigation demonstrate that the effects of pattern structure are independent of context. In all of the preceding studies, recall that each subject was exposed to several blocks of trials which included all pattern types. In the present experiment, pattern type was a between-subjects manipulation thus eliminating context or comparison effects yet the trends for the various pattern types observed in the Boswell and Paraskevopoulos studies were again repeated.

Finally, the performance differences between the copying and reproduction tasks for the 4- and 5-year-olds suggests that the locus of pattern structure is probably at a later stage of processing than "perception". This finding is also confirmed by the reaction time data which indicate that the children did not use more time in constructing the asymmetrical and symmetrical patterns in the copying task, but did require differential time periods in reconstructing these patterns in the absence of the model (the reproduction task).

In conclusion, the findings of the present study are supportive of the position that symmetry detection is a perceptual processing capacity which evolves early in the developmental process, certainly by the time the child is 4-years-old.

The finding that pattern structure affects processing at a stage of processing later than perception (e.g., retrieval) under conditions
when the elements of the model and the matching stimulus are identical does not reveal any information about the subject's ability to "decode" the arrangement when there are differences between the elements of the model and the matching stimulus. Furthermore, that finding does not indicate the conditions under which the overall structure will be the main criteria in determining the preschooler's perception of that stimulus. An objective of the second experiment is to investigate these issues.
EXPERIMENT 2

The preceding study investigated the effect of structural information on young children's visual processing and the locus of that effect under conditions when the elements of the model and the matching stimulus were identical. Experiment 2, exploratory in nature, was designed to address three questions. First, can the preschooler decode the arrangement when there are differences in the elements of the arrays? Second, what are the conditions under which the child's perception will be influenced by the overall structure of the array as opposed to the individual elements constituting that pattern? Third, is there any relationship between the child's ability to copy the arrangement when the elements of the model and the matching stimulus are identical and the child's ability to decode that arrangement when there are differences in the elements of the arrays?

Method

Subjects

Twenty 4- and 5-year-olds were recruited from various preschool and daycare centers in the Ames area.

Materials

In the first task, the stimulus materials included a set of pictures of five squares or dots placed in a 5 x 5 imaginary matrix which
measured about 4 inch x 4 inch. These arrangements represented the "good" and "poor" levels of pattern goodness identified by Garner and Clement (1963). A "good" pattern is one, which when rotated or reflected on its vertical, diagonal or horizontal axis always forms the same arrangement; a "poor" pattern is one, which when rotated or reflected along the various axis, forms eight different arrangements. Examples of the two levels of pattern goodness are shown in Figure 8.

This series of eight pictures included three stimulus forms per trial. For example, if the model on a trial reflected a poor arrangement of circles, then the two alternatives also presented on that trial included poor arrangements; one of circles in a different pattern, and another of squares in the same configuration as the model. Figure 9 gives an example of one trial.

In the second task, the three-dimensional form boards from the preceding experiment were used. In that task, the subject was asked to copy the arrangement he/she was shown with an identical form board and 6 blocks. Of the designs the child was requested to copy, three were pictures of asymmetrical patterns and three were symmetrical designs (one vertical, horizontal and double symmetry arrangement). Exemplars of these designs were formed as in the preceding experiment and pattern selection for each trial was random from each pool of designs.
Figure 8. Examples of two levels of pattern goodness included in the classification task in Experiment 2.
Figure 9. An example of one trial in the classification task in which the model and alternatives reflect the "poor" level of pattern goodness.
Design

In this experiment, 4- and 5-year-olds participated in two tasks: the classification procedure and the copying task. Although the results of these two tasks are reported by descriptive statistics (e.g., frequency counts, correlations), and hence limit the types of statements that can be made regarding the children's performance on these measures, the purpose of this investigation was exploratory and descriptive in nature.

From the 8 trial classification tasks, the subject was given a score based on the number of trials he/she used the individual elements in grouping the stimulus forms or in judging likeness.

In the copying task, each subject earned a score for the average number of elements placed in the exact positions for the asymmetrical and symmetrical designs.

Procedure

One week before testing, the experimenter visited the preschool/daycare centers to pass out the permission slips (Appendix B). Subjects were then selected from those children who had returned completed forms. Of the twenty forms sent, all were returned.

On returning to the center, the experimenter asked each child if he/she would like to play some games. When agreement was reached, the child was taken to the testing room. On entering, the child was seated at a small table to the experimenter's right.
The experimenter then introduced the classification game. (This task was always first, since the child would have no restraints as to what criterion (overall shape or elements) to use. It was believed that balancing the classification and copying tasks might result in a "set" for some of the children since the copying task requires the child to abstract the overall configuration of the array.) The experimenter then proceeded to explain how the classification game was to be played. "In this game, I will show you a picture." (The experimenter placed a picture on the table in the top vertex position of an imaginary triangle.) "Take a good look at this picture. Now, I will show you two more pictures." (The experimenter placed these in the lower vertices of an imaginary triangle.) "I want you to tell me which picture is just like this one" (experimenter pointed to the top picture). After the child made his/her choice, the experimenter questioned the subject as to why that picture was selected. A pilot study indicated that some children would have difficulty verbalizing their reason, so it was expected that the child might use some gestural response in replying to the question.

Three days later, the experimenter returned to the center and played the copying game with the children who participated in the first task. This time, the child was told: "In this game, I will show you a picture and give you a chance to put your blocks just like mine." As in the Study 1, the experimenter constructed the pattern without letting the child see what she was making. The child was told: "I
don't want you to watch me make my picture. Look out the window. I'll tell you when it is ok to look. Now, don't peek!" She then displayed the pattern by putting her form board directly in front of the child, thus covering the child's board. The experimenter said: "See the picture that I made? Can you make a picture just like that?" To insure that the child was visually attending to the pattern, he/she was told to touch each of the blocks. The experimenter then placed her form board to the left of the child's and pointing to the child's form board said: "Here is your form board. See if you can make a picture just like mine. Tell me when you are finished." The child was given a 1 minute time limit to construct the pattern. As in the preceding pilot and study, none of the subjects worked beyond forty seconds. During that time, the experimenter recorded the block placement on a 5 x 5 ruled answer sheet. After every trial, the child was told "good", "fine" or "ok" and then asked to remove his/her blocks.

Results and Discussion

At the end of the classification task, the experimenter tabulated the number of times over the 8 trials in which the child used "elements" in grouping two pictures as alike. The number of times that criteria was used in determining likeness is presented in Table 1. Inspection of the data reveal several trends: First, when there are differences between the elements of the model and the stimulus, 4-year-olds use the individual elements as criteria in grouping considerably more often ($\bar{X} = 6.8$) than 5-year-olds ($\bar{X} = 2.6$). Of these trials, elements are
used as criteria when the patterns are good on an average of 2.9 trials for the 4-year-old subject while that criteria is employed by the 5-year-old for those same patterns on an average of less than 1 trial. Although there is differential use of this criterion with the poor patterns as well (4-year, $\bar{X} = 3.9$; 5-year, $\bar{X} = 2.3$), this difference is not as noticeable since nearly all of the 5-year-olds tested employed the element feature in grouping poor patterns.

Second, a breakdown of the subjects in each age group by months indicates a switch in criteria. Up to, and including 55 months, it seems that the element criteria is used in both good and poor patterns. From 59 to 64 months, the data suggest that the preschooler adopts the element criteria only when the model is a poor arrangement. Thereafter, it appears that the preschooler tends to use the overall structure in determining likeness, even when the patterns are poorly structured.

The trends observed here support Meili's statements that the young child will respond to details in a stimulus configuration if the whole is complex or weakly structured, but will favor the whole if the stimulus arrangement is simple or well organized. However, this observation appears to be applicable first around 59 months. Up to that time it seems reasonable to suggest that the structure of the configuration has little or no relation to the processing of information in a classification task where there are no differences between the elements of the model and the stimulus (as cited in Reese & Lipsitt, 1970).

Analysis of the children's explanations for their choices indicates that up to 55 months children know that they base their groupings on
Table 1. The number of times the element criteria was used in determining likeness in the classification task in Experiment 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Months</th>
<th>Total Times</th>
<th>Element as Good</th>
<th>Pattern</th>
<th>Poor Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>48</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>4</td>
<td>48</td>
<td>8</td>
<td>4</td>
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<tr>
<td>4</td>
<td>50</td>
<td>8</td>
<td>4</td>
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<tr>
<td>4</td>
<td>50</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
<td>52</td>
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<td>4</td>
<td>54</td>
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<td>4</td>
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</tr>
<tr>
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<tr>
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<td>4</td>
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<tr>
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<td>4</td>
<td>0</td>
<td>4</td>
<td>4</td>
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<tr>
<td>5</td>
<td>62</td>
<td>4</td>
<td>1</td>
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<td>5</td>
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<tr>
<td>5</td>
<td>70</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td>6.8</td>
<td>2.9</td>
<td>3.9</td>
<td></td>
</tr>
</tbody>
</table>
individual elements. This is reflected in the typical statements from children this age. For example, they say "they have the same circles", "they have the same squares" or they have "these things" (the child points to the element in the model). Between 59 and 64 months, when the child uses the overall structure in grouping the good patterns and the individual elements in the poor patterns, their responses reflect this. However, the preschoolers were unable to verbalize the concepts of shape or structure and primarily indicated their reasons in terms of pointing gestures for the good patterns. With the poor patterns, these same individuals were able to verbalize the element similarity. At 64 months, most of the children were able to indicate pattern structure for both types of arrays.

As in the preceding studies, the measure in the copying task was the number of elements placed in the exact positions. The scores presented in Table 2 are the mean number of elements placed in the exact positions under the various conditions of the copying task. Several similarities between the results of this study and the data from the copying task in Experiment 1 are evident. First, when each subject is exposed to all pattern types (a within-subjects variable), it appears that there are no overall performance differences between children of the 4- and 5-year-old range. This is in line with the data from Experiment 1 in which the copying performance of the 4-year-old ($\bar{X} = 4.92$) did not differ from that of the 5-year-old ($\bar{X} = 5.07$). Recall that in the prior study, pattern type was manipulated as a between subjects
factor. Likewise, the average performance difference between these subjects does not differ in copying the asymmetrical and symmetrical designs.

Table 2. Mean number of elements placed in the exact positions under the various conditions of the copying task in Experiment 2.

<table>
<thead>
<tr>
<th>Pattern Type</th>
<th>Age</th>
<th>Symmetrical</th>
<th>Asymmetrical</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>4.50</td>
<td>4.50</td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5.03</td>
<td>4.86</td>
<td>4.95</td>
</tr>
</tbody>
</table>

Correlation coefficients between the element scores on the classification task, the child's age (in year and months) and performance on the copying task are presented in Table 3. These coefficients indicate that the more the child uses "elements" in grouping stimulus forms, the less well he/she performs on the copying task. Furthermore, the older the child is the less the tendency to use "elements" as the grouping criteria in the classification task.
Table 3. Correlation coefficients between various factors in the two tasks included in Experiment 2.

<table>
<thead>
<tr>
<th></th>
<th>Symmetrical Arrays</th>
<th>Asymmetrical Arrays</th>
<th>Overall Copying</th>
<th>Years</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements</td>
<td>1.00</td>
<td>-.5939**</td>
<td>-.5289*</td>
<td>-.5749**</td>
<td>-.7563***</td>
</tr>
<tr>
<td>Symmetrical Arrays</td>
<td>1.00</td>
<td>.8910***</td>
<td>.9715***</td>
<td>.3959</td>
<td>.4327</td>
</tr>
<tr>
<td>Asymmetrical Arrays</td>
<td>1.00</td>
<td>.9703***</td>
<td>.3309</td>
<td>.3907</td>
<td></td>
</tr>
<tr>
<td>Overall Copying</td>
<td>1.00</td>
<td>.3760</td>
<td>.4195</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years</td>
<td>1.00</td>
<td></td>
<td></td>
<td>.8177***</td>
<td></td>
</tr>
<tr>
<td>Months</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .01 level.
** Significant at .006 level.
***Significant at .0001 level.
GENERAL DISCUSSION

These experiments present sound evidence for the importance of the variable of structural array. It appears that the ability to process structural information evolves early in perceptual development. Furthermore, the results of Experiment 1 suggest that structural factors affect a stage of processing later than "perception". The author contends that this idea is supported by the differential performance for the symmetrical and asymmetrical patterns in the reproduction task and the lack of performance differences for these arrays in the copying task. Additional support for this notion is evidenced in the reaction time data from that experiment. Like accuracy of element placement, response latencies show no differences between patterns for the copying task, yet reveal longer RT's for the asymmetrical arrays in the reproduction task.

Whereas Experiment 1 examined the effect of array structure on reproduction and copying performance when the elements of the model and the stimulus were the same, Experiment 2 was more exploratory and descriptive in nature and was concerned with the preschooler's ability to decode the arrangement when there were element differences. That investigation suggested that up to 59 months, the child appears unable to decode the arrangement when there are element differences. Thereafter, his/her decoding ability seems to depend on the type of organization in the model stimulus. That is, if the structure of the model reflects Garner and Clement's (1963) good level of pattern goodness,
the child decodes the arrangement. However, if the organization of the model reflects the poor level of pattern goodness, the 50-month-old child appears to be more influenced by the characteristics of the individual elements than the overall structure of the array. The data indicate that this tendency continues until the preschooler is about 64 months.

Stage of Processing Affected by Structural Information

Although the author contends that the effect of structural information is at a stage of processing later than "perception", there is some pilot data that suggests otherwise. In that exploratory investigation, 3-, 4-, and 5-year-olds performed the copying and reproduction tasks as in Experiment 1. The outcomes of 3 trials per subject showed that the 4- and 5-year-old performance depended on the task and pattern (symmetrical or asymmetrical arrangement), as in the results of Experiment 1. However, that investigation demonstrated no differences between the tasks as well as no effects of pattern type for the 3-year-old subjects. On the basis of the logic presented in Experiment 1, one would reason that such a lack of performance differences would necessarily indicate that structural information affects processing at an earlier stage (e.g., perception)—at least with 3-year-old subjects. This inference would imply that the locus of effect of a variable changes, depending on the developmental stage of the child. Although such a notion is in line with current developmental theory, at present there is a limitation in the copying task in Experiment 1 which cautions the adoption of this position. The copying of a visual form,
like the reproduction of it, does not reflect a simple "printout" of a perceptual input, but rather a conceptual schemata that has been constructed by the child's reflection upon his own activity. Piaget and Inhelder (1956) support this thinking by stating that:

A drawing is a representation, which means that it implies the construction of an image, which is something altogether different from perception itself and there is no evidence that the spatial relationships of which this image is composed are on the same plane as those revealed by the corresponding perception (p. 47).

It seems reasonable to suggest that Piaget and Inhelder's distinction implies that the child's perception, at least in terms of a visual recognition task, should far outstrip the child's ability to copy such forms. Under those circumstances, one could only suggest that the effect of structural information might be at the perception stage if it were possible to demonstrate that the child who could neither copy nor reproduce the arrangement could also not recognize the discrepancies between his pattern and the experimenter's model. Data from the pilot study shed light on this suggestion. Because the experimenter found it rather difficult to believe that the child could not copy the stimulus arrangement (at the end of each trial), she asked the subjects if their picture was just like hers (both form boards were exposed). Nearly all the 3-year-olds identified the discrepancies between the experimenter's model and the child's construction of that pattern. The author contends that the ability to recognize differences between the stimulus forms implies that the perception of the stimulus configuration is accurate and that the ability to copy or reproduce the array must result from some "lag" between perception and performance.
Lag Between Perception and Performance: Explanation

Three explanations can be mentioned to account for this lag. The first involves the nature of the perceptual information that is picked up by the child; the child may not have learned enough of the perceptual distinguishing features (Maccoby & Bee, 1965). A second alternative is that the child's knowledge may be adequate, but the complex motor skills involved in carrying out what the child knows or intends may be inadequate. The third and, to the author's thinking, the most plausible possibility is that the child may not have an appropriate system or schema for thinking about or representing the pattern as a basis for his/her reconstruction.

Maccoby and Bee (1965) have suggested that the lag may be due to the number of discriminated features involved. They suggest that one attribute may be sufficient for recognition, whereas several may be required for construction (copying or reproducing). These researchers (1965, p. 375) state, "to reproduce a figure, the subject must make use of more attributes of the model than are required for most perceptual discriminations of the same model from other figures." This hypothesis is undoubtedly true to some extent; it accounts for the studies they review and it is compatible with the findings of Herman, Lawless, and Marshall's (1957) replication of the Carmichael, Hogan and Walter experiment in which subjects who noted all of the features carefully were able to make a more adequate reproduction.
But the hypothesis that the perceptual distinguishing features account for the ability to copy a form leaves some problems. First, a purely quantitative notion of the difference between perceiving and performing would run counter to one of the more plausible statements of this relation, that of Piaget and Inhelder (1956). The latter make a sharp distinction between perceptual space and representational space. Just because a child can recognize a square, there is no evidence he/she knows "of what a square consists", or that he/she can draw it. They point out, "The fact that at least two years work is required in order to pass from copying the square to copying the rhombus...shows pretty clearly that to construct a euclidean shape, something more than a correct visual impression is required (p. 74)." The child's copying is an index of how he represents space, just as one drawing of a stick-man represents what we know about a man, and not some printout of the perceptual world. Representation does not come from more looking or from more and better perceptions, but from an invention of a system for representing the world. Piaget's theory is one systematic treatise on how it is ever possible to move from perception to representation. Suffice it to say, at this point, it does not come simply from more looking at more of the features.

Second, there remains the problem of how one makes use of an attribute in the copying of a form. Production, unlike recognition, is a sequential or segmented process as Maccoby (1968) has acknowledged.
One strength of this hypothesis is that it is testable. If the lag from perception to production is to be explained in terms of the number of discriminated features, it can be hypothesized that the learning of this larger set of features would lead to the construction of the various patterns.

Although the history of psychologists attempts to teach children to construct the arrays in a manner suggested by this hypothesis is nonexistent (as far as the author knows), another point must be considered first. It will turn out to be a major problem to figure out the "features" of each of the patterns.

So, we are left with the lag between perceiving and performing. The author will argue presently that it is to be attributed to the child's conceptual system as Piaget has argued. But first, it is necessary to discount the possibility that the lag can be accounted for in the performance itself. That is, in the motor integrations and coordinations involved in the response side of the organism. It is to this latter possibility that attention is now focused.

If the failure of the 3-year-olds to perform better when the model was present (copying task) than without the model (reproduction) cannot be attributed in any single way to perception, the next most accessible source of the child's failure is in terms of the performance itself, the complex motor integrations involved, or what may be described as a limitation in visually guided behavior. It is possible that both the perception and the conceptual representation of the patterns was adequate, but this knowledge is not observable because of the complex motor
integrations involved.

While motor performance skills can interfere with the child's copying or representation of his conceptual knowledge, this is not the case with the form board. Recall that before the test trials began, the subject's ability to place the blocks in the holes was assessed. No 3-year-old experienced any difficulty on these warm-up trials. Since the test trials require the same motoric movements as the warm-up procedure, it is impossible to attribute the lack of performance differences on these tasks to the motoric integrations involved.

If perceptual or input error and motor performance or output error accounts can be eliminated, it is hardly surprising that the child's lack of performance differences on these 2 tasks is determined by his/her conceptual systems. In this case, the explanation must hinge on a cognitive process that develops around 3 years of age. It is the reorganization of the child's knowledge that permits the child to copy the pattern. It now becomes the problem of future studies to specify how the "pre-pattern" child represents or conceptualizes the various configurations and how this changes when he/she learns to copy a stimulus configuration.
REFERENCES


Claparède, E. Exemple de perception syncretique chez un enfant. *Archives de Psychologie*, 1908, 7, 195-198.


ACKNOWLEDGEMENTS

From the title page, this is "my" paper. Nothing could be further from the truth. It may take only one person to write, but it takes the combined efforts of several people to produce a project. The author gets most of the credit; the others do much of the real work and get little notice, yet without their contributions, these pages would not be in print. In this brief note, let me mention these people.

To begin with, there is Dr. David C. Edwards, my advisor, colleague and friend. Thank you for all the opportunities you gave me to develop my skills. There were a few times when I was unsure I could pull off what you expected. Your encouragement over the past two years has helped me grow both professionally and personally. It won't ever be forgotten.

Next there are Drs. Ronald H. Peters, Thomas W. Bartsch, Gary D. Phye and Jacques Lempers who served as members of my doctoral committee. Your insights into the issues of this dissertation proved invaluable.

Then there is B. E., a fellow graduate student. Your statistical information made these analyses less cumbersome.

Fourth, there are the teachers and students of the Ames daycare and preschool centers. Without you, I could never have begun.

Last, but most importantly, I owe my thanks to my Dad and Mom. Without your encouragement and support, I would not be receiving this degree. It is to you that I dedicate these pages.
APPENDIX A: PERMISSION LETTER SENT TO THE PARENTS OF CHILDREN PARTICIPATING IN EXPERIMENT 1

Dear Parents:

Your child has been selected to take part in a research study being conducted as part of my Doctoral Degree in Developmental Psychology at Iowa State University.

The study will be conducted in a small room in your child's pre-school/daycare center. Participation in the study will entail your child's leaving the classroom (at the teacher's discretion) for a period of approximately 5 minutes.

In the testing session, the child will be shown an arrangement of blocks (6) and asked to either copy or make from memory the same picture with another set of blocks. There are 10 trials to this task. At the end of the testing session, the child is thanked for playing the Game and returned to his/her classroom. If the preschoolers at the Early Childhood Development Center in Notre Dame, Indiana are representative of preschoolers elsewhere, I am sure that your child will find the task fun.

The proposed research will help identify the developmental stage at which the child becomes sensitive to the arrangement of a pattern. A long term goal of this research is to relate this perceptual processing to reading skills.

I urge your cooperation in signing the permission slip and having your child return it to his/her teacher by ____________________.

Should you have any questions regarding this research, please feel free to contact me either at my home (232-2576) or at the departmental office (294-1742).

Sincerely,

Mary Skowronski, M.S.
Psychology Department, ISU

I agree to allow my child ____________________ to participate in the early childhood development research being conducted by Mary Skowronski.

Child's Birthdate: ____________________

Parent
APPENDIX B: PERMISSION LETTER SENT TO THE PARENTS OF CHILDREN PARTICIPATING IN EXPERIMENT 2

Dear Parents:

Your child has been selected to take part in a research study being conducted as part of my Doctoral Degree in Developmental Psychology at Iowa State University.

The study will be conducted in a small room in your child's preschool/daycare center. Participation in the study will entail your child's leaving the classroom (at the teacher's discretion) for 2 periods of approximately 5 minutes each.

In the first testing session, the child will be shown a series of pictures of squares or circles and asked to "point to the picture that is just like this one" (the experimenter is pointing to a standard). There will be 8 such trials. In the second testing session (occurring approximately 2 days later), your child will be shown an arrangement of 6 blocks and asked to "make his blocks just like mine". The child will have a set of 6 blocks. There will be 6 copying trials. If the preschoolers at the Early Childhood Development Center in Notre Dame are representative of preschoolers elsewhere, I am sure that your child will find the "games" fun.

The proposed research will identify the developmental stage at which the child is able to identify the same pattern or arrangement despite differences in the elements or objects that make up the pattern. A long term goal of this research is to relate these perceptual abilities to the development of pre-reading skills.

I urge your cooperation in signing the attached permission slip and having your child return it to his/her teacher by ____________.

Should you have any questions concerning this research please feel free to contact me either at my home (232-2576) or at the departmental office (294-1742).

Sincerely,

Mary Skowronski, M.S,
Psychology Department, ISU

I agree to allow my child __________________ to participate in the research being conducted by Mary Skowronski.

Child's Birthdate ____________________________

Parent ____________________________
### APPENDIX C: ANALYSIS OF VARIANCE FOR ELEMENTS IN EXPERIMENT 1

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| Task (T)                | 1                  | 226.179863  | 373.58167*** |
| A * T                   | 1                  | 0.059082    | 0.09759 |
| T * O                   | 1                  | 0.305176    | 0.50406 |
| C * T                   | 3                  | 3.151634    | 5.20556** |
| A * C * T               | 3                  | 0.023561    | 0.03892 |
| C * T * O               | 3                  | 0.030072    | 0.04967 |
| A * T * O               | 3                  | 0.001582    | 0.00261 |
| A * C * T * O           | 3                  | 0.696270    | 1.15003 |
| T * S (ACO)             | 48                 | 0.605436    |         |

** **p < .001.  

***p < .0001.
APPENDIX D: ANALYSIS OF VARIANCE FOR RESPONSE LATENCIES IN EXPERIMENT 1

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** p < .005.
***p < .0001.