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ABSTRACT

This paper describes a visual-motor training program that has been successfully implemented with children aged 3-11. Various studies related to the development of children's visual-motor skills are reviewed and a rationale associated with the teaching of appropriate visual-motor processes is explained. Application of this rationale to the visual analysis skills used in copying is proposed. A hierarchy of objectives and criterion-referenced tests are presented together with instructional methods. The Design Board Program is suggested as a useful method of teaching the child to analyze concrete visual information. A number of validation studies are cited and briefly described. Additional studies are in progress. (Author/LR)

THE DESIGN BOARD PROGRAM

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1971

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ABSTRACT

This paper describes a visual-motor training program that has been implemented successfully with 3-year-old through 11-year-old children. A hierarchy of objectives and criterion-referenced tests are presented along with instructional methods. Validation studies are cited and described briefly

The Design Board Program

Jerome Rosner
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A child's ability to copy moderately complex geometric designs is often considered as one criterion for determining academic readiness. This is indicated by the inclusion of a copying subtest in most school readiness instruments (e.g., MRT, 1966). A recent study by Rosner and Cooley (1970), showing copying skills to be a significant predictor of first grade achievement in mathematics and reading, provides additional evidence of a relationship between visual motor ability, as measured by a copying test, and school performance.

Developmental studies by Gesell (19[illegible]) and others have shown that most children acquire the visual-motor skills of copying on a relatively predictable schedule. A 3-year-old, for example, usually can copy a circle with some degree of accuracy, will be much less successful with a square, and cannot begin to approximate the copying of a triangle. As he grows and develops, he normally acquires the ability to copy more complex designs.

Some children, however, do not acquire appropriate visual-motor skills at the predictable rate. As a result, many perceptual training programs have been developed in recent years. The programs involve a variety of activities and reflect contrasting rationales. Some are based on such procedures as direct tracing over designs and the use of templates, revealing the designer's bias toward overt tactile-kinesthetic learning. Others depend upon discrimination tasks, such as matching stimulus to a sample, suggesting that overt motor involvement is of negligible importance to copying beyond the physical manipulation of the pencil. In most instances, regardless of rationale, the programs are designed to teach to specific shapes.

An earlier paper (Rosner, 1969) has described a rationale related to the teaching of appropriate visual-motor processes. In condensed form, that rationale states that a child's visual-motor development may be monitored by observing changes in three aspects of his performance. These are:

1. The very young child's sensory-motor behaviors depend heavily upon the motor component of the task. In time, the overt motor involvement becomes much less essential and the child demonstrates the ability to use his eyes <u>as though</u> his hands were involved. The sensory component of the sensory-motor behavior assumes the dominant role. The motor component is covert. (sensory-MOTOR ⟶ SENSORY-motor)

2. The child's motor skills become more differentiated and, coincidentally, he demonstrates the ability to analyze visual stimuli of increasing complexity.

3. As the changes described in items 1 and 2, above, become apparent, the child also depends less upon the environment for the structure needed to organize visual stimuli. He learns to infer structure on visual sensation and to perform <u>as though</u> the structure was provided.

This paper will propose application of the rationale to the visual analysis skills used in copying and will describe one instructional method suggested by the rationale. The general objective of this training method is to teach the child an organized process for the analysis and reproduction of two-dimensional visual presentations. Specific designs such as diamonds are not taught. If the terminal training objective is achieved, the child should be able to reproduce any design, so long as the degree of complexity is kept within reasonable limits.

Visual Analysis

What is involved in copying a design? To copy a design accurately, one must analyze the separate elements of the pattern and interpret the spatial interrelationships of those elements as they combine to form the total pattern. In other words, the copier must sort out the individual lines and order them in a way that represents their spatial interrelationships. Figure 1 presents a geometric design used in the Rutger's Drawing Test (Starr, 1961) and a reasonable task for a first grade child at mid-year.

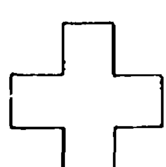


Figure 1

How can the task be made less demanding? The cartographer has a reliable copying technique that merits discussion. Figure 2 presents the same design superimposed by a simple spatial coordinate matrix, a technique not unfamiliar to commercial artists and map-makers.

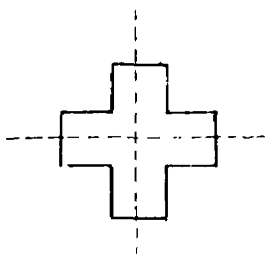


Figure 2

Figure 3 presents the same design again. In this instance, however, the matrix is more refined.

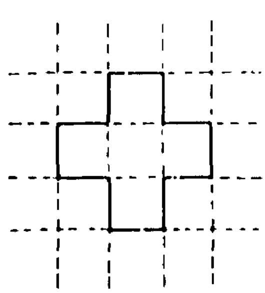


Figure 3

Given the task of copying the design only (not the matrix), which of the above three formats would result in the most accurate replication? It seems logical to assume that Figure 3, superimposed as it is with a matrix that provides many precise spatial relationship clues, would be copied most accurately.

If, in addition, the copier was asked to draw his copy on a sheet of paper that contained a matrix identical to the one shown in Figure 3, his reproduction of the design would probably be almost exact. Certainly, it is likely to be much more exact than the outcome of an attempt to copy Figure 1 upon a blank sheet of paper. Given this latter set of conditions, the copier must "imagine" a matrix and copy the design in a manner that indicates this ability.

A matrix, explicit or imagined, provides an organized format upon which the spatial interrelationships of the individual elements of a visual pattern may be plotted, once the elements themselves have been sorted. Hence, the more refined the matrix, the more potentially precise the analytical processes. (One must caution, however, that too discrete a matrix may result in lowered efficiency and segmentation.)

I have proposed, then, that normal visual-motor development provides the child with the ability to sort, order and reproduce concrete visual information as though a matrix were superimposed upon it. As these processes become more efficient and automatic, the sorting and ordering processes tend to unite or "chunk" certain combinations. The four-year-old, for example, learns to reproduce a square as four interrelated lines rather than a relatively global shape. As he matures, the segmented quality of four individual lines is gradually replaced by a single line that takes four different directions at specific points within the drawing sequence. Ultimately, as language develops, words representing spatial interrelationships such as center, above, under, next to, left, right, and so forth, start to assume the function of the visual matrix.

The Design Board Program is based on the above rationale. Its intent is to provide the child with a sequence of experiences that will teach him to analyze concrete visual information. Initially, it depends upon overt motor involvement and overt structural support in the form of matrices. As the child learns, both supports are gradually eliminated from the program.

Equipment

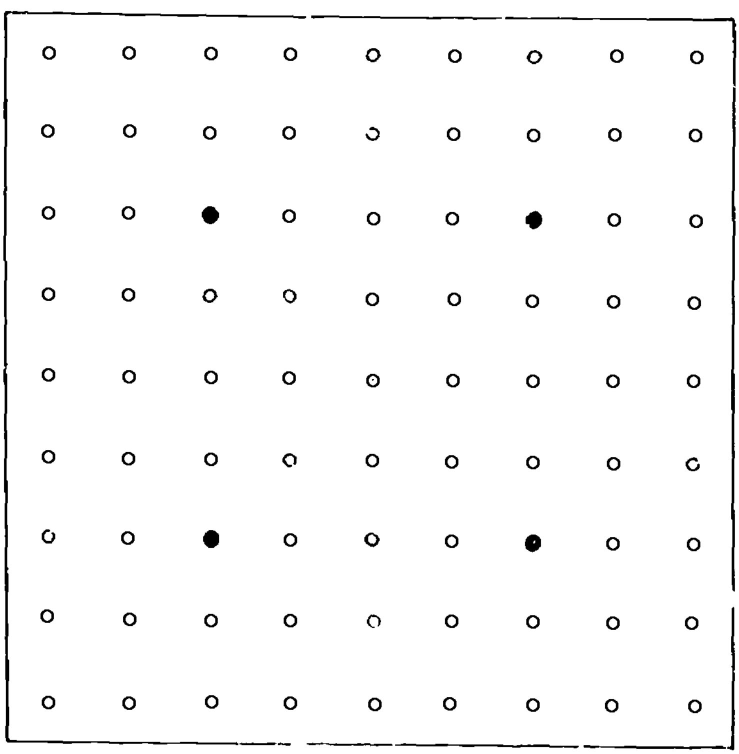
The equipment is fairly simple, usually available from local sources, and inexpensive. The basic equipment may be constructed from the following:

1. a ten (10) inch square of 1/8" perforated hardboard; perforations are to be spaced one (1) inch apart.
2. twenty-five (25) 1/4" machine screws and bolts; screws to be approximately one (1) inch long.
3. an assortment of rubber bands.

By inserting the bolts through the perforations of the hardboard and securing them with nuts, a pegboard is produced in which the number and arrangement of the pegs are variable, limited only by the number and location of the perforations.

The Design Board Program, as currently implemented, uses four different arrangements that require from as few as four to as many as twenty-five pegs. These have been given the letter designations *D*, *F*, *I* and *P*. Figure 4 shows *D*, the simplest peg arrangement currently in use.

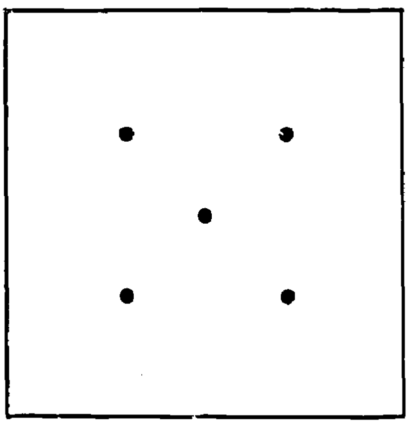
Four screws (indicated in the figure by filled circles [●]) are fastened to the board to form the pattern. (The 77 unoccupied perforations are indicated by unfilled circles [o].)



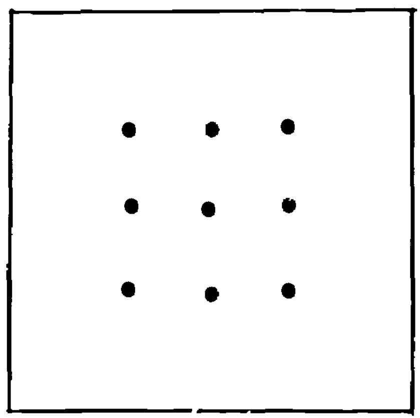
D

Figure 4

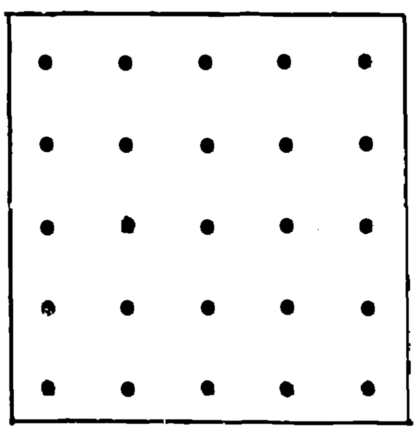
Figure 5 shows the three other peg arrangements that currently are used in the Program. The F arrangement uses the basic D (shown in Figure 4) plus an additional center peg. The I arrangement uses the F arrangement plus four additional pegs. The P arrangement is constructed from I, with sixteen additional pegs placed along the four sides of the perimeter. The rubber bands are stretched between pegs to construct the pattern.



F



I



P

Figure 5

Training Sequence

The objectives of this sequence are taken from the Visual-Motor component of the LRDC Perceptual Skills Curriculum. The curriculum is organized into six units. Each of the units represents a type of perceptual behavior in response to solving a problem presented by visual stimuli. The Design Board Program is used currently in the first five units.

Unit 1 - Superimposition - The primary goal of this unit is to teach sorting skills. One characteristic often displayed by inadequate visual-motor performers is their inability to view an arrangement of visual stimuli as a finite collection of separate elements. Their responses often indicate global viewing processes; they "see" an indefinite quantity of elements, too numerous and interwoven to consider separately. This may be compared to the task of drawing a precise replication of a section of lawn. There are so many blades of grass that one can only represent rather than replicate them.

Teaching sorting skills, then, means providing the trainee with experiences that yield an appropriate awareness of the individual elements that combine to form a stimulus. The Design Board Program supplies three variables, all of which may be manipulated to alter the complexity (i.e., the difficulty) of the task. They are: (1) the number of pegs (e.g., arrangements D, F, I or P), (2) the number of rubber bands used in the design (e.g., from a single band to many), and (3) the arrangement of the rubber bands (e.g., three bands that do not intersect are ordinarily less complex than two intersecting rubber bands). The direction of a rubber band can also cause confusions, particularly with young (3, 4 and even 5-year-old) children. As a rule, diagonals are more complex than vertical or horizontal orientations.

The terminal objective of the DBP in Unit 1 states that the child is to be able to superimpose three rubber bands over a pre-constructed three band F board arrangement, as shown in Figure 6.

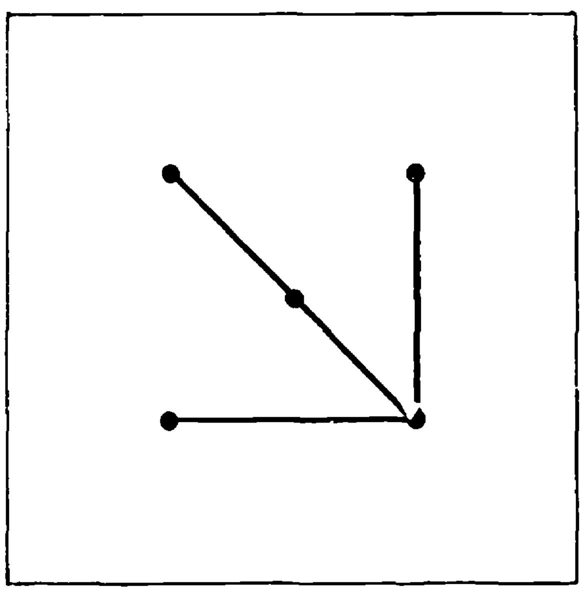


Figure 6

The dots in Figure 6 represent the pegs on the board. The drawn lines represent the rubber bands. The trainer constructs the pattern on an F board, places it before the child, gives him three rubber bands, and says "Put your rubber bands on mine. Put one of yours over each one of mine."

If the child does not respond successfully, the trainer simplifies the task by keeping the board arrangement (F) constant and using less rubber bands to construct less complex patterns. Once the child can perform the behavior successfully, using a single, then a two rubber band arrangement, the test pattern (Figure 6) is presented again. Instruction continues until the terminal objective is mastered. Criterion for mastery is successful completion of the test.

Unit 2 - Construction of a Concrete Arrangement from a Model - The primary goal of this unit is to teach the trainee that a defined area of space may be duplicated by using mapping rules. Thus, points in one area may be located precisely in another and lines connecting the points in one area may therefore be replicated precisely in the other. The terminal objective of the program in Unit 2 is: "Given a Design Board F on which a construction of three rubber bands is shown, the child accurately reconstructs the pattern on a second F board." This is shown in Figure 7. The trainer, prior to testing, constructs the pattern on an F board, places it before the child with another F board, provides him with an assortment of rubber bands and says "Make your board look just like mine. Put the rubber bands on your board so that they are the same as mine."

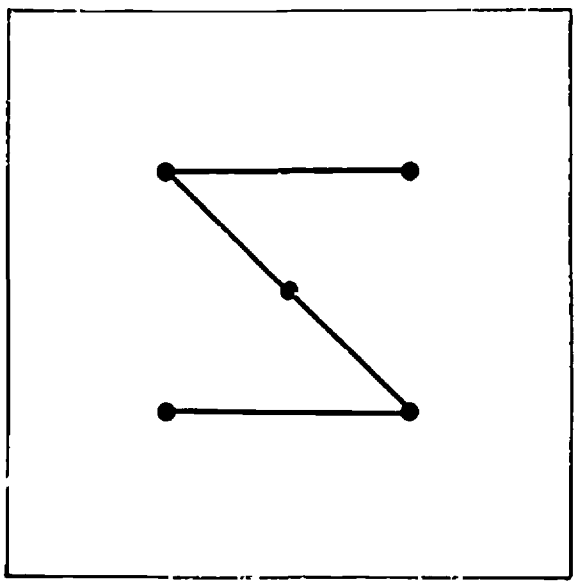


Figure 7

If the child does not respond successfully, the trainer simplifies the task by altering the number of rubber bands and/or simplifying the board arrangement (to D). Once the child can demonstrate successful performance with simpler designs, the test pattern is again presented. Instruction continues until the terminal objective is mastered.

<u>Unit 3</u> - <u>Construction of a Concrete Arrangement from an Abstract Representation</u> - The primary goal of this unit is to teach the trainee that scaled graphic representations may replace concrete models. The mapping strategies that were taught in Unit 2 are continued and made more elaborate, by using additional spatial reference points. Thus, the child is taught to construct from a drawn plan; he is taught, also, that the drawn plan need not be identical in size to his construction, so long as the relative spatial relationships are maintained and that a peg is supplied for each drawn one.

The terminal objective of the DBP in Unit 3 is: "Given the drawing of a Design Board P on which is shown a geometric design constructed of horizontal, vertical and diagonal lines, ten in total, the child can construct the pattern with rubber bands on a P board." The pattern is illustrated in Figure 8.

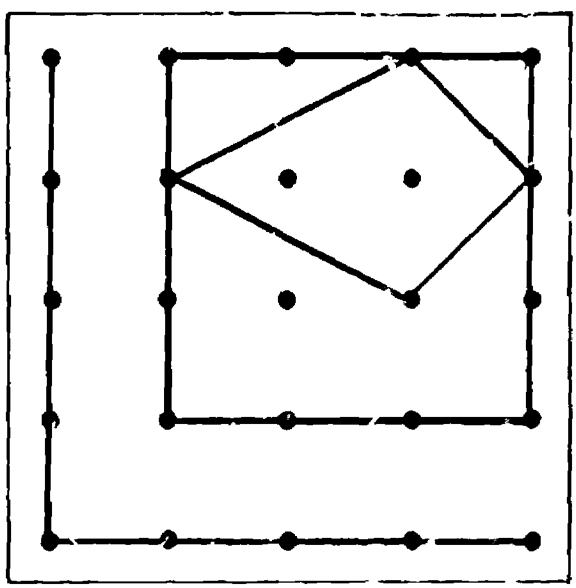
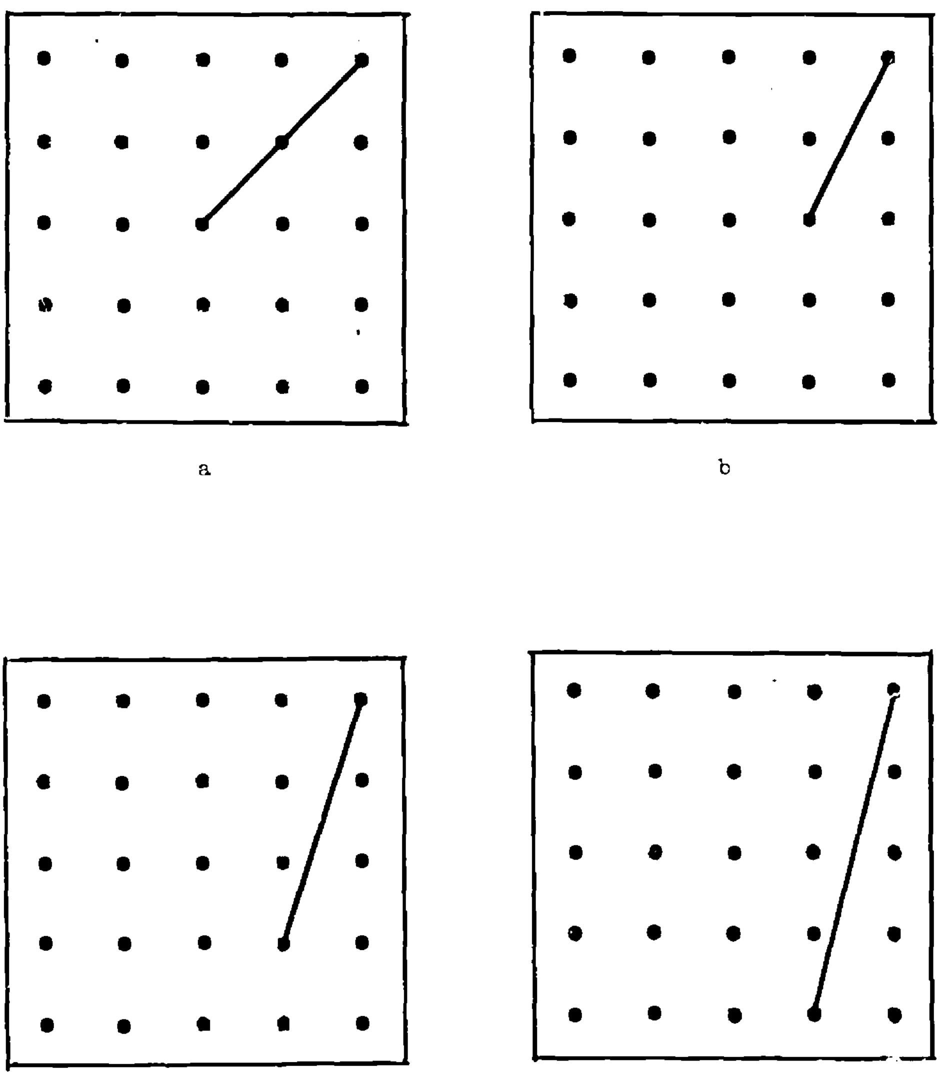


Figure 8.

The test pattern is drawn on a P matrix contained within a 3-1/2 inch square; the dots are situated 3/4 inch apart. The child is shown the drawn pattern and told "Make this design on your board. Make your board look like this picture." If the child does not perform the task successfully, the trainer simplifies the task by altering the board arrangement and/or the rubber band patterns.

Drawn patterns have been produced for all four board arrangements. Ten D, ten F, twenty-five I, and sixty P patterns are made available to the trainer. In each series, the initial patterns are quite simple, never involving more than one vertical or horizontal line; these become increasingly more difficult in small increments. The final pattern in each group is sufficiently difficult to ensure successful completion of the first pattern in the next series. The progression, from simple patterns to difficult ones, reflects the criteria already referred to, with one additional component. As stated, diagonal lines are more difficult than vertical and horizontal. Within the category of diagonal, there are variations. A diagonal line that connects a point in one row or column to a point in an adjacent row or column (see Figure 9-a) is less confusing than one that passes between a pair of dots in an adjacent row and terminates at the next (see Figure 9-b). This, in turn, is less difficult than a diagonal line that passes between a pair of dots in the two (see Figure 9-c) or three (see Figure 9-d) rows or columns adjacent to the point of origin before reaching its terminus.

Figure 9



a b

c d

If tutoring is required in this unit, certain approaches seem to be effective. Successful performance requires that the child relate drawn reference points to actual ones on the board. The most readily identified points are those situated in the four corners. Given a child who appears to be "lost" among the 25 reference points of the P board, assisting him in locating a corner starting point can be very helpful. The trainer should point to a corner dot on the drawn pattern and say "Show me this peg on your board." Once located, the trainer shifts his finger position, one dot at a time, horizontally and/or vertically (but not diagonally), until it is on a rubber band terminal point. In this manner the child learns problem solving strategies that can be performed with more speed as he becomes familiar with the task. Ultimately, the procedure becomes "chunked" and implicit.

Unit 4 - Production of an Abstract Representation from a Concrete Model - This unit is concerned with providing the experiences necessary to ensure that the child will acquire the capacity to draw geometric patterns. The training and test patterns used in Unit 3 are presented again, but now the child must draw the lines between the appropriate dots instead of representing them with stretched rubber bands. Under such conditions, a major source of support is withdrawn from the child. When stretching rubber bands, the child is either correct or incorrect. He chooses the correct peg or he does not. There is no other alternative, no "almost" category. In Unit 4, he must visually direct and monitor his drawing so that he does connect the proper terminal points.

The terminal objective of the program in Unit 4 is "Given a drawn Design Board Pattern P on which is shown a geometric design constructed of horizontal, vertical and diagonal lines, ten in total, the child can copy the pattern, with pencil or crayon, onto a second, matching printed matrix." The test pattern and the P matrix onto which the child draws his response are the same size, identical to the patterns used in Unit 3. The same patterns, in fact, are used, except that they are rotated 90° to alter their appearance and create a new, though very similar, series of problems. The test pattern for the Unit 4 terminal objective is shown in Figure 10.

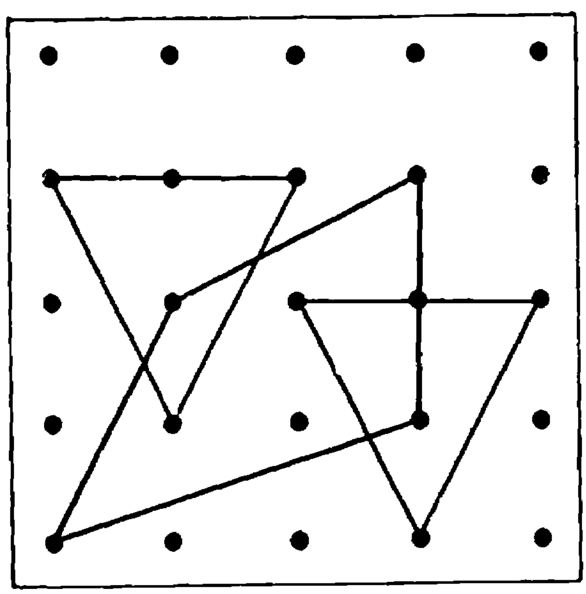


Figure 10

The child is shown the drawn test pattern, another printed matching matrix, and told "Draw this (pointing to stimulus pattern) design on your sheet. Make yours look just like mine." If the child does not perform the task successfully, the trainer again has the available alternatives of providing simpler patterns in the P series or, if indicated, using patterns from the D, F or I series. In any case, the child is to be entered into the sequence at his level of competency and encouraged to work through the patterns until the terminal objective has been mastered.

Although optional, it is recommended that the response sheets used for training purposes be covered with an acetate sheet so that they may be wiped clean and used again. A crayon is used for drawing the lines in such situations.

Unit 5 - Concrete to Abstract (Fading of Support) - If the instructional program has been successful to this point, the child will have learned: (1) to discriminate the individual lines in a relatively complex pattern, and (2) the mapping rules needed to replicate patterns drawn on a 5 x 5 matrix of dots. The dots, of course, enable him to replicate the spatial positions of the lines in a segmented fashion. If we wish to teach generalizable copying skills, we must now teach the child to understand the spatial interrelationships of the elements.

It was stated above that the rationale of this program accepts the assumption that the capable copier of geometric designs views those designs as though through an organized arrangement of spatial coordinates. The general goal of Unit 5, then, is to teach the child to do just that--to "imagine" the spatial coordinate system that, to this point in training, has been available overtly.

The terminal objective of the program in Unit 5 is "Given a drawn Design Board Pattern P on which is shown a geometric design constructed of horizontal, vertical and diagonal lines, ten in total, the child can copy the design in a defined space that contains no dots." In effect, the child must "imagine" the presence of the dots and position his drawn lines accordingly. Figure 11 shows the test pattern and the response space in which he is to copy the geometric design.

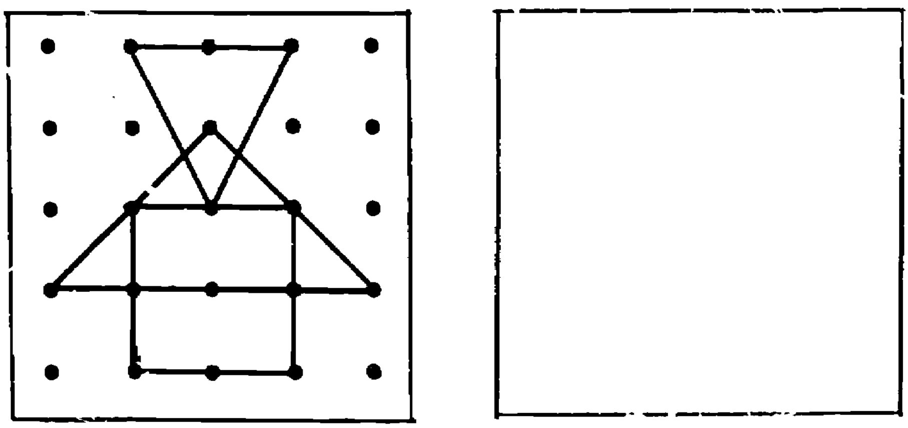


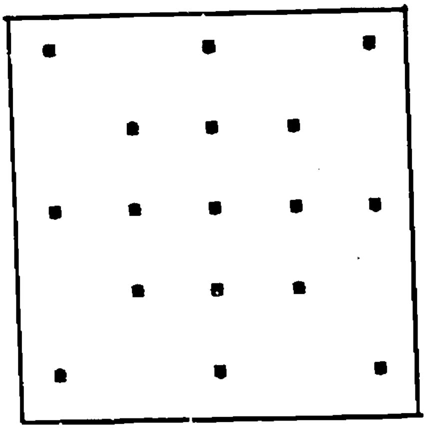
Figure 11

The child is shown the test pattern (Figure 11) and told "Draw these lines (pointing to stimulus pattern) in this blank box. Don't draw the dots, only the lines. Imagine (or pretend) that the dots are in this blank box and draw your lines so that they are in the same place here (pointing to blank response space) as they are here (pointing to stimulus pattern)."

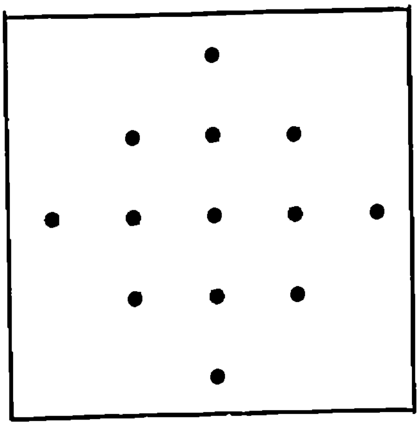
Should the child not be able to demonstrate mastery of this objective, given that he can demonstrate the terminal behavior of Unit 4, he is taught to "imagine" the dots in gradual stages. In other words, he is initially shown less complex drawn patterns and taught to draw them onto a matrix from which only eight dots (PF8) have been faded. He is allowed, for instructional purposes, to draw in the missing dots but ultimately must demonstrate the ability to respond as though they were present. When this skill has been acquired, similar instructions are provided using matrices from which twelve (PF12), sixteen (PF16), twenty (PF20) and twenty-four (PF24) dots have been faded. These are illustrated in Figure 12.

Validation Research

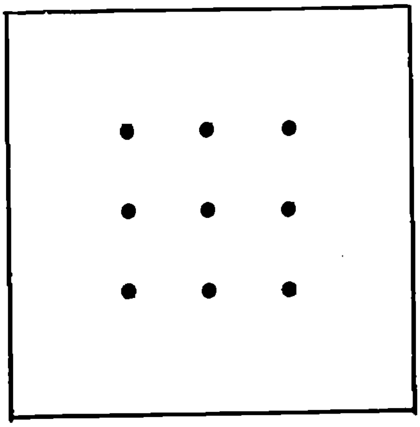
As stated above, the general objective of this training method is to teach the child an organized process for the analysis and reproduction of two dimensional visual presentations. Specific designs are of no importance. If the basic skills have been acquired, if the child has learned to sort and order the individual elements of a relatively complex geometric design and reproduce that design as though seen through a matrix of spatial coordinates, he will reflect the analytical behaviors in other tasks of a similar nature. A recent study (Rosner, Levine and Simon, 1970) indicated that more than copying skills are taught with the Design Board Program; positive changes in three other subtests of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI - Wechsler, 1967) were also shown. These were the Block Design, Mazes and Animal House, all



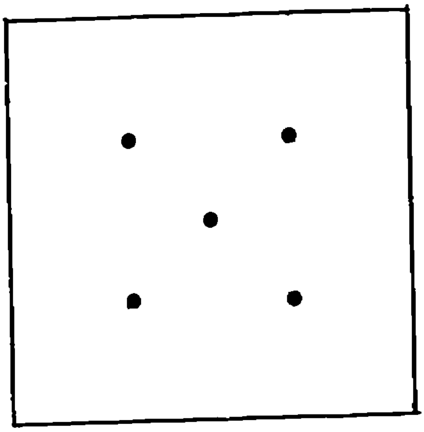
PF8



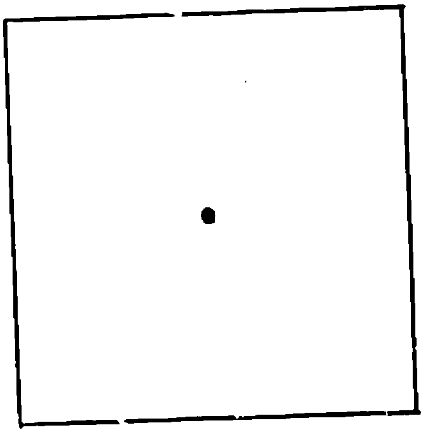
PF12



PF16



PF20



PF24

Figure 12

visual-motor tests that involve the presentation of certain visual problems that are best solved by analytical strategies. Another study (Rosner, 1970) reported that Design Board training produced significant changes in the copying skills of a group of 4-year-old pre-school children as compared to a second group of the same age whose copying skills, prior to the experiment, were not different to any significant degree. This control group was then given the same Design Board training, after which the differences between groups were no longer apparent. Both groups showed copying skills equivalent to those of kindergarten children whose mean age was approximately ten months greater than the trained groups. Hence, the skills apparently may be taught to very young children.

A third study by this author, currently in preparation, indicates that mastery of the Unit 4 terminal objective tends to predict copying skills to be at a 6-year-old level, as measured by the norm-referenced Rutgers Drawing Test, Form A (Starr, 1961).

Conclusion

It is suggested, then, that the Design Board Program is a useful method for teaching some of those skills, though ordinarily assumed by a first grade curriculum, that may not yet be included in the child's repertoire of available responses. Additional studies are currently in progress and information will be reported as it becomes available.

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