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ABSTRACT

Elementary school (kindergarten through sixth grade) deaf children were exposed to varied thinking activities based on J. Piaget's principle of action rooted intelligence to determine if thinking might be successfully encouraged in the classroom through activities which were not highly dependent on verbal performance. Each class of approximately eight students was divided in half, with one half being placed in the experimental thinking lab and the other half in the control language lab. Each child attended one of the labs for one half hour once a school day. The experimental group was engaged in thinking games involving classification, perspective, symbol-picture logic, and probability. The control group was trained in areas such as vocabulary, sentence structure, and conversational skills. Results of testing were inconclusive since both groups improved on thinking skills and neither showed improvement on measured verbal tests. Reasons thought to account for the results were that the skills to be tested developed only gradually and cannot be readily assessed and that the training period was short (1 1/2 years). (Author/GW)

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Department of Health, Education, and Welfare

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Bureau of Education for the Handicapped

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The Laboratories were conducted at the West Virginia School for the Deaf at Romney, West Virginia.

TABLE OF CONTENTS

SUMMARY

A laboratory for thinking was instituted at the West Virginia School for the Deaf in which pupils were exposed to varied thinking activities based on Piaget's principle of action-rooted intelligence. The purpose of this project was to determine if thinking might be successfully encouraged in the classroom through activities which were not highly dependent on verbal performance. It was hypothesized that: 1) deaf children could function in a setting which encouraged the development of thinking, even without knowing verbal language well, 2) a regular thinking period would have a measurable effect on thinking development, and 3) these thinking activities would not hinder linguistic learning and if anything should help it. As a control, a special Language Lab was created in which control subjects received specific training in language. This was intended to place the burden of proof on the hypothesis.

The experimental group was engaged in thinking games such as classification, perspective, symbol-picture logic, and probability. The control group was trained in areas like vocabulary, sentence structure, and conversational skills The lab activities were begun in December, 1968, and continued until May, 1970. A lab session lasted 30 minutes and included 8 to 10 children at a time. Subjects' thinking performance was tested at the

following six month intervals: December, 1968; May, 1969; October, 1969; May, 1970; and January, 1971.

The regular thinking sessions functioned well and observations indicated beneficial effects on the deaf students. Results of testing were inconclusive since both labs improved on thinking skills and neither showed improvement on measured verbal tests. Reasons for these results are found (1) in the nature of the skills that develop only gradually and cannot readily be assessed, (2) in the shortness of the training period that included both hesitations and interruptions. An indirect outcome of the project was its contribution toward a more radical application of the thinking philosophy in the education of deaf children. This approach is continued in the special education program at the New York State University at Geneseo.

Part I: Brief Description of the Project

A. Introduction

Piaget's psychology of intelligence is unique in not ascribing to linguistic verbal skill a crucial status in general intellectual development. Rather, he considers language as an active formation of symbolic abilities which are primarily controlled by structures of thinking. His theory is particularly appropriate to linguistically-deficient deaf children. If language played the role it is supposed to play in many contemporary theories of intellectual development it would be difficult to explain the intellectual level which deaf children have been observed to reach.

Deaf pupils usually spend a large portion of their school hours in the study of language and training in speech and lipreading. However, this concentration in linguistics has usually failed to achieve the desired results. According to various surveys published in the literature not more than 10 to 20% of 16 year old deaf pupils read at above a fourth grade level. In addition, emphasis on linguistic training can lead to a neglect of activities which allow the children to engage in thinking exercises. As a result, the deaf child's intellectual capacity is often not adequately stimulated. It is understandable that intellectual curiosity among deaf pupils

is low, while frustration and feelings of failure run high.

The purpose of this project was to make a controlled investigation of the effects of exposing deaf children to regular classroom periods involving thinking activities. The objectives of this application of Piaget's framework to the linguistic difficulties of deaf children were threefold:

1. To promote directly the spontaneous development of intellectual growth by means of a regular classroom period emphasizing independent thinking;

2. To provide needed scholastic support for deaf children whose intellectual development is frequently insufficiently stimulated both outside of school and in school because of the necessity of spending most of their time in the rote exercise of acquiring linguistic and vocal skills;

3. To bring about indirectly an improved use of linguistic ability insofar as better thinking entails a better use of language.

B. Method

Subjects

The population of subjects was taken from the lower school (grades K-6) of the West Virginia School for the Deaf. Classes were grouped with more emphasis on ability and years in school than on age. Each class, composed of approximately 8 students, was divided in half--one half being placed in the experimental

Thinking Lab, the other in the control Language Lab. Each child attended one of the labs for one half hour once a school day. Each lab, containing a total of about 40 students was divided into six classes, which met at different times during the school day. The lab sessions lasted from December 1968 to May 1970.

A summary of biographical information for each of the labs and age groups is presented in Table 1. Although this table includes those 28 children only from each lab who were present over the two year span for repeated testing, the data are representative of the groups as a whole. Table 1 shows that the two labs were alike in the type of children they served. (See next page).

Thinking Lab

The activities of the Thinking Lab were in the form of thinking games. Children were exposed to the following tasks: sorting, card games, "Block-head" and "Boobytrap," hopscotch, recall, ordering objects, symbol-picture logic, and free play--working with beads, blocks and clay. Sorting involved placing objects varying in two dimensions (i.e., size and color) in two different circles. For example, one circle would be for red things; the other for square things; and the overlap area for red squares. For card games, the children

Table 1

Description of select subjects, divided into younger and older age groups,

of the Thinking Lab and the Language Lab

Lab	Age group	N	boys	girls	Age in months[1] mean	Age in months[1] range	Years in school[1] mean	Years in school[1] range	Profound deaf	Deaf birth	Deaf parents	Other defects	Parents skilled trade
Thinking Lab	Y	11	7	4	85.4	66-98	2.1	1-3	10	8	1	2	2
	O	17	8	9	121.1	108-138	3.9	1-5	14	14	1	7	2
Language Lab	Y	12	6	6	85.8	67-104	1.6	.5-3	11	10	0	2	2
	O	16	11	5	121.0	106-143	3.8	1-5	14	10	2	4	4

[1] At the beginning of the project, December, 1968.

learned to sort cards into suits, and played the well-known games of War and Concentration. "Blockhead" and "Boobytrap" are both commercially prepared games, the first of which was used for developing skill in balancing odd-shaped objects on top of each other, and the second for teach[illegible] children to predict where stress falls on objects in a box of round pieces, with a spring attached to one side. Hopscotch, played in the usual manner, was used to teach the children to master specific rules. For the game of recall, the children were asked to look at an arrangement of objects for a short period and then to recall what arrangement they had just seen. The task of ordering required the children to order from large to small and then from small to large various kinds of objects such as rods and rulers. Finally, through symbol-picture logic, the children learned the meaning of such logical statements as A $\longrightarrow$  , A $\not\longrightarrow$  (Apple--is not--a tree), and $\bar{A}$ $\longrightarrow$  (Not an apple--is--a tree).

Later, as the above mentioned tasks became easier for the child, more difficult tasks were added. For example, objects, varying in three dimensions, as well as a third hoop were added to the sorting tasks. Another variation allowed the children to sort pictures of objects according to where the objects themselves could be purchased. A task of spatial relations was added. Here, the children would view a triangle

from an overhead projector and then try to draw how it would look upside down, or backwards. As simple designs such as the circle were mastered, they were replaced by more difficult ones. Similar to spatial relations was a perspective task in which a three-dimensional object was placed on a table and pictures of the object, taken from various angles were placed at the front of the object. The children were asked to imagine how the object would look from different sides of the table and to pick the picture that represented the correct perspective.

Principles of simple probability were also explored by the children. Varying ratios of two different colors of marbles were placed in a can and a child was asked to predict which color he thought he would draw. The task of sequence of events was taught by using prepared pictures of stories, varying from 3 to 6 cards in length. Arithmetic progressions were explored by using letters, numbers, or beads. For example, the children were asked to complete the progression a b c a b _ _ _. Another activity was permutations, in which a child was to make as many pairs as he could from the letters x and o (xx, xo, ox, oo). Creative activities designed to get the child to think about objects both in many different ways and in unique ways (such as round things, lines, and triangles) were introduced. For example, the children were shown a squiggly line and then

asked to draw as many different and unusual things as they could using the stimulus line.

To enhance hand-eye coordinations, the game of feel and find was developed in which the child was to reach into a box full of objects and to find by sense of touch the mate to an object which the teacher had pointed out on a table. Role playing was also included in the lab's activity schedule. In this task, a child would act out a scene, with or without a costume, and the other children were to guess what scene was being acted out.

Language Lab

During the first year, the activities of the Language Lab centered around the functional use of language which the children already possessed. They were encouraged to describe everyday experiences, ask independent questions, think on their own, and learn to follow directions. Then, the children were given new vocabulary and sentence structure to express their ideas. They were required to write simple sentences and construct stories about pictures using the past tense. Proper grammar was emphasized.

Activities of the second year were a continuation of the previous year's activities. Building vocabulary was again stressed as were developing conversational skills and using new language construction. The children were required to read

a sentence, paragraph, or story and reproduce it in their own language; and they were encouraged to think through simple problems. In addition to receiving language training, they learned habits of courtesy and kindness as well as habits of learning and study.

C. A Report on the Thinking Laboratory for Deaf Children[1]

Piaget says that the child himself is the architect of his intellectual growth. Deaf children are poor architects. Lacking language, and lacking free social interchange, and lacking experiences understood or shared, the young deaf child cannot be a good architect. He has no building blocks.

Essentially the Thinking Lab at the West Virginia School for the Deaf was conceived to provide some of the building materials which the deaf child so badly needs.

Piaget maintains that all normal people go through four stages of intellectual development. In a baby, knowledge is the actions which are responses to objects encountered. As a child begins to reflect on his actions, he enters the second stage "preoperational representation," intuitive thought, largely based on perception. Here the action of the child is all important to him, but his knowledge is not systematized. He cannot order and relate his own actions. At the age of about seven he enters a third stage, that of "concrete operations." Here he begins to order his own actions, and to order and manipulate objects, and to understand relationships. His understanding is limited by the direct experience he has had. Truly abstract thinking, the ability to deal with the possible without reference to the actual, comes with the beginning of adolescence. The child enters the stage of "formal operations." and only then can he construct theories, and make logical deductions from them, without needing empirical evidence.

Piaget maintains that language does not structure logical operations, but it can direct attention to pertinent factors of a problem, and can control perceptual activities. Moreover, among hearing children, performance on Piaget

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[1] From a progress report presented by Sydney Wolff at the Convention of American Instructors of the Deaf, Berkeley, California, June, 1969.

type tasks has a high correlation with verbal ability. Very little testing in this area has been done among the deaf population, but it is questionable that average deaf high school graduates frequently exercise activities proper to the stage of formal operations, or theory construction.

The Department of Health, Education and Welfare gave a grant to Dr. Hans Furth in September of 1968, so that we could test the assumption that the modes of thought of deaf children could be improved, and that improvement in concept formation would result in improvement in testable areas, i.e., school achievement, including language.

In the summer of 1968, we paired each student in the primary school with a peer of approximately equal ability and age, labeling each pair 1 and 2. Students numbered 1 go to the control lab. The control lab provides intensive language training in an informal situation, attempting to motivate children through experience. The second group of children go to the experimental Thinking Lab. Both groups are divided into classes of eight children each, and each class has one half hour of work in the lab every day. Each lab has approximately forty-six students from the primary level.

The Thinking Lab is working only in the preoperational and concrete operational stages of development. In these areas the child's experiences are the raw materials which he will transform into concepts that are the foundation of all logical thought. In the lab, experiences can be arranged which should, first, make the deaf child aware that he is thinking; second, help the deaf child have a series of successful experiences, that stimulate his natural pleasure in thought; third, help him to form concepts, to organize his thought.

Because throughout the learning experience we want the deaf child to find the greatest pleasure possible in thought, we have made the Thinking Lab non-verbal. This insures that even those children with a poor aptitude for language can be completely successful.

All the materials in the lab are presented as games, and when it is possible the children work in teams. It is necessary to encourage what Piaget calls "social transmission," encounters with other people, particularly where those people may work toward the same end, but view the means of achieving it differently. Deafness promotes solitary action, and the lab tries to foster group action.

I will first describe an attitude of thought, and then describe a few of the games which we are using to promote that type of thinking.

Children have great difficulty grasping more attributes in the relationships of objects than they can see. They cannot draw a triangle upside down, if they are shown that triangle right side up. When children draw a chimney on a house, the chimney is often at right angles to the slope of the roof, gaily defying gravity. If what you see of an object differs from the child's viewpoint of the same object, the child cannot predict what you see, and usually is not aware that it is different.

Accordingly, we have worked out a group of perspective games, to give the children practice in changing viewpoints. This is practice in mental, rather than physical, manipulation.

The teacher draws an equilateral triangle, base down, on a sheet of acetate film. Using an overhead projector, she projects the triangle onto a white, washable chalk board. The children are given water color markers, and asked to draw the triangle upside down on the board. Then the children reverse the image on the projector, and check themselves. When they have successfully upended many images, we return to the triangle, adding eyes and a smile. The children invariably invert the triangle, but not the face inside it. In the same way, the group works on left to right reversal, the teacher being careful always to mix images so that some change when they face another direction, as an E, and some do not, as an O. The older classes (ages nine to eleven) have

become quite adroit at this, and with few exceptions can now mirror write easily.

The younger classes also enjoy playing "Do as I Do," in which the teacher stands in front of, but with her back to, the class, and raises her right arm, stands on her left leg, and so on. The class faithfully repeats her movements exactly. Then the teacher turns and faces the class, and raises her right arm. Instantly all the left arms go up. The teacher turns away again and the children compare their left arm to her right one. They change their minds and raise arms. The teacher turns once more, and now some children have right arms raised, and some have left ones up, and one child, way in the back, has them both up. He won't be caught again.

Another game; a toy car is placed in the middle of one of our big tables. We have previously taken polaroid photographs of it from four or five different angles around the table. The class stays on one side of the table, except for one child, who moves from viewpoint to viewpoint around the table. At each viewpoint, the class chooses a photograph which fits, not what they see, but what they believe the other child should see. A variation of this is to show the group viewpoint pictures of a small assortment of blocks or objects, and ask the class to build the grouping shown in the pictures.

Another area of concept building in which deaf children need practice is classifying and ordering. We use large hoops and pieces of cardboard in three colors, three shapes (triangle, square, and circle), and three sizes. Beginning with one hoop the children place all the round pieces inside, and all the others outside. After they can sort for color, size, or shape, we add another hoop, overlapping the first. Then we sort for red objects in one hoop, and squares in the second. The children learn to put red squares into the circle made by the overlapping hoops. When this is simple, we add a third hoop, and sort for size, shape, and color all at the same time. Since the overlapping of three hoops produces seven areas to sort into, this is a complex problem for even the

most sophisticated children.

We have also made a special deck of cards, which enables us to sort in the same way, but which adds a fourth attribute, number. Some of the cards have only one square, some have two, etc.

Regular playing cards can be used for sorting, and all our children enjoy Solitaire, Fan-Tan, and War, three simple card games in which sorting for one or more attribute is important.

Using the overhead projector, we play a game in which the teacher flashes a picture of four objects onto the screen for a very brief time. The screen is divided into quadrants, and one object appears in each quadrant, for example, three circles and one square. The children have to name the quadrant in which the wrong object, the object that is not part of the set, appears. Here, speed and close attention are combined with sorting skills.

Thinking requires the coordination of senses and brain, and we play a game called Feel and Find that gives the children practice in coordination. The teacher prepares identical pairs of objects, as two wrapped sugar cubes, two pearl buttons, two silver spoons, and two stainless steel spoons in a slightly different pattern, two marbles, two small plastic blocks, two safety pins, two paper clips. The list of things to be easily found is endless. Then one of each pair is put into a box and its mate is placed on the table in the classroom. Without looking, the child reaches into the box and finds an object whose mate has been shown to him on the table. He is not allowed to touch the item on the table; he cannot look into the box. This is great fun, and can be made quite difficult if objects of similar size and shape are previously chosen. We frequently play this as a team game, where one team chooses objects for the other team to find. Here, strategy plays a role in the outcome. Many children don't understand that some objects are more difficult to find than others, and will persistently choose a large plastic block, or a popsicle stick

for the other team to find.

Memory plays an important role in thought, and we have used a commercially prepared game, 'Recall,' to help train memory. In this game an arrangement of cards is shown to the children for fifteen seconds, and then the children have fifteen seconds in which to duplicate that arrangement from a similar set of cards.

We also play Concentration, using a regular deck of cards and playing it as it is seen on television, although we have omitted the rewards for success that television offers.

And, using the overhead projector, we sometimes flash very quickly, a three or four digit number on the screen, and ask the children to reproduce it on paper.

We have done some work in probability, where children are asked to predict an outcome. The children are shown two groups of marbles, ten red and ten yellow. Then leaving the red marbles on the table, the teacher places all the yellow marbles in a can. One child closes his eyes and picks a marble from the can. What color does the class think he will get? We were amazed to see even ten year olds predict red, although all the red marbles are in plain sight on the table. We then change the odds (always showing the children how many marbles are in the can) and draw from nine yellow and one red. After many tries on many different days, the children begin to see that what goes into the can determines what will come out. Even if their favorite color is red, if we are drawing from yellow marbles, we will get a yellow marble.

Now the children can start to make charts. They will draw twenty times from a can that holds two red marbles and one yellow one. They draw two red and one yellow marble at the top of a lined sheet of paper. After twenty draws from the can, there will be a red column twice as long as the yellow one, made

of red marks for red draws, and yellow marks for yellow ones. We use spinners, too, where one-third of the ground is yellow, and two-thirds of it red. These may be the favorite activities of all in the Thinking Lab. At every draw the children grip the table with all the intense emotion of heavy betters at the track.

One half hour of every week is set aside for Symbol-Picture Logic. The material which we use was prepared at Catholic University by Drs. James Youniss and Hans Furth, specifically for use with elementary school age deaf children. It is essentially a non-verbal series of exercises which, taken together, make up a particular system of thinking. I quote, "After working through the exercises the child will have been exposed to a systematic method of analyzing the world around him. He should have learned that a particular object or event ...bears multiple relations to other objects and events...(and) that any one thing can be classified accurately in a number of ways...The child (is confronted) with the notion that any object or event can be an occasion for asking a question, that some questions have reasonable answers, while others have few."

Limitations of time make it impossible for me to demonstrate Symbol-Picture Logic here. If I could show it now, you would see that the Symbol-Picture Logic has none of the forbidding aspects that its name suggests, but is, instead, one of the most popular games that the children play in the Thinking Lab. It offers them a real challenge, and they respond joyfully.

Those of you who are familiar with Piaget's work will have noticed that we have not spoken of conservation tasks. The ability to conserve means that the child grasps the mathematical idea that number is not changed when a set of objects is divided into subgroups, and the physical idea that a change in shape or appearance does not change mass or substance.

That is, in mathematics, twenty onions will remain twenty onions, whether they are one big sack or in five small bowls; in physics, that you have the same

amount of bubble gum whether you have just rolled it into a ball to tuck under your desk, or are pulling it, pink and shiny, into a long sticky string.

The attainment of the ability to conserve marks the transition from intuitive subjective thought, to thought that is more socialized and more conceptual, hence more adult.

Because of conservation's clear position in the beginning of the concrete operational stages of thought, this is a good area in which to test the changes in our children's thought. There we do no experimental work with it in the Thinking Lab.

In September, before we began the experimental program, graduate students from Catholic University came to the school, and administered a series of Piaget type tests to all the primary children. They were also given appropriate intelligence, reading, and achievement tests. Testing was done again in May and will be repeated next fall and the following spring. A careful comparison of the test results for the control and experimental groups should provide much information about deaf thinking, and, hopefully, a new method of teaching.

Our testing is not finished. We have only worked at this for a year, and we need much more data to reach even tentative conclusions.

Again: the lab provides young deaf children with an opportunity for intellectual growth in an area in which they are not handicapped, their thoughts; it is our sincerest hope that we can prevent their thinking from becoming stunted and shallow.

D. Conclusions and Recommendations

The project's primary objectives were reached in that it was demonstrated that young deaf children can be exposed to a great variety of thinking activities as part of an ordinary class period. These activities were carried out chiefly by means of actions, imitations, natural pantomine, some gestures, fingerspelling and verbal speech. However, no child because of lack of verbal skill was excluded or handicapped in being active during this period.

At the beginning the children were confused and uncertain how to behave insofar as the rest of the school day was differently structured and almost totally geared toward linguistic performance. In the Thinking Lab something else was encouraged, namely, the child's own thinking activity. After a few weeks the children got used to this period and appeared to comprehend its functioning. They were then very eager to come to this lab and for the rest of the one-and-a-half year's period no behavioral problems were encountered.

The teacher employed one single criterion for the choice of activities: "Were they challenging to the child's spontaneously developing intelligence?" To use this criterion something must be known about the child's development and in this respect a theory like Piaget's was absolutely essential.

The role of the project director was to consult and suggest activities; the teacher was encouraged to choose activities that she condidered conducive to the stated purpose. Concretely, such a choice was not overly difficult; it is certainly not necessary that each teacher must have a profound understanding of Piaget's theory. It suffices for the teacher to grasp the difference between teaching a certain performance level (in the case of deaf children usually some linguistic skill) and exposing the child to a situation that elicits the child's spontaneous and intelligent interest. The lab's function was therefore not to teach anything (in the traditional sense of teaching something) but to provide opportunities for constructive self-initiated activity.

The children were playing thinking games rather than directly learning a subject matter. By playing these games the children were not idly amusing themselves since they learned many of the things described in detail in this report. They learned them not as something that the teacher gave them to remember but as something they themselves discovered and were active in.

If one asks what precisely did they learn, the answer would be they learned to behave as thinking human beings. They learned to observe and work together in different situations that required thinking skills. They learned to be active

themselves and not to look constantly to the teacher for the answer to every problem.

Whereas these things could be observed to the extent that visitors and other teachers were impressed, it was not possible to demonstrate the third objective, the beneficial impact of this thinking period on the children's scholastic achievement by usual testing procedures. A control group attended a special Language Lab. The two labs were designed so that differences, if any, due to the nature of the lab could be demonstrated. The testing procedures and results are described in detail in Part III. However, the results can be summarized as follows: On thinking tests, both the Thinking and Language Labs improved over age; on language tests, neither group improved with age; overall, there were no substantial differences between the two labs.

To interpret these results several factors should be kept in mind. First, the total period of the labs was only one-and-a-half years, not more than half an hour a school day and on many days, for various reasons, the lab did not meet. It took some weeks at the beginning to get the children and the teacher habituated to the novelty of the situation. Second, it should be realized that there are many things that cannot adequately be measured. A recent study by M. Almy, "Logical thinking in second grade" (Teachers College, 1970) is only one of many which failed to show any measurable results after a year's

training program in mathematical thinking. Third, the control group, although it was language directed, shared some of the thinking atmosphere of the Thinking Lab since the special teacher of the Language Lab could not help but communicate with the special teacher of the Thinking Lab.

At worst, the measured results indicate that the deaf children of the Thinking Lab developed thinking skills they would have developed without the lab; however, the measured results of the Language Lab and the regular school curriculum were even less favorable with no apparent progress on language for either lab. In any case, children in the Thinking Lab were never found to lag behind others in linguistic skill: our results at least demonstrate that there was no linguistic loss due to spending one period on other than linguistic activities. It is likely that one half-hour period embedded in the rest of the traditional school day is insufficient to show large measurable differences.

The main implication and recommendation coming from this project would therefore be a plea for an overall thinking atmosphere for the deaf school child where language is resolutely subordinated to the development of thinking. This project illustrates that teachers need not wait for extensive verbal knowledge in their children before engaging them in thinking activities. Deaf children grow in intelligence progressively and

acquire thinking skills even with very little linguistic knowledge and improvement. Perhaps an overall atmosphere of thinking as the primary goal of school activities could be shown to be more conducive to the ultimate goal of teaching speech and language than the traditional emphasis on some limited language goal alone.

As an indirect result of this project the principal investigator has applied the notion of a primary school for thinking to elementary schools in general and described in the book "Piaget for Teachers," Prentice-Hall (1970), some of the activities at the West Virginia School for the Deaf. Furthermore he has enlarged on the theory underlying an education for thinking in the forthcoming book: "Deafness and learning: A social-developmental psychology (Wadsworth, 1973). The final chapter contains a brief description of this project as an example of a thinking atmosphere.

A second positive and even more important indirect outcome of this project is the fact that the supervising teacher of the project Mr. S. Wolff in 1970 left West Virginia to take charge of training teachers for deaf children at Geneseo State University of New York. In this capacity he has already organized several workshops and seminars on thinking activities in deaf children, and there is now a broad interest at several schools in New York and elsewhere to introduce this new philosophy of education into the early curriculum for teaching deaf children.

Part II: Detailed Description of Thinking Activities[2]

1. Games of Classifying

The Thinking Lab was begun with the activities of sorting, ordering, and classifying. Because these are overlapping activities, involving basically the same thinking process, the children were able to move easily from one area to another.

The materials used were all very simple and most could be made quickly and easily. In addition, the forms could easily be varied so that a child could work on these areas for a long time without tiring of the materials. One of the most important and the only expensive set of materials (costing approximately $25) was a set of sixty plastic blocks made in England by Invicta. The blocks vary in four atrributes: size, shape, color, and thickness. They are made of a smooth, dense plastic, in clear red, yellow, and blue. They come in five shapes: circles, squares, rectangles, triangles, and hexagons; and in two sizes and two thicknesses. The children were very fond of them and used them not only in sorting but also as building blocks.

Another but more inexpensive set of materials was a collection of picture cards, some of which were made in the classroom

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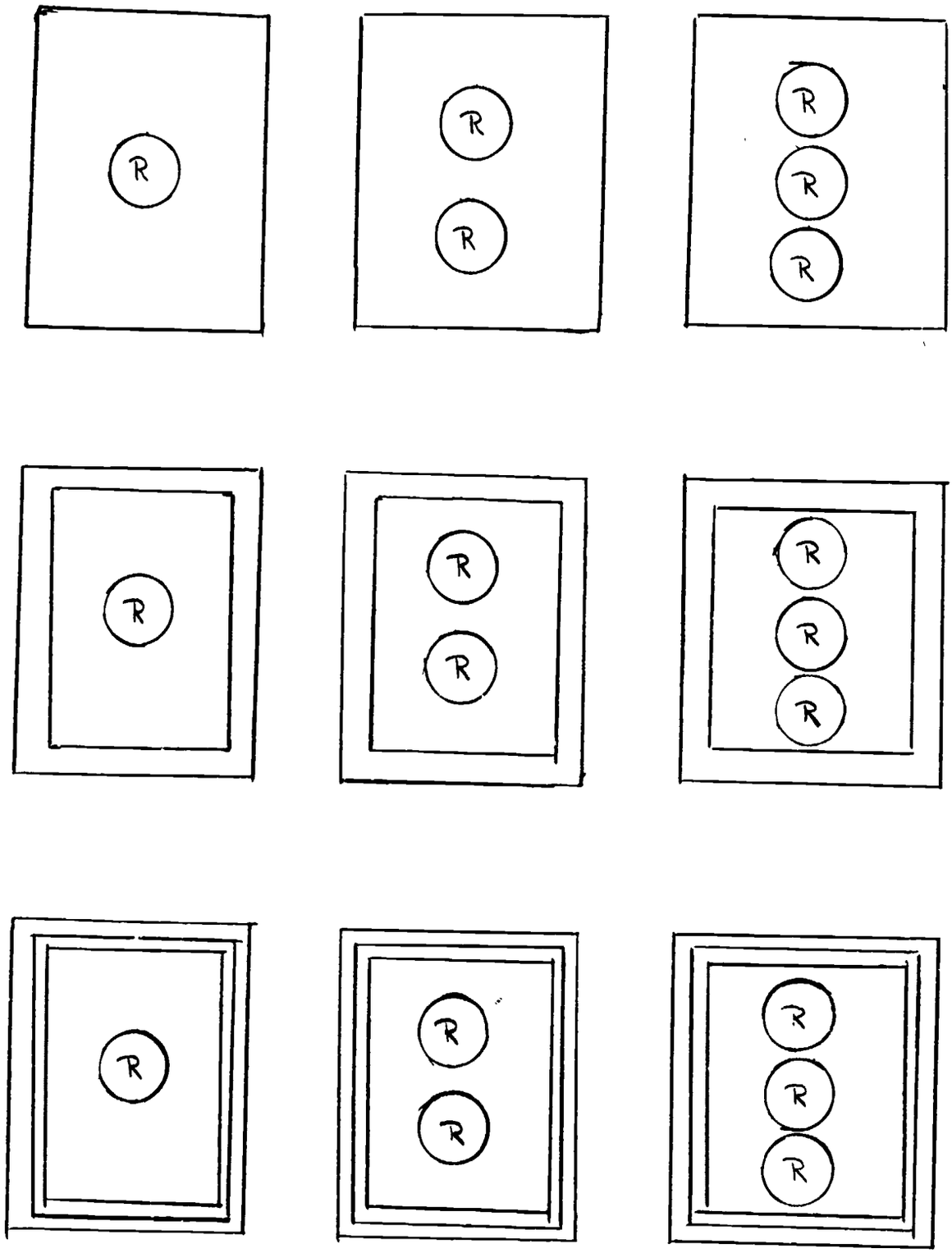
[2]By Caryl Wolff, special teacher of the Thinking Lab. Additional games, particularly the Symbol-Picture Logic Game are described in Part II of "Piaget for Teachers" (Prentice-Hall, 1970) by H. G. Furth.

and others which were gathered from old word lotto sets and miscellaneous picture materials. There were pictures of pets, domestic animals, wild animals, toys, tools, food, furniture, clothing, cars, boats, trains, and photographs of the children and the teachers in the school. Most of the pictures were relatively small and were laminated to file cards.

Another set of materials was a deck of cards varying in four attributes: shape, color, number, and border. Triangles, squares, crosses, and circles were cut from red, green, and black construction paper, and were laminated onto file cards, some of which had borders drawn on them. If one considers the circle cards to be a suit, the red circle cards would look like Figure 1 (see following page). The suit would also include green and black circle cards. The other suits, triangles, squares, and crosses, would be similarly constructed, so that the entire deck would number one hundred and eight cards.

A similar deck was made of families, of two colors, in fat and skinny shapes, such that the entire deck would vary in four attributes: sex, shape, age, and color. A skinny red family can be seen in Figure 2 (see page 27). This deck would be composed of only sixteen cards, two red families, and two green ones.

Other materials included a deck of regular cards, a set of



R = red

Figure 1

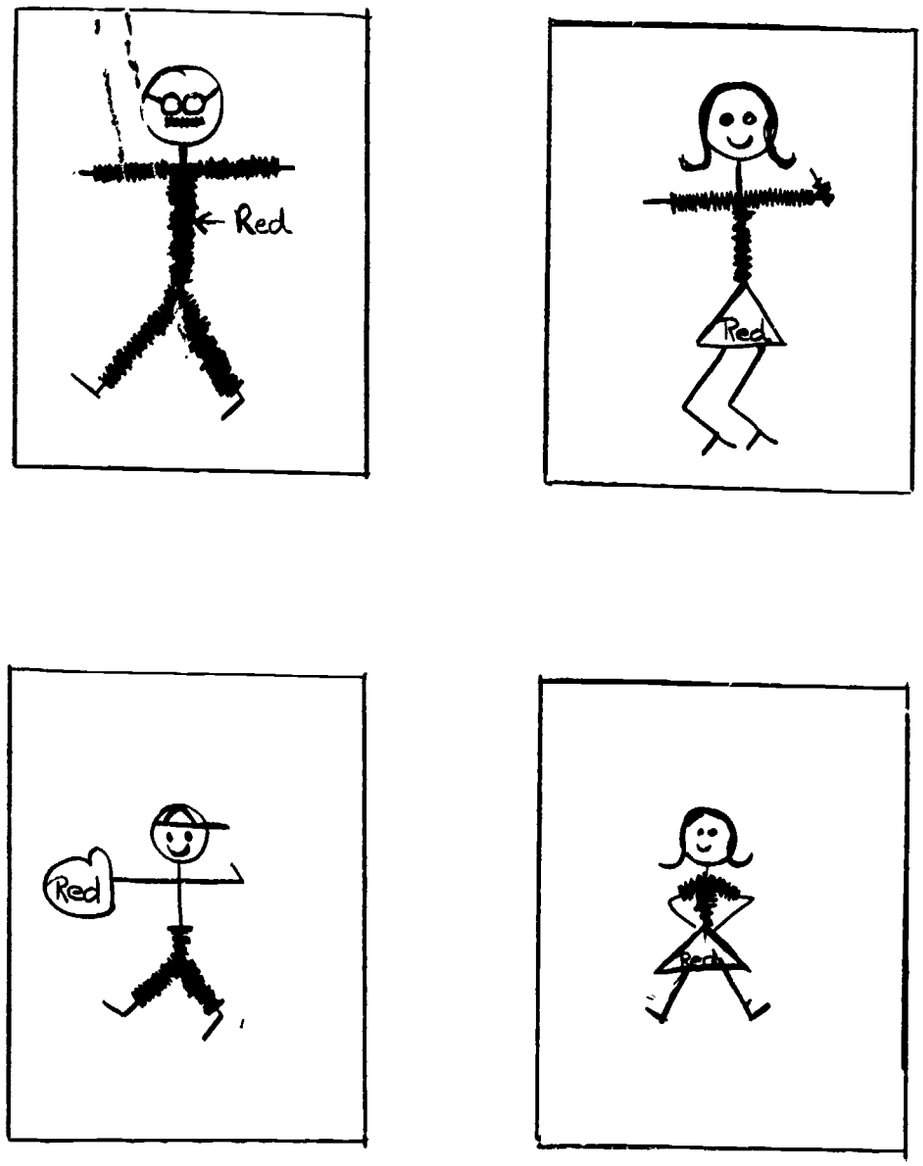


Figure 2

cubes, varying in six colors, and a box of large wooden beads, in six colors and three shapes.

Circle Sorting

Circle sorting began with the plastic blocks scattered over the table. While the children were examining the blocks, the teacher cleared a space in the center of the table and drew a large circle on it. During one typical session the teacher placed a large red triangle inside the circle followed by a small red rectangle and a large red square. At this point one of the boys added a large red circle. Since only red objects had been placed into the circle, his choice was correct, and the teacher praised him. One of the girls also correctly added a small red circle. However, when another pupil put in a large yellow circle, the teacher responded by appearing surprised. Another child removed the yellow circle, indicating to the pupil that he was to try again. He hesitated, looked at a blue circle and then placed a small red triangle inside the circle. As the activity progressed, the circle filled until all the red blocks were inside. Once the circle was filled with all of the objects of the correct sort, the teacher congratulated everyone and cleared the circle.

In a typical class for pre-schoolers, or beginners, the teacher might have initiated sorting for blue things at this point. In a class of second graders, however, she would have then

sorted for a completely different attribute such as shape. For example, she once began the game by placing a blue square into the circle. One of the pupils immediately threw a blue triangle in. The teacher signed, "Wrong," laughed and took the triangle out. He then instantly put in a small blue square. The teacher signed "Yes, good." One of the girls looked for another blue square. When she added the two she had found, all the blue squares had then been used. Another little girl found a blue rectangle and added that. When the teacher signed, "Wrong," she began to sign "Finish," meaning that the game was over since all the blue squares had already been put into the circle. The other children agreed that the game was over, but the teacher found a small red square and put that into the circle, signing, "Right." She then handed one of the boys a large blue triangle, which he put down <u>outside</u> the circle. Again, the teacher indicated that this was correct. This is an important example of how the children were shown that the circle divides the table into two areas, an inside and an outside, the inside being designated for the things the children are looking for, the outside for all the rest.

At this point, one of the girls picked up a yellow triangle and put it down outside the circle. Since this was correct, the teacher handed her a yellow square, but that too went outside the circle. The teacher indicated, "Wrong," and the little girl

quickly slid it over the line into the circle. Notice here that the function of the teacher was to present, not to explain. The child's job was to discover why, and if the teacher had said: "I am placing only square blocks in the circle," she would have been defeating the purpose of the activity and insuring the failure of children with language difficulties. These children were perfectly capable of discovering the concepts which operate in sorting. Many of them would fail, however, if they were told to follow a rule, either because the language was too difficult for them, or because they believed it to be too difficult. Many of the children had a long standing sense of failure, which began to operate as soon as an activity was translated into language. The motivation for all the activities in this report came from the natural pleasure the child felt when he succeeded. The children were doing what was natural for them. They were not working to please the teacher, and it was the teacher's responsibility to see that the game was neither played to satisfy her, nor to produce a language rule. The process of thinking was the important thing to be encouraged, but right answers were incidental to this process.

Multi-dimensional Sorting

Once the children were able to sort for one attribute and to play the role of teacher in the sorting games by posing the

questions to one another, multi-dimensional sorting was introduced. When another circle was added to the table, it looked like Figure 3 (see following page) and the children could sort for two attributes at the same time. As an example, squares could be sorted into one circle, red objects into the other. Red squares could then go into the area where the squares overlap. For multi-dimensional sorting, the teacher used exactly the same method as before. In addition, when the children could both answer and ask the questions for all combinations of two of the four attributes, the teacher made the task harder by adding a third circle.

In sorting with two circles, the children were working with four areas, three formed by the two circles, and the outside. However, three circles created eight areas to consider, as shown in Figure 4 (see following page). The addition of a third circle was not as difficult for the children as the previous stage. Deaf children are very much conditioned to the idea that each question has only one right answer, so the intersection of the circles in step two is the heart of the sorting and classifying problem. When the children were able to see the intersection as the joining of two separate questions, additional circles added only quantity.

After working with the three circle problem for two or three sessions, the older children were able to predict which

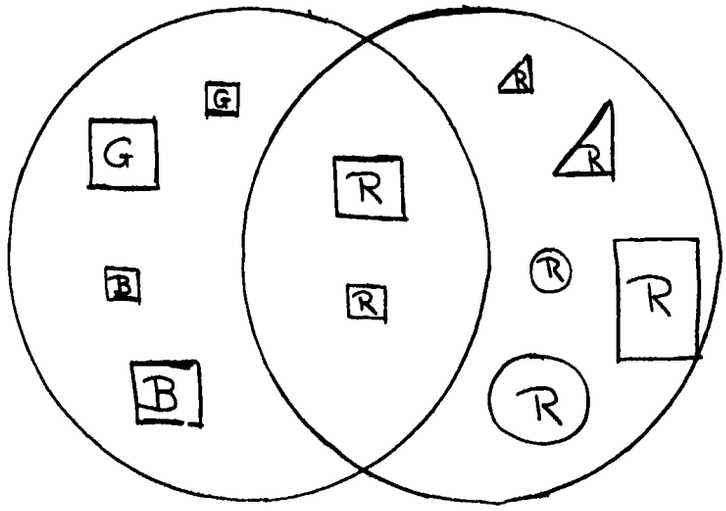
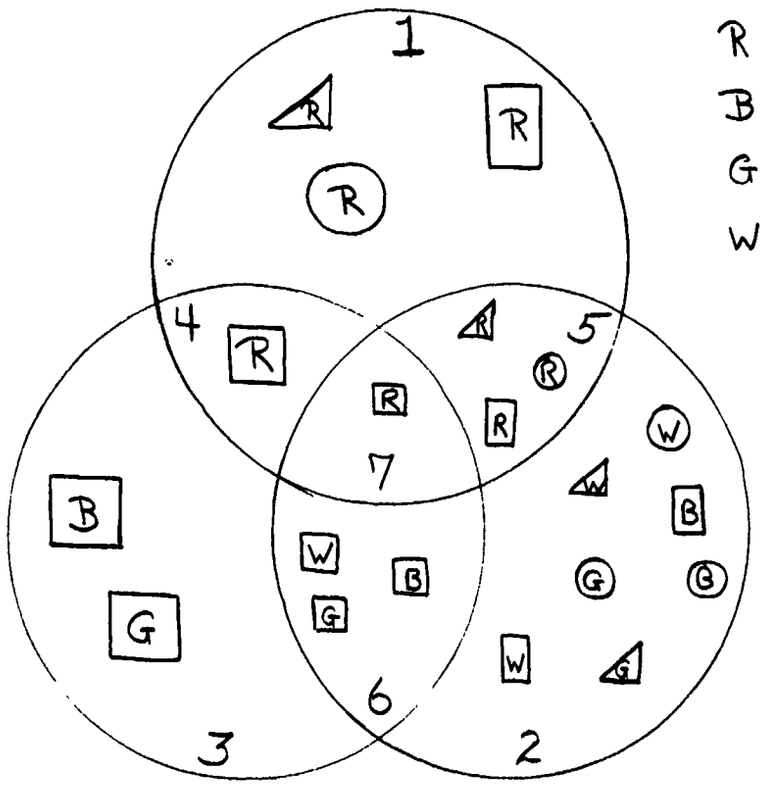


Figure 3



R = red
B = blue
G = green
W = white

Circle 1 holds red things; 2 small things; and 3 square things
Area 4 holds red squares; 5 small red things; 6 small squares;
and 7 the small red square.

Figure 4

piece would go into the center section (area seven in Figure 4). The twelve year olds in West Virginia frequently established the attributes for areas one, two, and three, filled in area seven, and then backed up to fill in areas four, five, and six. It seemed to be more difficult for the children to determine what attributes these middle areas were to contain. And while it made the problem more difficult, even for the teacher, who had to remember which circles required which attributes, she continually varied the attributes that fell into a specific circle. That is, if one area held a color the first time around, she would designate it for holding shape, size, or thickness the second time. Although this was a little more confusing for the teacher, it helped to prevent rigid thinking on the part of the children.

Multi-dimensional sorting took place over a period of time. The teacher tried never to allow the children to become bored, or to work until they were tired or confused. At the first sign of lapsing interest, she put the equipment away, knowing that the children would want to play with it another time.

Any of the materials described at the beginning which vary in two or more attributes can be used for the circle sorting activities. The beads, which vary in color and shape, can be sorted into a two circle arrangement. Cards and families vary in four attributes. They can be sorted into three circle arrangements

and later into four circles.

Store Front Sorting

The smaller children liked a game called store front sorting. Small picture cards chosen at random by the children were placed into the proper categories or "stores." Cardboard folders representing a pet store, supermarket, clothing store, and toy store, were set up on the table. If a child had chosen a picture of a kite, he would place it inside the toy store; a picture card of a bottle of milk would go into the supermarket, and so on. Limiting the game to these four commercial categories was a good way to begin this type of sorting with very small children. However, there is no reason to limit the children as they gain experience. Categories of a similar kind, such as a hardware store or garage, could be added, or the basis for selection could be changed altogether.

Categories which required the children to look at things differently were particularly interesting and challenging. Hard and soft, edible and non-edible, living and non-living, are all categories which are good examples of different ways to sort objects. When the children had understood a simple form of sorting, there was no limit to the questions that could be set up. Real objects, things brought from home, or discovered in the classroom, or on the playground, were fun for the children to work with. For instance, a treasure hunt could easily be created

around living and non-living things.

The children were allowed as much mobility as possible. The class was fortunate in that it had its own outside door and the children could go in and out hunting on their own initiative. Once, there was a very intense argument in an older class about a see-saw board which was brought in as an example of non-living material. The class resolved it by changing the categories living and non-living to growing and not growing.

Fantan

Fantan is a game which uses sorting and ordering and introduces strategy. Two decks of regular playing cards were completely dealt out to all players; eight children participated. Each player also got fifteen markers, such as poker chips, buttons, beads or marbles. The player on the dealer's left would play a seven of any suit or pass if he had no seven. Once the first seven had been played and placed face up on the table, all players had to then play or pay. The next player could play another seven, starting another suit, or he could build on the original seven by playing a six or an eight of the same suit, or he could pay by throwing one of his markers into the center. The game continued in this way with each suit being built upward to a king or downward to the ace. The winner of the game would be the one to play all his cards first. The winner would receive all the markers in the center of the table and one marker from each of the other

players for each of the cards he still held in his hand.

When the children first began to play Fantan, their attention was directed entirely toward proper sorting and recognizing that there were many spaces to be filled on the table. And as they learned to see several opportunities for play at one time, they slowly became aware of the strategy of the game. The game properly changed from one of primarily sorting and ordering to one requiring forethought and planning, a different way of thinking altogether. The children never tired of Fantan and perhaps one reason for its appeal was that it required a regular bridge deck which they felt was adult material. All the children preferred them to special crazy eights or old maid decks. They seemed never to lose interest in card games, unless they were clearly too young to play. However, even the four and five year olds enjoyed playing War (where red "captures" black) and sorting into suits and sequences.

2. Discovering Patterns

Stringing beads

All the young children loved to string beads and often brought them out and started to string at random, generally making necklaces. The teacher would join them, start a simple pattern like red, blue, red, blue, and then ask a child to finish it for her. The youngest children after two or three days of practice could construct simple patterns of their own.

The older children, while outwardly protesting that bead stringing was a baby activity, apparently enjoyed it, especially when they were strung backwards, as in the following example: First, the teacher would place a sequence backwards on the board like:

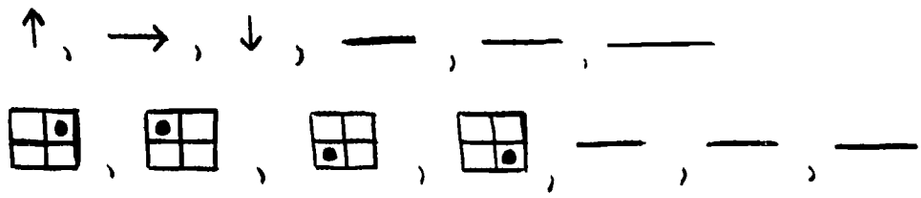
10, 9, 8, 7, __, __, __, or

Z, X, V, T, __, __, __.

Then the class would decide if it was possible to make a string of beads from the sequence and continue it where there were blank spaces on the board.

As the children became more sophisticated the questions became more difficult. Children who were frightened by either the numbers or letters were given questions which employed

other symbols like the following:



The older children delighted in constructing fiendishly difficult questions for each other and sometimes were so overconfident that they created unanswerable ones. A child does not understand a concept he is handling, however, until he can construct it himself or pose it as a question and in the classroom they were given many opportunities to do so. In fact, if the children did not produce wrong questions themselves, the teacher would make up some herself so that the children could discover the faulty reasoning.

In addition to the beads, the special deck of cards described in the section on sorting and ordering, was used for these activities. Using, for example, only the red circle suit, a sequence could be created which looks like Figure 5 (see following page). The children would have to fill in the answers in two direction and would quickly see the relationships established, even diagonally. They were encouraged to make pictures which could be arranged the same way, such as pictures of sailboats in three sizes, one, two, and three to a card. Figure 6 (see following page) shows one possible arrangement using the sailboat pictures and Figure 7 (see following page) shows a backward sequence. As

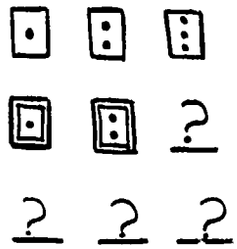


Figure 5

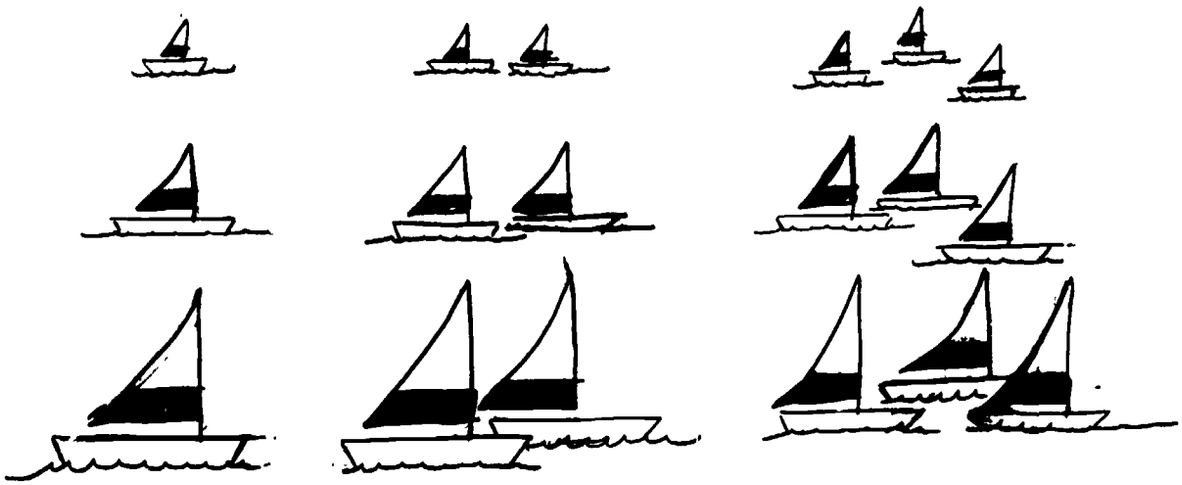


Figure 6

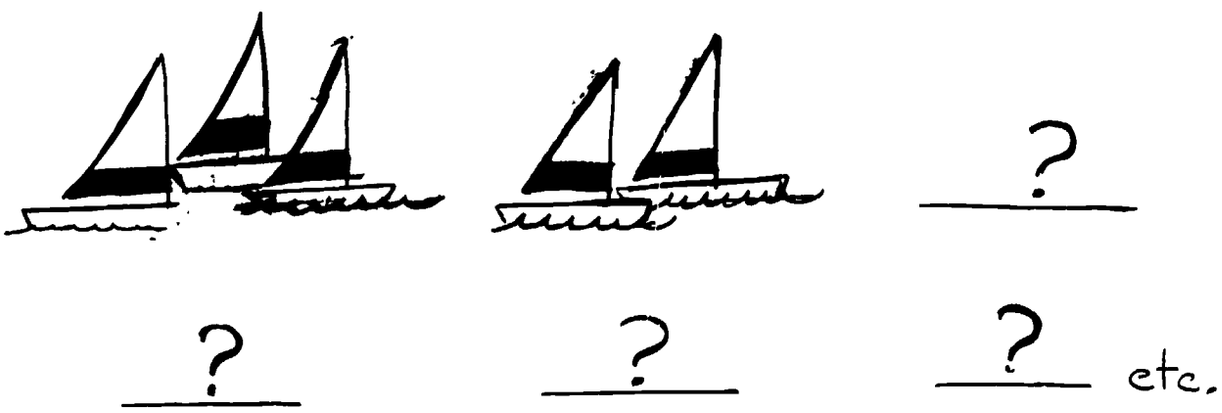


Figure 7

with sorting, there were many possible arrangements that the children would complete (see Figures 8 and 9 on the following page).

Permutation

Permutation is the game of making all possible sequential arrangements of two or more elements given an unrestricted supply of these elements. The equipment used was very simple; a large supply of marbles in solid colors, poker chips, paper, pencils, crayons, colored chalk, and an overhead projector.

The activity began with a demonstration on the overhead projector. The teacher drew a yellow circle, red circle, and a grid of two columns, and five or six cross lines. This was projected onto the board, and the children drew directly onto the board. The teacher put a red circle in the first column and leaving the second column blank (as in step 1 of Figure 10 seen on following page), signed to the children "What?" The most eager child was motioned to the board to fill in the blank. The board tray always held a large assortment of colored chalk and washable markers, so that the child chose the color himself. If the child drew a shape which was not a circle onto the grid, the teacher indicated the two circles she had drawn and asked "Which?" Either the red or the yellow circle would have been equally correct in the beginning. The first child filled in the grid such that it looked like step 2 of Figure 10. Then another child went to the board to fill in the

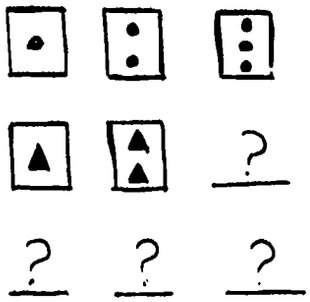


Figure 8

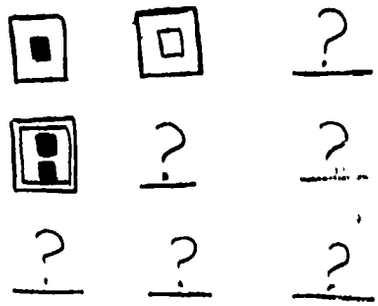


Figure 9

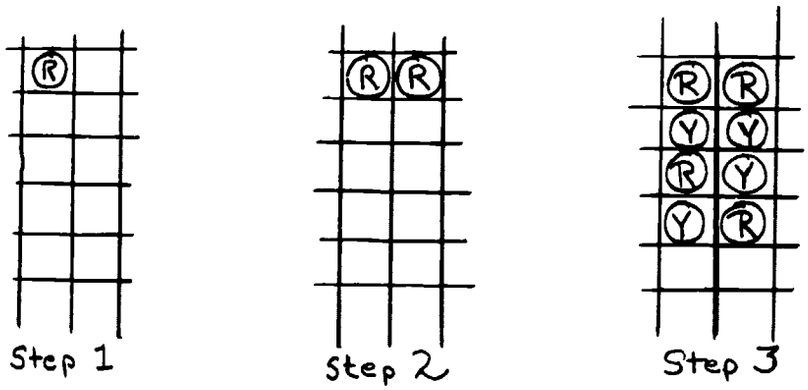


Figure 10

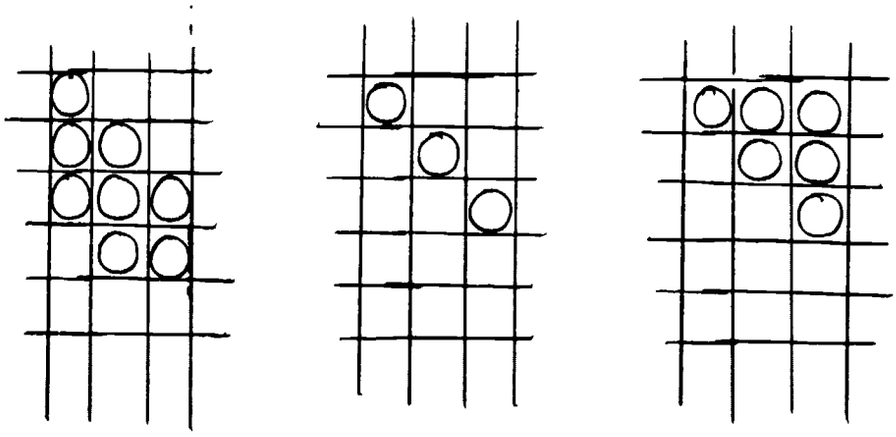


Figure 11

board to fill in the next two lines. The teacher signed, "Make it different," but the boy very carefully and very slowly drew two red circles. The other children looked at him and at the teacher, who signed, "Wrong. Its's the same." She pointed to the circles on the first line and then to the child's circles, and handed him an eraser. He rubbed them both out and stood looking at the teacher. "Again," she signed, "Different." He turned to the class and again to the board. The children were waving their arms and hppping up and down. They all wanted to try now. Slowly the boy drew two yellow circles. The teacher signed, "Right." The class congratulated him and a little girl ran up to the board to draw one red and one yellow circle. Then another girl drew one yellow and one red circle, making the grid look like step 3 of Figure 10. One of the boys then tried two yellow circles, but the class signed, "Finished." He erased the first and substituted a red circle, looked at the grid, signed "Finished," and erased them both. He drew a yellow and had started on a red, when he realized it would be identical to the line above. He turned to the teacher for help, saw that she was smiling, and happily signed "All finished."

Later, the children each tried the same thing on a sheet of paper, drawing two shapes or two colors or whatever they chose. If they had difficulty or were very young, poker chips or other objects that could be manipulated were used. When the

children understood the problem, the class worked with the grid using two colors in three columns.

When the children first started this activity, the answers came mostly by chance, resulting from random trials. The object of the game, however, is to allow the child to discover a logical method of finding all the possible combinations and realize the advantage of establishing a system. When a child manipulates two elements in three columns it is easy to see whether the answers are related or are random trials. There are many ways in which a logical method may be established: for instance, all the examples in Figure 11 have used some sort of logical method.

In one class of eleven and twelve year olds it was particularly clear that about half the class was working systematically and half was working at random. The teacher was sure that the children who were working by trial and error would quickly see the benefits of the systematic approach. Drawing an enormous grid on the board and working with just the children having difficulty in finding all the answers, the teacher filled in the grid. The class filled it in three times, using three different systems. However, when asked to fill in a grid individually, they all worked by trial and error, even though they had seemed to understand using a logical system when they worked together with the teacher. It was impossible to implant the need for

a system into their thinking, even though this need was completely obvious to the teacher. Later, several of these children began spontaneously to construct logical methods of solving this problem.

3. Probability Games

Probability games are based on the ability to correctly judge mathematical odds. These classroom games differ from the more expensive varieties of the sport, such as playing the slot machines, in that all the necessary information is available to correctly calculate the odds. Materials used for these games included marbles with tea tins, and a spinner made from a plastic lazy susan. Also, instead of money colored blocks and rods were used.

The children began probability with twenty marbles ten black and ten white which were carefully counted by the class. The procedure for the game was as follows: first, the white marbles were put in the tea tin lid and placed on a table in full view. The black marbles were put into the tea tin. The teacher then shook the can and took out a marble, but kept it in her hand, hidden from the class. The children were then asked what color the marble was. Since this was the first time the game was used, half of the children were convinced that the marble was white, even though they could see the lid containing all the white marbles. The children were shown how to draw a

circle on the first line of a sheet of paper, and how to color it in for a black marble, or leave it empty for a white one. They were to draw the color of the marble they expected to see when the teacher opened her hand. It was a black marble... and the children who had the correct answer were delighted. The marble was then put back into the can and the children were again required to draw on their paper the color marble that would be drawn from the can. After everyone was finished drawing his choice, the teacher chose one child, told him to cover his eyes, and to pick a marble out of the can. The child pulled out a black marble, and again half of the children were amazed.

Eventually, all the children saw that when you choose from only black, a black marble is the only possible answer. This was not explained to the children, the arrangement of the black and white marbles was pointed out, but the students were allowed to discover the principle on their own.

After the children understood this elementary principle of probability, the teacher then began to change the odds in the can. First, nine white marbles and one black one were placed on a table. Some children did not seem to see the relationship between what was on the table and what was later placed in the can. These children tended to alternate their answers, black, white, black, etc. The only right answer is the color which the odds favor, and the only time alternating has any meaning

is when the odds are fifty-fifty. The function of the game is to promote the understanding of how the right answers are formed, so the teacher never corrected or explained...the lesson should be one of discovery for the children.

The children at West Virginia were not satisfied only to play in this way because they wanted to see who was winning. So each child was given a file card colored half black and half white and fifteen little colored wooden sticks. If the child thought that the next marble to be chosen would be black, he put a stick (his bet) on the black half of his card; if he expected a white, on the white half of the card. One child drew, and another child, the banker, collected the losing bets and gave each winner another stick.

When this game was used the odds were varied frequently and the winning colors were alternated to keep the children from always betting on their favorite color or from betting on the color that was last drawn. By changing the odds frequently the teacher could observe when a child made a choice through an ability to function with the concept or when correct answers were achieved merely by chance. For that same reason odds of fifty-fifty should not be offered frequently.

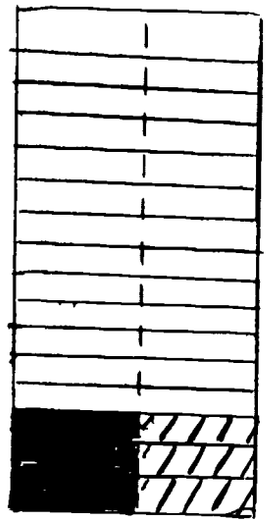
Some children who could use the probability concept effectively were interested in extending their skills to charting their results. For this each student was given a piece of lined

paper, folded down the middle, the long way. White marbles were marked on one side, black on the other. Then ten marbles were placed in the can in any proportion. The teacher next instructed the children to color in one line in the appropriate column each time a marble was drawn from the tin. They were also told to replace the marble in the tin after the drawing. The finished graph would resemble Figure 12 (see following page) for odds of one to one. For odds of five to one it would be like Figure 13 (see following page). By using this method, the children could count the number of black and white spaces filled in which would be directly related to the odds for that time.

When an enormous supply of marbles was used a jar was filled with two colors of marbles in a certain proportion, e.g., two red to one yellow. If they had been mixed thoroughly each time a child drew three marbles he should have pulled out two red ones and one yellow.

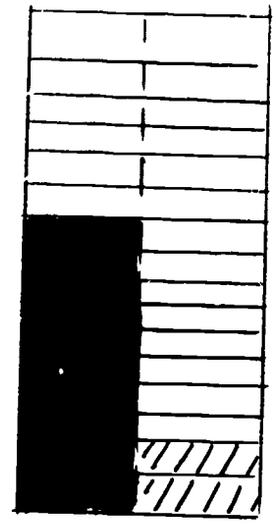
The spinner was also used for probability by placing pie-shaped pieces of colored paper on a circle and sticking that on the spinner. An arrow was drawn on the table and the children twirled the spinner and predicted the outcome in the same way as with the marbles (see Figure 14).

The spinner was also used in combination with the marbles. For example, good odds could be offered on the marbles and very poor odds on the spinner (e.g., marbles: 10-1, spinner: 6-5).



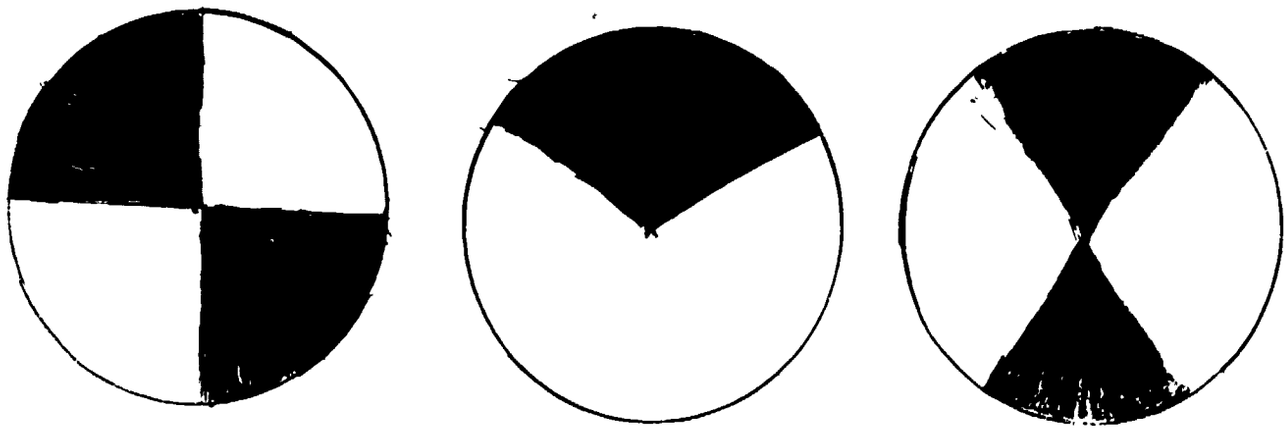
one-to-one

Figure 12



five-to-one

Figure 13



one to one

two to one

two to one

Figure 14

The children were allowed to choose either the marbles or the spinner on each play. This was another good method for the teacher to observe a child's grasp of the concepts involved in probability. Those children who consistently chose the one with the best odds were illustrating their skill with the concept. The odds were varied frequently so as not to favor the spinner or the marbles. This activity as well as all the others were regarded as discovery lessons for the students, not as tests or as situations where a teacher instructs a student on the rules involved.

4. Perspective Games

Basically, Perspective games involve three different tasks. Materials for figure reversal include: An overhead projector, transparencies, and a white board on which washable felt tipped markers could be used. Paper folding materials were: Paper, scissors, and rulers. For three dimensional perspective, colored blocks, various objects, and a Polaroid camera were utilized. Also ideas were taken from the Fitzhugh plus Program, Spatial Organization Series, Workbook Three.

The younger children began their training with "body perspective." The activity was conducted as follows: the teacher stood in front of the class and raised her right hand. The students were instructed to perform the same action. However,

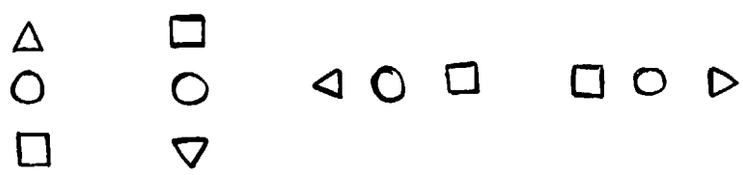
young children would most probably raise the left hand as it is on the same side as the teacher's They must learn to reverse their perspective when transferring action from the teacher to themselves. This activity can aid children in distinguishing left from right. The problems which arise with this task appear in all perspective tasks. The child must learn to move himself in space mentally, and this requires a concept of coordination in space and the opportunity to practice and develop this coordination.

Another perspective game was done with the colored blocks. The teacher built a small construction of four blocks in front of herself and then asked the children to build similar ones in front of themselves. The West Virginia children had little difficulty in picking out the correct colors, but when they arranged the blocks, they faced the same direction as the teacher's blocks. The children could copy the block arrangement, but not from the perspective of the original builder (teacher). To help the children grasp the concept, the teacher had one child come around and look at her arrangement from the teacher's point of view and then compare it to the arrangement of her own blocks. However, the student had difficulty in changing the arrangement to correspond to the teacher's. An easier task for the children would be to look at one arrangement from one point of view and then make the same arrangement from that perspective. However

this is a memory problem and not one of perspective. A follow-up to this activity is found in the subsequent activities.

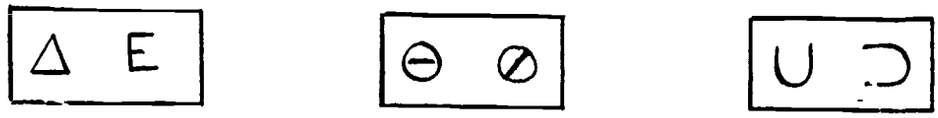
Important in learning about perspective was developing a skill in figure reversal. First, the teacher drew a triangle on a transparency and placed it on the overhead projector. The child was required to draw the triangle upside down. Then to check the answer, the film could be turned upside down. After the children could perform that simple task a square and circle were tried...where no reversal was necessary. Sometimes eyes and a mouth were drawn in the triangle and the result both rightside up and upside down is shown as follows.

Geometric figures, letters, and numerals were used, as were series of shapes as seen below. They were turned upside down and also to the left and right:



Another variation for this task is to spread the figures out on the transparency. This separation seemed to make the task more difficult so that a child who could turn over all the figures individually needed practice to turn them over together. Figures that showed both a change of direction and position when

reversed were particularly difficult for these children as in the following examples:



After spending quite a bit of time on the reversals of figures and single letters, words were added. Mirror writing was an interesting activity for the children..they enjoyed writing their names and then going to a mirror to check their accuracy. To add to the children's interest in the task, they were allowed to think up their own problems and try them out on the class and the teacher.

For the paper folding activity each child was given a nine inch square of paper, a pencil, and a ruler. The teacher had an identical square of paper, and while the children watched, it was folded diagonally in half. Then the folded paper was shown to the children and they were asked to draw the fold on their papers. They should not fold their papers, but just decide where the line for the fold would go by looking at the teacher's paper. Then the paper was opened and the students saw where the fold was and compared this to where they drew their lines.

The activity was continued by the teacher refolding the paper

on the first fold, and then folding it on the other diagonal (see Figure 15 b on the following page). Again the children were asked to draw lines where they expected the folds to be. The children were not required to be perfectly accurate in their line drawing. The paper should look like Figure 15 a.

In addition, the paper was refolded to the triangle and then folded in half again bringing the corners A and B of the triangle together. The paper should look like Figure 16 b. At that point, the children had two lines to draw, lines DD and D'D' (Figure 16 a). After they checked their work, the paper was refolded to the triangular figure and then half a heart was cut on the line CD (Figure 17 b). When the paper was unfolded the design looked like Figure 17 a.

After the children drew in the hearts they were given a fresh piece of paper and they started again. The children were allowed to fold their own paper and could make such things as snow flakes and valentines. The children were cautioned not to cut out corner D because that is the center of the paper and holds their designs together.

It is possible that this task would be too difficult for children under the age of eight. Surprisingly children who were diagnosed as having learning problems frequently excelled at this task.

For another type of perspective game pictures were taken of

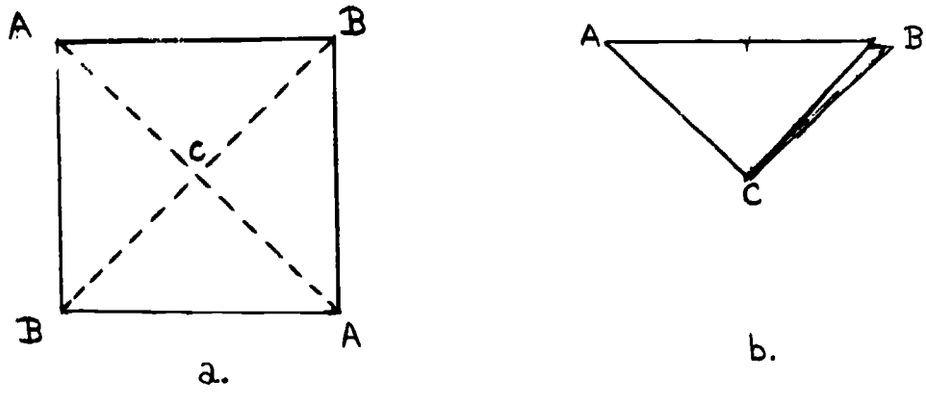


Figure 15

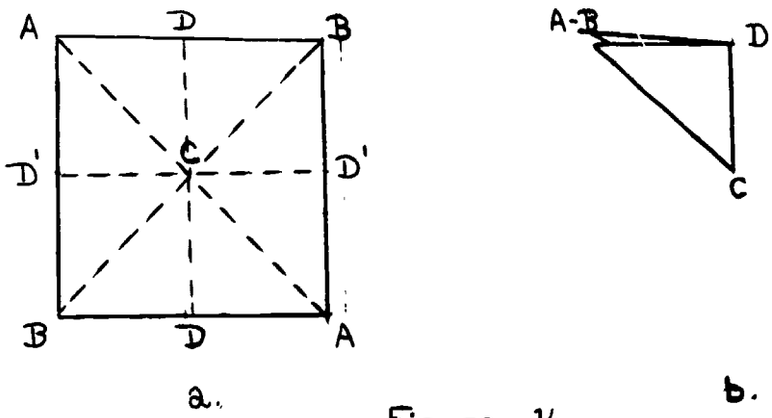


Figure 16

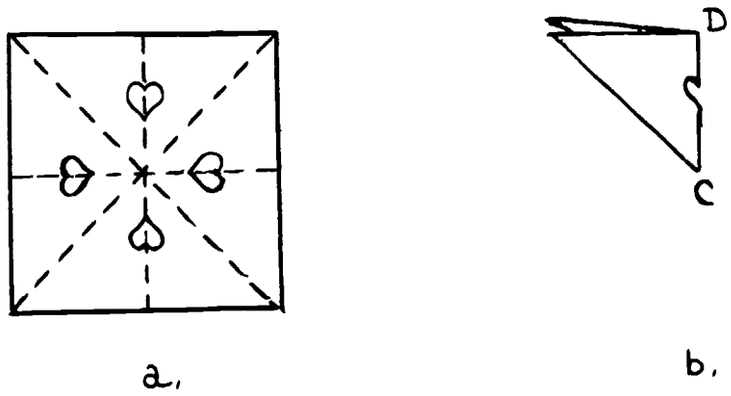
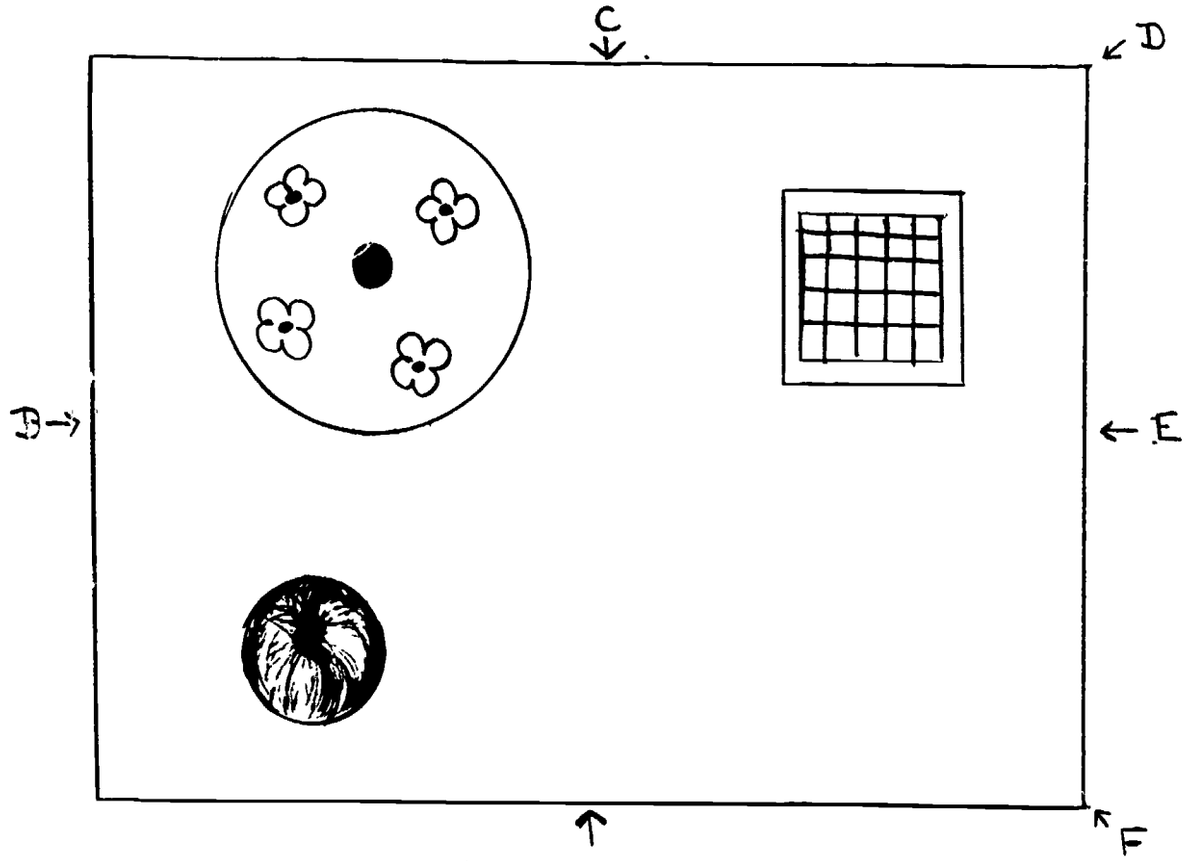


Figure 17

a three dimensional scene. The scene consisted of a flour canister, a small tea tin, and a plastic apple. (Figure 18, shown on the following page, is the arrangement as seen from above.) Using a piece of white poster board as a backdrop so there would be no clues in the background of the pictures, photographs were taken of the objects from different positions around the table. Six perspectives were involved as shown in Figure 18. The camera was placed on the table level with the arrangement and equidistant from its center for each picture. Each picture showed the objects in a different relationship, e.g., in D, the tea tin hid the apple.

When the children came into the classroom the arrangement was on the table and all the children were kept to one side of the table at perspective "A." From there the arrangement looked like Figure 19 (shown on the following page). The photographs of all the perspectives were arranged randomly along the table edge so that the children could easily see them. The teacher then stood at position "A" and asked the children, "What do I see?" The children were then instructed to pick the photograph that was the same as what the teacher was looking at.

Then the teacher moved to perspective "B" and asked one student to choose the picture that was the same as what she was seeing at that position. (From this perspective one of the



Perspective A

Figure 18

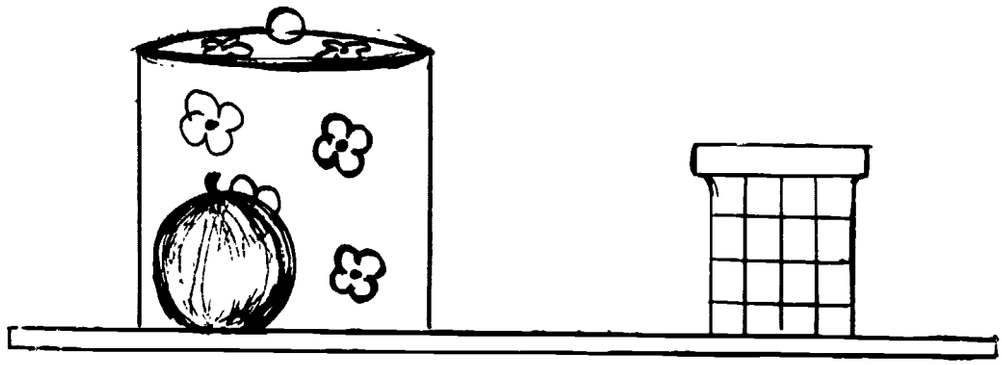


Figure 19

objects was hidden.) In the beginning the children picked a photograph which contained all three objects. The perspectives where one object was hidden were more difficult than the others for the children. A good technique for helping the children to discover the principles involved was to have them choose a picture then come around to that position and compare the picture to what was actually there. The children were not instructed as to the rules involved. They discovered them by themselves through observations of such three-dimensional arrangements from all angles.

(Note: when choosing 3 objects they should be in such a proportion that from D the tea tin must hide the apple and from C the canister must hide the apple.)

5. Role Playing

Role playing seems to be a natural extension of the perspective games. In forming the perspective concepts the change of position is mental through space. In role playing the child actually changes roles with the fireman, the baby, the teacher, the family members. A comprehensive source book on theatrics for children is Improvisation for the Theater by Viola Spolin (Evanston, Ill.: Northwestern University Press, 1963). Many of the games she recommends are easily adapted to play with deaf children.

Because role playing involves creative expression, it is an

important activity for all children, especially those who are linguistically handicapped. A deaf child might be unable to express an idea in spoken words or even signs, but could express it through the medium of role playing. The child is not forced to play a stereotypical role, but is able to assume a person's characteristics as he sees them.

Moreover, role playing is a readily accessible medium, that the teacher and her linguistically poor students can share. A child released from his shyness of performing can show his expressive abilities. Because the entire situation, directions and actions are not tied to language, the child can better understand what role he is to play and better express his ideas. For example, a child in pantomime, could show the actions of brushing his teeth...opening the medicine cabinet, taking out the toothbrush and toothpaste, unscrewing the cap, applying the paste to his toothbrush and then begin brushing, but if asked to apply language to the situation to explain his actions, he would be unable to perform the task. The reason for his failure would not be a lack of understanding of the ideas, but a lack in the linguistic sphere.

The Hat Collection

A collection of hats was kept on open shelves in the classroom, which were used frequently by the children. They first came into the class because of suggestions by the children, and

then they brought their favorites, a yellow fiberglass hard hat, and a navy blue straw hat. The children wore them constantly, and there were many mothers, and sailors, and construction workers seriously working on perspective tasks. Because of the children's interest and the accessibility of the hats, many impromptu plays occurred during the class. Each child would assume a role in accordance with his hat. These were never directed by the teacher. If given a hat the teacher would join the class in their 'drama.' By keeping the costuming simple, like just using hats, much less rigid roles emerge. The same navy blue straw hat that the movie star and the mother wore, became, with its brim pushed up in front, the hat worn by a notable swordsman and swashbuckler.

A Makeup Box

A box of makeup was also part of the classroom equipment, but it was only used when the class had more time than just a half-hour. The box contained lipstick, rouge, eyeshadow, eyebrow pencils, cold cream, and tissues. The only other piece of necessary equipment is a mirror, which should be present in every classroom for the deaf. The children were allowed to experiment themselves with the makeup with a helping hand from the teacher if needed. To assure easy removal of the makeup after the class, a thin layer of cold cream was applied before putting on the makeup.

Using makeup would transform each child into a role even more

than just a hat. It was especially good for shy children, because they did not look like themselves and could be completely transformed into another person.

The Filmstrip Game

Another approach to creative activities was to use speech rhythm filmstrips distributed by Captioned Films for the Deaf. The class began by using a simple series which showed a picture of a large circle and then a picture of a small one. The instructions on the film asked the children to make a loud sound for the big circle, and a soft sound for the little circle. For the small ball, the teacher asked the children to clap their hands quietly; for the large ball, a large clap. The third picture showed a line of three small circles and one large one. Three small claps and then a big one. Then the teacher suggested jumps, low ones for little circles, high ones for big circles.

As the children began to understand the activity, they too added their suggestions for possible actions. One child suggested three small steps and then one large one. Then another student began to walk like an old lady for three steps, and then take a giant leap into the air. The class then tried the activity that way. One child then began to imitate anger, making three menacing steps and then a large one with a frown.

The filmstrip is not actually necessary for this activity... the designs can be drawn on the board. But any way that it is

done, it gives the child another means of free expression and contributing his own ideas to the class activities.

Charade Lotto

The materials used for Charade Lotto were taken from a game of Picture Lotto. The game consisted of cards which were like bingo cards but with pictures on them, and smaller cards with a single picture on each, corresponding to the pictures on the larger cards. It is not necessary to use prepared cards such as these; making them would not be a difficult task. By making them, the teacher could introduce new items to keep the game interesting and challenging for the children (see Figure 20, shown on the following page, for a small part of a set of cards).

To begin the game, the class was divided into two teams, and each team member was given a lotto card. Teams should be chosen with a fair distribution of the children who pantomime the best.

The game goes as follows:

1. One team member chooses a card from a group of cards placed face down on a table.
2. He looks at it and shows it to the opposing team.
3. He must act out the word for his team, without using any signs, fingerspelling, or speaking.
4. The team is allowed two guesses, if they are correct, they

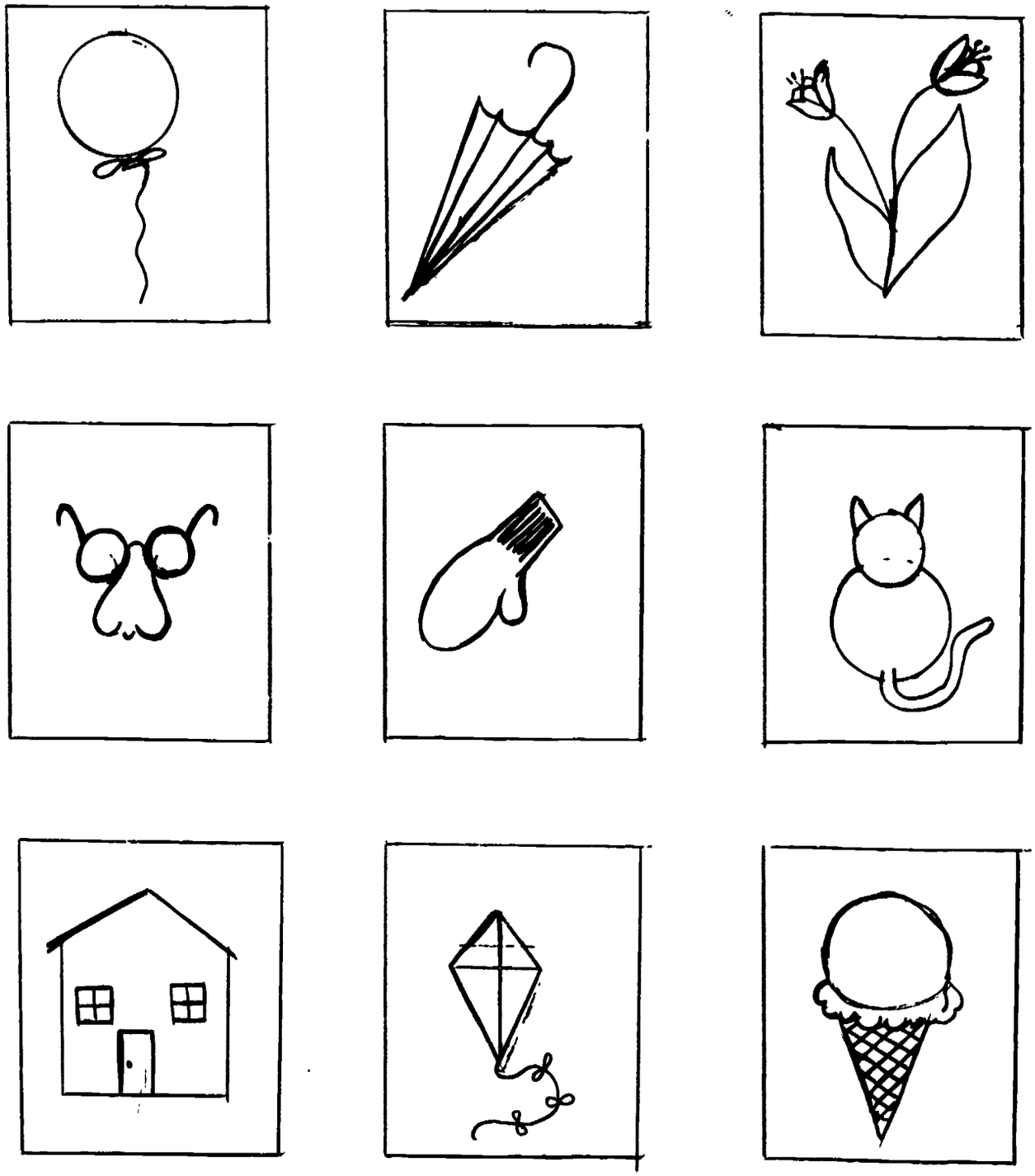


Figure 20

cover that picture on their cards. If they are wrong, the turn goes to the other team.

5. The other team then goes through the same process.
6. Either the teacher sets a time limit for the game or it is played until all the pictures have been used. The winning team is the one that has covered the most pictures.
7. The teacher acts as referee, watching the children to make sure they are not using signs, etc., but only pantomime. (If a sign is used by a person, the turn then goes to the other team.)

Part III: Testing Procedures and Results

1. Procedures

a. Thinking Tasks.

(1) Logitudinal Battery

During a three-year period, five Piaget-type tasks were administered at the following times: December, 1968: May, 1969; October, 1969; May, 1970. Each of the tasks was given within two or three consecutive days and at each of the four test dates, except for Classification Matrix which was not given December, 1968. To improve psychological observations some procedural modifications were made after each testing period. Subsequently, to make performance comparable over time, each child's performance was submitted to a Piagetian developmental analysis into performance levels. These levels represented a rough continuum from minimal success (Level 1) to success with behavioral justification (Level 7). Following each task description, the performance assigned to each of the seven levels is indicated.

Classification Matrix.--Using a board on which was drawn a 3 x 3 matrix, the child was asked to sort objects varying in two dimensions. For example, he was instructed to put on the board 9 objects in 3 colors and 3 shapes in such manner as he thought appropriate. He was then asked to order them in reverse. A rating of 1 was given for random ordering on both copy and

reversal trials. Levels 2 through 6 were assigned according to the degree of order the child imposed upon his classification of the objects in both trials. A 7 was given for totally ordered classification on both trials.

Conservation of Weight.--The child was first shown 2 balls of clay, of equal weight. The experimenter then altered the shape of 1 ball and the subject had to judge if the balls were of the same or different weights. A total of five test trials was given. The child's performance was assigned to Level 1 if he missed all five trials, 2 if he had one correct answer, 3 for two correct answers, 4 for three correct answers, to Level 7 if all five trials were answered correctly.

Horizontal Notion.--A bottle partially filled with water was shown to the subject and then placed in a cloth bag. The bottle was tipped at various angles and the child was required to draw what the water would look like in each position. A rating of 1 was given if the child missed all seven trials, 2 if he had one correct, 3 if he had two correct, etc. A 6 was given for either five or six correct answers and a 7 for all correct answers.

Probability.--Two cans were filled with different portions of blue and white chips. The child was asked to pick the can from which he would more likely pull a white chip. Ratings were based on the number of times the child chose the side with the

higher probability of pulling a white chip. Children with five or fewer correct answers out of ten test trials were assigned to Level 1. Level 2 was not used for this test; Level 3 was assigned to children with six answers correct, 4 to children with seven answers correct, etc. Finally, a 7 was assigned to children who had all ten answers correct.

Transitivity.--By using sticks of various lengths, the child had to infer the size-relation between two sticks A and C, when shown that $A > B$ and $B > C$. Some transitivity problems dealt with equalities such as $A > B$, $B = C$. On the first two testing dates eight transitivity problems were given and the 7 levels assigned in the following manner: Level 1 was assigned for no or one correct answer, 2 for two or three correct answers, 3 for four correct, 4 for five correct etc. On the second two testing dates, six problems were given and the following rating scale was used: no correct answer was given 1, one correct answer was rated 2, etc.

(2) Post-training Battery

These tasks, described below, were administered January, 1971. Most are similar to, but more difficult than the five thinking tasks given in the Longitudinal battery.

Classification, Venn Diagrams.--The child was required to classify objects varying in two and three dimensions, into two and three overlapping circles respectively. A total of nine

test trials was administered and the child was given four blocks to order within each trial. The trials became successively harder and with trial seven, a third ring was introduced. The child was rated 1 if he did not comprehend the task; 2 if he made errors on trials one, two, and three even with correction; 3 if he passed these trials only with correction; 4 if he passed trial three and two other; 5 if he passed five or more trials but failed trial seven; 6 if he passed trial seven but not trial eight and 7 if he passed trial eight. Passing a trial was defined as having correctly placed three of the four blocks for that trial.

Conservation of Liquid.--The same amounts of water from two glasses of the same size were poured into two containers of different shapes. The child was asked to choose the container holding more water. A total of five test trials was given and, if the child did not succeed on the first five trials, trials one and three (in which water from one of the standard glasses was poured into a tall, narrow glass and into a short, wide glass, respectively) repeated with corrections, and the original test readministered. Levels were assigned in the following manner: a rating of 1 was given if the child did not understand instructions; 2 if he understood instructions but clearly failed the test; 3 was given if the child showed a beginning of success; 4 for moderate success at the task; 5 for success after correction

on trials one and three; 6 for general success with some self-corrections after reflecting on his original answer; and 7 was given if he completely succeeded on the task the first time.

Horizontal notion.--The same tasks as described before.

Complex probability.--For part A, different proportions of two colors of ping-pong balls were placed in two jars. The child was given the choice of trying to pull one color from one jar or the other color from the second jar. He was expected to choose the jar with the greater liklihood for a particular color. The child was assigned to Level 1 for six or more errors out of twelve problems, to Level 2 for five errors, 3 for four errors, 4 for three errors, 5 for two errors, 6 for one error, and to Level 7 for no errors. In part B, the same procedure was followed using three colors in each jar. The child was assigned to Level 1 for nine or more errors out of eighteeen, 2 for eight errors, 3 for six or seven errors, 4 for four or five errors, 5 for two or three errors, 6 for one error and 7 for no errors.

Seriation.--Metal rods differing in length by 1/8" were presented to the child to place in order according to length. Then he was given additional rods to insert between those already ordered. Three sets of trials were given in increasing difficulty. The third set was given using rods which differed from each other by only 1/16". Level 1 was assigned if the child could seriate

the first set of eight rods with the experimenter's help; Level 2 was assigned if he could do this on his own. If the child also could seriate the second set by measuring, but did not measure in sequence, he was rated 3. If he could do this by measuring in sequence, he was given 4. If, in addition to the above, he was able to seriate the third set by measuring but did not make enough measurements, he received 5. If, in addition to measuring he grasped the necessity of measuring around the term in question, but still missed some trials, his performance was assigned to Level 6 and finally, if he could do all of the above without missing more than one trial, his performance was rated 7.

Islands.--The child was required to build three towers of blocks each of which would be equal in volume to a standard block. Each tower had to be built up on a base differing in size from the other two bases. A level of 1 was assigned if the child built all three structures one block high and could offer no explanation as to why the height should equal one for all buildings. Level 2 was assigned when the child built the structures one block high and counted the blocks in each structure. A 3 was assigned when he built the structures two blocks high which was equal to the height of the standard block; when asked why they were so constructed, he did not mention the number of blocks. Level 4 was assigned if the child constructed

his towers of differing heights. Level 5 was given to the child who built the towers of differing heights but indicated an attempt to use a consistent number of blocks. Level 6 was assigned to children who were inconsistent in height, but were very close in estimating the same number of blocks for each building, actually measured with the standard, and talked about the numbers of blocks used. Level 7 was given for three correct answers.

Permutations.--The child was asked to make as many different pairs as possible from two, three, four and five numbers, and also from four colors of chips. Four trials using numbers and one trial using three colors of poker chips were given. Level 1 was assigned if the child did not understand the task; 2 if he understood but used trial and error to make pairs; 3 if he showed some indication of using a system; 4 if he used a clear system but did not use it consistently; 5 if he consistently used a clear method but left out one or more logical blocks of numbers; 6 if he used a method but left out four or fewer pairs; and 7 if he succeeded completely.

Rotation of Square.--One square was rotated about another fixed square, the axis being a corner of each square. The board was covered, the square rotated to a certain position. The child was required to predict what the arrangement would look like. Eight test trials were given and levels were assigned in

the following way: Level 1 for no correct answers; 2 for one correct; 3 for two correct; 4 for three or four correct; 5 for five or six correct; 6 for seven correct; and 7 for eight correct.

Block Design.--Test materials and procedure were taken from the Wechsler Intelligence Scale for children. Tests were scored according to directions in the WISC manual. Levels were assigned in the following way: a raw score of six where the child did not pass the training trials was rated 1; 2 was assigned to a raw score of six where the subject passed the training trials but failed test trials one and two; a raw score of 7-14 was rated 3; from 15-24, 4; 25-33, 5; 34-44, 6; and 45-55, 7.

An Inventory of Piaget's Developmental Tasks.--The IPDT is a written but basically a non-verbal test in which many of the problems measure the same abilities as those tested by thinking tasks described above. The IPDT covers the following kinds of tasks: quantity, levels, sequence, weight, matrix, symbols, classes, distance, inclusion, inference, and probability.

b. Standardized Achievement Tests

The Stanford Achievement and the Gates Reading Tests were administered routinely by the school, and while they were not given specifically as a part of this study, scores from the tests

were used in the project for lab and age comparisons.

c. Subjects

For purposes of testing a representative sample from both labs was taken to include only those children who were present during the five main testing sessions. Table 1 on page 6 summarizes the relevant data on these children. Where other subjects were used, this is indicated at the appropriate place in the Result section.

Subjects within each training group were divided into younger and older groups. This was done so that the youngest subjects at the beginning of training would be equal in age at the end of training to the age of older subjects at the beginning of training. For example, a child who began the study at age six was in the younger group while at the end of training he was eight years of age. An older child would be one who began at age eight and finished at age ten. This method allowed us to compare differences due to training over time and simultaneously control for absolute age. That is, if a subject of eight years of age after two years of training showed improvement, his change over time could be legitimately due either to training or to increased age (general experience) or both. If, however, his improvement placed him above the level at which older subjects began the study, one could estimate that improvement was due to training and not just to age. This method of internal control

appears to be one way to avoid difficulties in interpretation which confound many training studies of this type.

2. Results of Testing

a. Thinking Tasks.

(1) Longitudinal Battery

Classification.--Mean levels over time are reported in Table 2 (see following page). While all four groups of subjects show consistent improvement from one to another test session, only the older subjects showed reliable improvement ($p < .05$) from the first to the last session. (For this and subsequent assessments of within-group improvement, Wilcoxon matched pairs tests were computed with each child's level at one time being compared with his level at a later time.)

As to group differences, neither age nor lab differentiated subjects on the initial test. On the last session, however, the older subjects in both labs were at higher levels than the respective younger subjects ($p < .05$). (For this and between-group comparison, Mann-Whitney U tests were used.)

A close inspection of the mean scores in the table reveals that performance on this task was primarily a function of age since training effects were not found and since the younger groups performed at the end of training at the approximate levels at which the older subjects began training (cf., for Thinking Lab,

Table 2

Mean Level as a function of age, lab condition, and time

		Time			
1. Classification	(N)	1st	2nd	3rd	4th
Younger Thinking Lab	(11)	---	5.4	5.7	5.7
Younger Language Lab	(11)	---	4.4	5.0	5.2
Older Thinking Lab	(17)	---	6.2	6.6	6.9
Older Language Lab	(15)	---	5.3	6.5	6.7
2. Conservation of Weights					
Younger Thinking Lab	(9)	1.0	2.3	2.9	1.9
Younger Language Lab	(9)	2.0	2.2	3.4	2.2
Older Thinking Lab	(16)	2.1	1.5	3.0	4.4
Older Language Lab	(15)	1.8	2.9	1.9	3.3
3. Horizontal Notion					
Younger Thinking Lab	(10)	4.1	4.8	4.7	5.0
Younger Language Lab	(9)	2.8	3.9	4.0	4.7
Older Thinking Lab	(16)	5.4	5.7	5.7	6.2
Older Language Lab	(15)	5.1	6.1	5.6	5.7
4. Probability					
Younger Thinking Lab	(11)	2.6	3.6	4.2	4.7
Younger Language Lab	(9)	2.1	2.8	2.7	2.9
Older Thinking Lab	(17)	3.2	4.9	5.4	6.5
Older Language Lab	(15)	3.5	4.9	5.1	5.5
5. Transitivity					
Younger Thinking Lab	(11)	3.4	3.2	4.4	4.8
Younger Language Lab	(11)	2.8	2.8	4.7	5.1
Older Thinking Lab	(17)	3.9	4.5	5.1	5.5
Older Language Lab	(15)	3.8	4.5	5.0	5.3

5.7 compared to 6.2; for Language Lab 5.2 compared to 5.3).

Conservation.--As with classification, performance on conservation was primarily a function of age with differences due to training being minimal. Mean levels for this task can be seen in Table 2. The older subjects of the Thinking Lab were superior to their younger counterparts on the last test. Notice further that the younger subjects in both labs performed at the end of training as the older subjects had at the beginning of training. Over time, both younger and older subjects in the Thinking Lab improved significantly.

Horizontal notion.--Mean levels for this task are reported in Table 2. On this task age differences were obtained initially in both labs but at the end of training only in the Thinking Lab. In addition, subjects in all but the older Language Lab group showed significant improvement over time, again with comparability for the age control.

Probability.--No differences were observed on the initial testing but on the last administration the younger subjects of the Thinking Lab were better than the younger subjects of the Language Lab. On this last testing older subjects were superior to younger subjects in both labs.

Except for the younger group of the Language Lab all subjects improved over time. The improvement observed in the younger Thinking Lab group placed them at the end of training above the level with which the older Thinking Lab group had begun

training. Hence, the training effect obtained here can be legitimately considered as having influenced performance over a level that would have occurred simply with two years of general experience.

Transitivity.--Table 2 also reports mean levels for this task. The only group difference occurred on initial testing for the Language Lab with older superior to younger subjects. It can be seen that over time all four groups improved reliably with the younger subjects exceeding the levels at which their older counterparts had begun training.

Summary of performance over time. It is clear that subjects in both labs began this experiment at equivalent levels as measured by Piagetian tasks. The few differences obtained for initial administration were neither stable nor concordant with later performance and may be dismissed as chance effects. On the other hand, age was an overriding factor in determining success on the Piagetian tasks. When age failed to be manifest of the initial test, it generally was obtained on the final test. With three of the tasks, change over time could reasonably be attributed to the two years of general experience which intervened between test administrations. With probability and transitivity, however, the younger subjects improved beyond levels which might have been expected from age change alone. In the case of probability, improvement was selective to younger subjects of the

Thinking Lab, while in transitivity both younger groups increased levels of performance.

(2) Post-training Battery

Six months after the fourth test administration, the same subjects were seen again on several Piagetian measures. The object of this testing was to determine long term gains, if any, which would have accrued through training, schooling, or development.

Mean levels are listed according to group and task in Table 3 (see following page); for each task four statistical comparisons were made: Thinking Lab vs. Language Lab for each age, younger vs. older for each lab.

Multidimensional classification (Venn Diagrams): In the Thinking Lab older subjects were superior to younger subjects.

Conservation of Liquid: Younger subjects in the Language Lab were superior to younger subjects in the Thinking Lab. In the Thinking Lab older were superior to younger subjects.

Horizontal: Differences in both age groups favored the Thinking Lab, but not sufficiently to reach statistical significance.

Complex Probability: In the Thinking Lab younger subjects were inferior to older subjects in part A of the task, but for part B there were no reliable differences.

Table 3

Mean performance level on thinking tasks, given 1/71

	Classification: Venn Diagrams	Conservation of Liquid	Horizontal Notion	Complex Probability A	Complex Probability B
Younger Thinking Lab	2.6	3.2	5.7	3.9	2.3
Younger Language Lab	2.8	3.0	5.3	3.1	1.7
Older Thinking Lab	4.5	5.1	6.4	5.0	2.9
Older Language Lab	3.8	5.0	6.3	3.9	2.4

	Seriation	Islands	Permutation	Rotation of Square	Block Design
Younger Thinking Lab	3.0	2.5	3.0	2.6	3.5
Younger Language Lab	3.0	3.7	3.0	2.3	2.6
Older Thinking Lab	4.2	3.8	3.7	3.2	4.5
Older Language Lab	4.4	3.5	4.3	4.3	4.8

Seriation: Older subjects in both labs were superior to the respective younger subjects.

Islands: Older subjects were superior to younger subjects in both labs.

Permutations: In the Language Lab older subjects were superior to younger subjects.

Rotation of Square: Older subjects in the Language Lab were superior to younger subjects in the Language Lab and to older subjects in the Thinking Lab.

Block Design: Younger subjects in the Language Lab were inferior to younger subjects in the Thinking Lab and to older subjects in the Language Lab.

In summary, age and not condition of training was the major source of variance of the posttest measures. In other words, results obtained during training persisted for the six-month interim.

(3) Organization of intelligence: Relation among Piagetian operations.

The data up to this point imply a developmental phenomenon which operates along with schooling and general experience. Is it possible that deaf children whose achievement in English is decidedly immature, still progress in a normal fashion toward more mature (operational) organizations of intelligence? Improvement with age is only a weak indicator that they do. A more

precise conclusion could be made if it were found that success on various Piagetian tasks were interrelated in the sense that certain operations were prerequisites for other operations. This would show that organization of operations followed a course like that observed in hearing and language-using children.

Two types of analyses give evidence on this point. One analyzes success on pairs of tasks entailing similar operations (between tasks) and the other analyzes success within a task as a function of internal conditions.

Between-task performance.--There is an overall trend in Table 4 which deserves special mention. In comparing simpler to more complex tasks, there is a consistently large drop-off in success rate from the simpler to the complex. This is to be expected when the simpler problem is a prerequisite for the complex and the two are not simply correlated through a third factor (e.g., age). Having achieved a certain level on a simpler operation does not guarantee that further development will have taken place. Therefore it is important to take note of success on the more complex problem, since from that viewpoint one can reason retrospectively that some minimum accomplishment must have taken place on the simpler prerequisite. Conversely, failure on the simpler operation should be indicative of failure on the more complex problem except that a few subjects may have changed developmental status in the time span between tests.

Table 4

Relations between one task A (given 5/70) and a similar, more advanced task B (given 1/71) in terms of subject frequencies

Easier Task A	Harder Task B	Performance levels on A for subjects succeeding (level 6-7) on B.				Performance levels on B for subjects failing (level 5-1) on A.			
		B 6-7	A 6-7	A 4-5	A 1-3	A 1-5	B 1-3	B 4-5	B 6-7
Classification	Venn Diagrams	15	15	0	0	11	10	1	0
Horizontal Notion	Rotation of Square	6	5	0	1	20	15	4	1
Probability	Permutation	6	2	3	1	24	13	7	4
Transitivity	Seriation	12	5	5	2	34	15	12	7
Conservation of Weight	Islands	4	3	0	1	40	24	15	1
Probability	Probability A	13	10	3	0	24	14	7	3
Conservation of Weight	Conservation of Volume	21	10	1	10	40	23	6	11

Classification: Venn Diagrams. Table 4 relates performance on classification of two dimensions simultaneously with classification as measured by the Venn Diagrams which entailed three dimensions as well as more of an inference of information on the subject's part. It can be seen that success (defined as attainment of level 6 or 7) on the more difficult problem was restricted to those subjects who had attained level 6 or 7 on the simpler classification problem ($p < .01$, according to a two-tailed binomial test). In contrast, of the 11 subjects who had achieved moderate success (levels 4-5) or who failed (level 1-3) the simpler classification problem, 10 also failed on the Venn Diagrams ($p < .05$).

Horizontal Notion: Rotation of Square. Both of these tasks assess what Piaget considers to be mental imagery. On the former tasks, the child must imagine the result of rotation which actually is always the same--the liquid remains on the horizontal plane. On the latter task, each rotation of the variable square has a unique result since a change in one square changes the relation with the other square. So few subjects were successful on the Rotation problem ($N=6$) that a statistical relation was not found, although it can be seen that 5 of 6 successful subjects had achieved success on the Horizontal Notion problem.

As to the remainder of the subjects two points can be considered. Of the 20 subjects who had achieved moderate success or who failed the Horizontal problem only one subject succeeded fully on the Rotation task ($p < .01$). Further among the 33 subjects who failed the Rotation task, as many had succeeded on the Horizontal problem (N=18) as had failed or achieved moderate success (N=15).

Probability: Permutations. No clear relation was obtained between success on these two related cognitive operations. Only six subjects succeeded on the Permutation task. However, of the 12 subjects who failed Probability, only one was successful and two moderately successful on the Permutations ($p < .10$).

Transitivity: Seriation. As in the preceding comparison, no clear relation was obtained between successful performance on these two problems. Viewed from the perspective of failure on either task, the obtained level on one is not predictive of the obtained level on the other.

Conservation: Islands. Although the data show that only few subjects succeeded on the Volume problem, a fairly clear relation results in the case of subjects who failed both problems--of the 36 subjects who failed Conservation, one achieved success of Volume and 14 achieved moderate success (21 failing Volume *vs.* 15 succeeding, $p < .05$).

Probability: Complex Probability A. The expected relationship between the two tasks is clearly manifest.

Conservation of Weight: Convervation of Liquid. No relation at all is observed insofar as, of the children succeeding on Conservation of Liquid, one-half succeeded previously on weight but the other one-half failed. Of 40 children failing on Weight, 11 succeeded on Liquid.

Within task performance: This section of the results, summarized in Tables 5 to 9 (see following pages), deals with the question of whether deaf children are comparable to their hearing counterparts in responding to thinking situations which measure intelligence. It is to be recalled that Piagetian tasks notonly separate successful from unsuccessful subjects, but are designed to analyze what the subjects know about the problems posed. Hence, the category, "failure," is understood as including a heterogeneous set of subjects some of whom are total failures and others who can be considered transitional or as approaching success. The division of subjects into levels has already taken this point into account. However, it can be pursued even further since certain kinds of failure have already been observed as common and indicative of "normal" intellectual growth. This section deals with characteristics of failure among the sample of deaf children in relation to observations of hearing subjects reported in the literature.

Table 5

Percentages of subjects classifying on the Matrix Tasks on 2, 1, or 0 dimensions: Thinking *vs*. Language Lab, Younger *vs*. Older Groups

Matrix Type	Thinking Lab (N varies 22-27)			Language Lab (N varies 16-26)			Younger (N varies 12-22)			Older (N varies 25-31)		
	5/69	10/69	5/70	5/69	10/69	5/70	5/69	10/69	5/70	5/69	10/69	5/70
Color-Form												
Copy												
2	89	89	85	65	77	77	73	68	64	81	94	94
1	11	7	15	27	15	19	23	18	32	16	7	7
0	0	4	0	8	8	4	5	14	5	3	0	0
Reversed												
2	83	81	84	94	92	92	75	80	78	96	90	94
1	13	12	16	6	8	8	19	10	22	4	10	7
0	4	8	0	0	0	0	6	10	0	0	0	0
Size-Number												
Copy												
2	82	93	85	58	69	69	55	64	59	81	94	90
1	7	4	7	23	27	19	23	27	27	14	7	3
0	11	4	7	19	4	12	23	9	14	14	0	7
Reversed												
2	68	65	96	80	64	77	67	53	87	76	71	87
1	18	23	4	20	27	9	25	24	0	16	26	10
0	14	12	0	0	9	14	8	24	13	8	3	3

Table 6

Percentage of errors on Conservation items over time: Thinking vs. Language Lab, Younger vs. Older Group

Transformation	Thinking Lab (N=26)				Language Lab (N=24)				Younger (N=19)				Older (N=31)			
	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70
Thin, Flat (Pancake)	96	96	69	58	88	83	83	67	90	95	74	84	94	87	77	48
Long, Narrow (Sausage)	85	85	73	50	79	75	67	63	90	84	63	79	77	77	74	42
Longer, Narrower (Snake)	85	73	77	62	83	63	75	79	95	58	74	79	77	74	77	55
Three Pieces	89	85	50	62	88	67	58	63	90	74	47	79	87	77	58	52
Five Pieces	89	77	54	62	88	71	54	67	95	63	47	84	84	81	58	52

Table 7

Percentage of errors on Horizontal Notion items over time: Thinking vs. Language Lab, Younger vs. Older Lab

Rotation	Thinking Lab (N=26)				Language Lab (N=24)				Younger (N=19)				Older (N=31)			
	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70
Vertical down	8	4	4	4	21	13	8	4	26	21	16	11	7	0	0	0
Horizontal	18	8	14	6	40	25	25	15	50	34	34	18	15	5	10	5
Diagonal up	61	47	50	28	54	38	44	46	79	61	61	50	44	31	61	27
Diagonal down	61	57	53	49	67	38	54	50	76	58	63	66	55	40	47	39

Table 8

Percentage of errors on Probability items over time: Thinking vs. Language Lab, Younger vs. Older Group

Item	Thinking Lab (N=28)				Language Lab (N=24)				Younger (N=20)				Older (N=32)			
	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70
1	43	18	11	4	38	42	21	13	45	40	15	20	38	22	16	0
2	50	39	39	18	42	25	42	21	35	30	55	20	53	34	31	19
3	46	25	18	14	50	25	25	3[illegible]	55	25	40	45	44	25	9	9
4	36	32	29	11	21	21	25	25	25	30	40	35	31	13	19	6
5	25	18	14	7	29	21	17	25	45	30	15	30	16	13	16	6
6	39	18	11	7	42	42	17	25	50	35	20	35	34	25	9	3
7	57	25	32	11	58	46	33	13	45	60	60	10	66	19	16	13
8	18	32	7	11	38	29	25	29	30	55	20	40	25	16	13	6
9	57	39	46	21	43	42	46	33	60	55	65	30	44	31	34	25
10	21	4	7	11	29	21	21	25	35	15	15	35	19	9	13	6

Table 9

Percentage of error on Transitivity items over time: Thinking vs. Language Lab, Younger vs. Older Group

Inference Type	Thinking Lab (N=24)				Language Lab (N=24)				Younger (N=18)				Older (N=31)			
	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70	12/68	5/69	10/69	5/70
A > B, B > C (Item 1)	68	48	44	36	58	29	29	33	56	44	39	44	68	36	36	29
A > B, B = C (Item 2)	24	32	36	32	38	38	33	33	39	50	39	33	26	26	32	32
A = B, B > C (Item 6)	*	*	56	44	*	*	29	17	*	*	44	17	*	*	42	39

* Note: Procedural error omitted this type of item in the first two test sessions

Each table deals with the kinds of errors made by the two labs (age collapsed) and by younger and older children (labs collapsed) across four testing sessions on the five tasks reported in Table 2. The concern here is with characteristics of failure in order to determine whether deaf subjects show error patterns similar to those observed in hearing children.

Classification: Unsuccessful performance was expected to be ordered as follows. First, there were three possibilities with regard to ordering two dimensions; both, one or neither could be ordered. Hearing children in the age range of the present subjects would be proportionately distributed according to number of dimensions ordered. Second, success on color-form classification was expected to come before success on size-number classification. That is, in classifying color and form the subject is relatively unrestricted as to his placement of any individual item so long as he keeps each row and column constant. With size and number, relations are involved and within each relation there is an internal order--if the subject begins with the smallest size and smallest number in cell 1, he must put the largest size and largest number in cell 9.

Percentages of kinds of errors are reported in Table 5 for the trial on which the subject was to copy the matrix and for the reversal trial which was given to those subjects who

succeeded in two-way ordering. With minor exceptions, lack of two-dimensional classifying type declined over time for both problems under color-form with its corresponding cell on size-number; percentage error is with two exceptions smaller in the former than the latter. Within each problem a similar consistency holds for the expected dimensional relation, again with minor exceptions. The percentages for ordering both dimensions are not given but can be obtained by subtraction; they always exceed 58% and ordering of neither dimension never exceeds 15%.

Table 5 presents results of subjects grouped according to age, showing the number of subjects who failed by ordering only one dimension and those who failed by ordering neither. It can be seen that for subjects who were unsuccessful in ordering both dimensions, a greater proportion order at least one. Further, color-form ordering was simpler than size-number ordering. Finally, older subjects were clearly more mature than younger in that they rarely failed by ordering neither dimension; in fact after the first session percentages of no order dropped to a high of 7%.

Conservation: There was no particular prediction as to specific item differences on this problem; however, it was expected that a long, narrow transformation would be a more likely occasion to conserve than an even narrower, longer piece and

that a transformation into three pieces would be easier than a transformation into five pieces. The error data by item are shown in Table 6 and it can be seen that the expectation was not borne out. While percentage of error generally declined over time, performance was always in the direction of greater failure than success. Error scores of 80% or more probably indicate about-chance performance albeit nonconservation. The remaining error scores are not easily interpretable and may reflect chance, partial conservation, or neither. In any case, to put order into these data is risky since they may represent chance fluctuations from item to item in groups of children who are reaching toward, but have not yet arrived at, a stable level of conservation.

Table 6 also presents relevant data on the question of differences in performance due to age. The results help to clarify the effects, better the absence of inter-task effects between conservation of weight and of liquid. The important finding here is that over time, the older subjects reduced their error rate about 40% as opposed to the younger subjects who fluctuated over time and by the last session remained as nonconserving as they were initially. These error scores also explicate the low levels obtained in Table 2.

Horizontal Notion: The characteristic errors for this task follow two physical dimensions: bottle-upright should be easier to imagine than bottle-upside down and vertical rotations

should be easier than horizontal which in turn would be easier than diagonal rotation. Table 7 presents percentages of errors by items across time according to training conditions and age. Vertical-upright is not reported because all subjects were allowed to view this rotation and copy it in order to insure communication of instructions.

It can be seen that in general relative error followed a consistent order from most to least errors: Diagonal-upside down, Diagonal-upright, Horizontal, Vertical-upside down. Since across time there is a decrease in overall errors, the constant order takes on a special meaning. Over a two-year span the number of successful subjects increases; the other subjects followed a gradual approach to success corresponding to the spatial planes, with Vertical achieved first and Diagonal rotations attained last. It can be seen that even for older subjects of age ten diagonal rotations still present a problem.

Probability: Table 8 reports errors for the 10 items of the probability problem. Items varied in two respects; odds differences between Left and Right choices ranged from as large as 65% to as small as 10%. Second, there were differences ranging from 0 to 4 in the absolute number of balls in the color to be selected.

Over time, error scores declined on all 10 items in both

labs. Initially, performance was directly correlated with the two variables of odds differences and frequency differences. Items number 2, 7, and 9 with small odds and 0 ball differences were answered with most errors. Fewer errors were made on items with greater odds differences and greater differences in number of choice balls. These relative effects were maintained across sessions, more so for the Thinking Lab than for the Language Lab. Table 8 also reports results as a function of age. It can be observed that with some exceptions errors generally declined over time. Notice further that the three hard items (numbers 2, 7, and 9) failed to differentiate age at the fourth testing period whereas other items showed sizeable differences.

Transitivity: Error scores on transitivity are reported in Table 9 for three inference types. The expected order of difficulty can be understood from the instructions given to the subjects; "pick the longer stick." The type A > B, B > C (item 1) should be easiest since along with transitivity the subject is shown that stick A is <u>long</u> and stick C is <u>short</u>. In type A = B, B > C (item 6) stick A, the inferentially longer term, is not given a differential designation, hence this type should be most difficult.

These expectations were not confirmed by the data. The high error rate for the A > B, B > C type was surprising. Although errors declined over time, they started off high and did

not go below 29%.

Results according to age also appear in Table 8. As can be seen across rows, errors declined over time except for the A > B = C paradigm which was relatively easy initially. Age differences were not entirely consistent but this result was foreshadowed by the equivalent levels reported in Table 2.

Summary.--Between and within task patterns were found to correspond closely with known characteristics of hearing children's performance. While expected patterns did not prevail on all tasks, there is sufficient evidence that these deaf children develop normally along dimensions with respect to sequence between operations and within task differences. The analysis of performance over time according to age verifies previous results or explicates them by showing when and why age differences failed to emerge.

(4) An Inventory of Piaget's Developmental Tasks (IPDT): Comparisons of Age Groups, Labs, and Previous Test Results: The IPDT contains some of the same tests used in the five test situations discussed above. Subjects' performances on the thinking tasks, correlated highly with performance on the IPDT ($r = .73$). Since these tests are developmental in nature, age should be an important factor. With the labs collapsed, mean scores on IPDT were significantly different for older and younger groups ($p < .01$). Another analysis comparing performance

of the two labs for the younger and for the older subjects showed no significant differences between the labs. Thus, age, not lab condition again appeared to be the more important factor in determining performance.

b. Achievement: Test scores over time.

This section deals with the same period as the above tasks but is concerned with Achievement scores reported in grade levels of years and months. The following statistical comparisons deal with scores summarized in Table 10 obtained on tests taken in 9-69 and 4-71 or a period of 16 school months.

Paragraph meaning: Table 10 reports mean grade levels for both test administrations. Age but not lab differences appear on both tests. Note, however, that age differences are slight with the largest difference being 8 months. Further, it can be seen that no significant improvement over time occurred in any group with the greatest within group increase being 2 months.

Vocabulary: Vocabulary scores also failed to show increases over time. Differences between ages were small but in the expected direction. Note that both here and on paragraph meaning, achievement scores on the Gates Reading Test were much higher than on the Stanford.

Arithmetic: Performance on this achievement measure was unique in that in spite of the apparent closeness of the mean

Table 10

Mean Grade Achievement over Time as a Function of Lab Condition and Age

	9/69			4/70		2 or 4/71	
	Gates	Stanford	(N)	Gates	(N)	Stanford	(N)
Paragraph Meaning							
Younger Thinking Lab	2.4	1.8	(8)	2.9	(8)	1.8	(11)
Younger Language Lab	2.5	1.9	(7)	2.9	(7)	1.9	(12)
Older Thinking Lab	2.8	2.4	(17)	3.3	(17)	2.6	(17)
Older Language Lab	2.9	2.3	(16)	3.2	(15)	2.4	(16)
Vocabulary							
Younger Thinking Lab	2.6	1.5	(7)	2.6	(8)	1.4	(11)
Younger Language Lab	3.0	1.3	(8)	3.0	(7)	1.3	(12)
Older Thinking Lab	3.2	1.5	(17)	3.4	(17)	1.7	(17)
Older Language Lab	3.2	1.8	(16)	3.2	(15)	1.9	(15)
Arithmetic							
Younger Thinking Lab	--	1.4	(8)	--		1.6	(11)
Younger Language Lab	--	1.5	(7)	--		1.6	(12)
Older Thinking Lab	--	1.9	(17)	--		2.4	(17)
Older Language Lab	--	1.8	(16)	--		2.4	(16)

scores three of the four subject groups improved significantly over time--only the younger children in the Language Lab remained at their initial level. Age differences were obtained on both administrations; however, the younger groups did not reach the achievement levels that the older groups started at.

Summary of Achievement Test Scores. The overall improvement on Piagetian measures was not accompanied by a concomitant increase in school achievement. This was particularly true for the language measures of paragraph meaning and vocabulary. The maximum mean gain on the former was less than 3 months and on the latter two months. The maximum individual gain by any child was 1 year-1 month on the former and 9 months on the latter. These data show clearly that improvement on Piagetian tasks need not be thought of as due to an indirect factor of improvement in language usage but was, instead, an independent process.

Improvement on Arithmetic achievement shows, of course, that school was not able to depress thinking completely and during the interim may have been of some value to the deaf students. In a sense these scores might even be considered artificially depressed since test items claiming to measure arithmetic concepts were actually heavily weighted in linguistic usage. Some work problems may have been understood arithmetically but when presented in a complex language to children reading at a Grade 2 level they may have been answered incorrectly.

Part IV: Special Studies

A. Linguistic Measures[3]

(1) Tasks

All the children in the deaf elementary school population were given a set of four paper-and-pencil written language tests in January, 1971. Each type of test response required was illustrated by examples both written and signed or gestured. Initial responses were checked to determine if the subject was responding appropriately and if not, an attempt was made to indicate the appropriate type of responses required. The four tests are designated the Scrambled Words Test, the Combine Sentences Test, the Question Answering Test, and the Temporal Ordering Test.

I. Scrambled Words Test

Description. --Subjects were presented with a set of familiar words and instructed to make an English sentence using all the words in the set. The types of sentences which could be constructed were (in order of increasing difficulty):

Simple Sentences

a. Simple intransitive sentences, e.g., The boy ran.

b. Simple sentences with the verb be and a predicate adjective, e.g., The girl is happy.

c. Simple transitive sentences, e.g., The boy hit the girl.

Sentences with Modifying Constructions

d. Simple transitive sentences with adjectival modifiers, e.g., The big boy hit the small girl.

[3] Report by Malcolm Gordon.

e. Sentences with prepositional phrase modifiers, e.g., The cat went to the store with the boy.

Sentences with adverbal phrase modifiers, e.g., The boy went to the store last night.

Sentences with verb complement constructions, e.g., The girl saw the boy run.

f. Sentences with relative clause modifiers, e.g., The boy who was big was happy.

Scoring.--Subjects were distributed into 7 performance categories:

0 = failure to respond or did not understand the task or could not construct any sentences.

1 = failed to construct sentences but did attempt to utilize words in the set, some evidence of phrasal sentence fragments, especially article and noun ordering.

2 = correct formulation of simple intransitive sentences, but failure in construction of other sentence types.

3 = correct formulation of simple transitive, intransitive and predicate adjective sentence types.

4 = correct formulation of all the simple sentence types and correct formulation of some sentences with verb complement, adjective, adverbal or prepositional phrase modifiers.

5 = correct formulation of all simple sentence types and incorrect formulation of only one category of sentences with verb complement, adjective, adverbal or prepositional phrases.

6 = correct formulation of all sentence types, except those involving relative clauses.

Significance. --This type of task indicates the extent to which deaf subjects have abstracted the basic constructional principles of English sentences. The extent to which subjects succeed in this task reflects the extent to which they can formally construct English sentences.

II. Question Answering Test

Description. --Subjects were given simple sentences which were active or passive and transitive or intransitive and were to answer a question by indicating one of the noun phrases in the sentence. The questions asked were (in increasing order of difficulty) for the sentence X zed Y: (1) Who zed? (2) Who was zed? (3) Who did not z? and (4) Who was not zed?

Scoring. --It became apparent that the subjects could not consistently answer either the negative or negative passive questions, so the scoring was based on the consistency and correctness of response to the first two question types. On this basis 6 scoring categories were utilized:

0 = subjects who performed so poorly on the Scrambled Words Test that no further tests were given.

1 = subjects who gave an inappropriate response, i.e., did not indicate a noun phrase in the given sentence.

2 = subjects who gave an appropriate response in the form of a noun phrase of the given sentence, but gave incorrect and inconsistent responses to both questions indicating either guessing or responding to every question with either the subject or the object noun phrase.

3 = subjects who could correctly respond to questions of the type (1) Who zed? and (2) Who was zed? when asked in isolation from

other questions, but not when asked with other questions in a set.

4 = subjects who could consistently and correctly respond to (1) Who zed? questions with no more than one error, but not to (2) Who was zed? questions.

5 = subjects who consistently and correctly responded to both Who zed? and Who was zed? questions with no more than one error.

Significance. --Since subjects utilized question words continually in their classroom instruction (Fitzgerald key method) this test indicated the extent to which they had abstracted out the functional significance of interrogative words, i.e., their use for questioning.

III. Combine Sentences Test

Description. --Subjects were presented with a set of from two to four sentences containing the same noun phrases and told to combine the sentences into one sentence, which meant the same as the set of sentences. All of the examples used required the subject to incorporate one or more adjectives into one or more noun phrases.

Scoring. --All of the deaf subjects performed very poorly in this task. Scoring criteria, then, was based not on the correctness of the performance, but on the evidence that the subject attempted to combine the sentences by means of some consistent mechanism. The scoring system was as follows:

0 = subject merely copied one of the sentences in the set.

1 = subject altered one or more sentences mainly in the direction of reducing its content.

3 = subjects attempted to combine sentences by grouping predicates, e.g., John ran sang.

5 = subjects attempted to combine some sentences utilizing either coordination with "and" or adjective incorporation

Significance. --This test investigates one type of embedding mechanism in English--adjective incorporation.

IV. Temporal Ordering Test

Description. --Subjects were presented with a set of three sentences and through examples instructed to put the three sentences in chronological order. The sets of sentences were of two types: (1) Sentences which included both a tense marker and an adverbial of time, i.e., "yesterday," "today," "tomorrow," to indicate temporal ordering and (2) Sentences which contained only a tense marker to indicate temporal ordering.

Scoring. --Five scoring categories were utilized:

0 = subjects who copied each sentence set in the same order as given on the test sheet.

1 = subjects who permuted the sentences, but were inconsistent from set to set in their ordering.

2 = subjects who consistently ordered both sentencesets with time adverbs and without time adverbs, but used a different ordering for the two sets, e.g., Present-Past-Future for sentences containing the adverbs and Future-Present-Past when sentences contained tense markers alone.

3 = subjects who consistently ordered both types of sentences the same way, but the order was paradigmatic, e.g., Present-

Past-Future, rather than chronological.

4 = subjects who consistently ordered both types of sentences in correct chronological order.

Significance.--This test attempted to see if subjects could utilize a strictly syntactical cue to temporally order sentences. The cue of tense was chosen particularly because most Sign Language verbs are uninflected for tense.

(2) Results

Comparison of Language and Thinking Labs

The distributions of younger subjects by labs for two language tests are indicated in Table 11, and of older subjects by labs in all four language tests are indicated in Table 12. Not enough younger subjects completed the last two tests for distributional comparison tests to be computed. The Mann-Whitney statistic was computed for all seven pairs of distributions, but none of the seven distribution pairs differed significantly. The inference is that the performance of the Language and Thinking Labs did not differ significantly on the language tests used.

Overall Test Performance

I. Scrambled Words Test

The subjects performing the best in the task had abstracted the constructional principles of simple English sentences and adverbally, complementally, adjectivally, and prepositionally modified sentences, but none of the subjects succeeded in constructing relative clause constructions. The subjects whose performance was the worst (approximately 1/3 of the total sample) did not give performance on the task better than word recognition. For the younger

Table 11

Linguistic Scores (0 to 6) for Younger Subjects

Subjects and Task	0	1	2	3	4	5	6
Scrambled Words							
(N=11) Language Lab	3	3	2	2	0	1	0
(N=11) Thinking Lab	7	1	1	2	0	0	0
Question Answering							
Language Lab	5	2	3	0	0	1	-
Thinking Lab	8	2	0	0	0	1	-

Table 12

Linguistic Scores (0 to 6) for Older Subjects

Subjects and Task	0	1	2	3	4	5	6
Scrambled Words							
(N=16) Language Lab	0	0	5	4	2	3	2
(N=15) Thinking Lab	1	1	3	1	4	2	3
Question Answering							
Language Lab	0	1	1	6	5	3	-
Thinking Lab	1	0	2	3	7	1	-
Combine Sentences							
Language Lab	4	1	0	4	0	6	-
Thinking Lab	3	0	0	5	0	5	-
Temporal Ordering							
Language Lab	2	2	4	3	4	0	-
Thinking Lab	1	0	5	3	3	0	-

group of subjects (mean age approximately 7 years) median performance fell in scoring Category 1, i.e., "failed to construct sentences, but did attempt to utilize words in the set, some evidence of phrasal sentence fragments, especially article and noun ordering." For the older group of subjects (mean age approximately 10 years) median performance fell in Category 4, i.e., "correct formulation of some sentences with verb complement, adjective, adverbal, or prepositional phrase modifiers." None of the subjects were able to correctly formulate a sentence containing a relative clause. Most subjects were at the level of being able to coordinate nouns and verbs in forming a sentence nucleus, but not to incorporate modifiers.

II. Question Answering Test

The best subjects could only perform adequately with simple Who zed? and Who was zed? questions about simple active sentences. None of the subjects were able to deal with negative questions or any questions about passive sentences. The median performance of younger subjects was in the Category 0, i.e., subjects who performed so poorly on the Scrambled Words Test that they were not tested in the Question Answering Test. The median rank for older subjects fell in Category 4, i.e., "subjects who consistently and correctly responded to the Who zed? question, but not the Who was zed? question. The data indicate that the average deaf subject could not interpret what negative and passive questions signified. Despite constant use of "who" in the Fitzgerald key method the average subject could not consistently respond to the Who zed? question in simple sentences. Apparently most of these subjects understood "who" more as a syntactic marker as used in the Fitzgerald key, than as a semantic request

for information about the actor in a sentence.

III. Combine Sentences Test

Median test performance of the older subjects fell into Category 2, i.e., subjects attempted to combine sentences by juxtaposing predicates. This mechanism is not even an acceptable syntactical transformation in English. The overall performance of subjects was quite poor. Even the best subjects did no more than produce inaccurate attempts at adjective incorporation or conjunctions with simpler sentence sets. Some of these same subjects had moreover successfully constructed sentences with adjectives in noun phrases in the Scrambled Words Test. One interpretation of this finding is that the subjects' understanding of English at this stage is more in the nature of a system of concatenate classes rather than a system of relations and transformations.

IV. Temporal Ordering Test

Median performance of the older subjects fell into performance Category 2, i.e., subjects who consistently ordered sentence sets containing temporal adverbs and sentences with just a tense marker, but the two orderings differed from one another. Very few subjects could order sentences in correct chronological order on the basis of tense markers alone. The average subject could arrange the sentence sets consistently on the basis of time adverbs and tense markers, but the orderings were different when tense alone was utilized than when adverbs of time were also present. Almost all the subjects who consistently ordered the series used a paradigmatic order of Present-Past-Future, rather than chronological order. This again indicates that the knowledge of the deaf children about English is more in the nature of syntactic relations than in

a system of semantic relations, in this case the coordination of tense markers with a chronological time line.

(3) Conclusions

The conclusions which can be drawn from these data are limited. Much more research is needed to ascertain whether the limitations in language performance shown for these subjects is a real deficiency in language knowledge or a function of the specific tasks used. One implication of these results which is supported by classroom observation of teaching methods is that the method of teaching by syntactic drills in isolation from living, functional use of language leaves an imprint on the deaf student in the relatively low-level semantic knowledge of English that they displayed.

B. Optometric Measures[4]

(1) General Procedure

Optometric tests, given in December, 1969, were designed to locate areas of perceptual-motor disability in order to discover possible learning disabilities. Performance on each of the measures, described below, was rated 1-4, with the higher number indicating the better performance:

a. Regular acuity tests at near and far distances from a standard eye chart were given and subjects were rated 1-4 as follows: uncorrected vision of 20/40 or worse was rated 1, 20/30 a 2, 20/25 a 3, and 20/20 a 4.

b. A cover test at both near and far distances from the focusing target was given to detect eye movement as the child attempted to maintain focus on the target while an occluder was passed rapidly from eye to eye. The child was rated on the degree of eye movement he displayed, 1 indicating

[4]Report by Paul Lewis.

extreme eye movement, 4 no eye movement.

c. The third subtest given was Near Point of Convergence in which the optometrist moved a focussing target toward the subject to detect the point at which his eyes crossed. If the eyes crossed with the target 5" from the face, the child's performance was rated 1; for crossing with target 4-5" from face, a rating of 2 was given; for crossing with target 2-4" from face, 3 was given; and for crossing with target anywhere from the nose to 2" from face, a 4 was given.

d. Locating and Tracking was designed to measure ability of eyes to smoothly follow movement. If the child indicated extreme stress in tracking th. object, he was given a 1; for very irregular tracking a 2; for slightly irregular tracking a 3 and for smooth tracking a 4.

e. In the Book Retinoscopy subtest, the optometrist took readings from the retina of the subject's eyes as to its color, brightness, motion, and flexibility while the child read a short paragraph from a book. These measurements helped to determine if the child was concentrating on what he was reading. On each aspect of book retinoscopy, the child was rated 1-4, i.e., failing to various degrees of passing.

f. The child was also asked to perform the following six gross motor tasks:

1) hopping on two feet across the room

2) hopping on one foot across the room

3) hopping on the other foot across the room

4) skipping forward

5) skipping backward

6) walking heel to toe in a straight line.

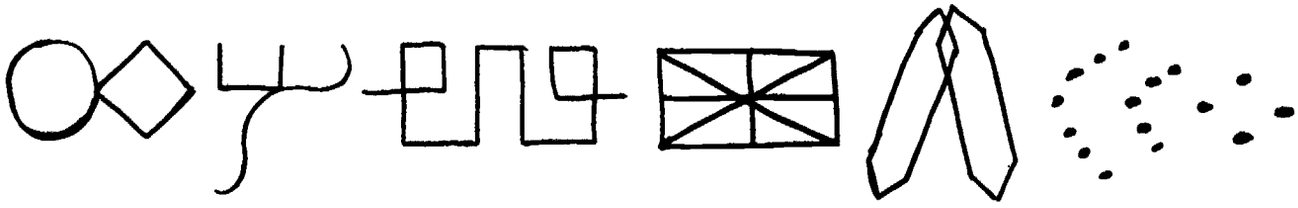
g. In addition, he was instructed to perform the following seven tasks:

1) tapping index finger to thumb as rapidly as possible
2) tapping thumb to index finger, middle finger, etc., in succession and then in reverse
3) blinking both eyes in rapid succession such that blinking was reflexive
4) winking one eye, then the other
5) sticking tongue in and out in rapid succession
6) flapping both hands and arms in unison with arms extended at shoulder level
7) turning both hands and arms with elbows placed on table.

On each of the Gross and Fine Motor Tasks, the child's performance was rated 1-4, i.e., failing through various degrees of success.

h. Another measure, the Form Boards Task, required the child to fit wooden forms which were split into two pieces onto a board with indentations matching the shape of the form. Six different forms were given to the child to fit together. He was rated 1-4 depending on the means he used to orient the forms onto the boards. If tactual means only were used, he was rated 1; if tactual means with some visual support were used, he was rated 2; if visual means with some tactual support were used, the child received a rating of 3; and if he used visual means only he received a rating of 4.

i. Finally the child was given the following copy forms:



Performance was rated 1-4 on each drawing--1 for a drawing which was grossly segmented and out of proportion; 2 for a drawing which was segmented or missing some parts; 3 for a basically adequate drawing and 4 for a drawing which displayed adequate form perception.

(2) Results and Conclusions

Comparison of lab performance.--Analyses of lab differences were done by the Mann-Whitney U formula and in cases where U was close to a level of significance, a correction for tied cases was performed. In comparing the two labs, no significant differences were found on any of the subtests. The greatest difference, which favored older Language over older Thinking Lab children, was on the Form Boards Task. The probability of the obtained U of 58 (where N_1 = 13, N_2 = 15) was not less than .057 for a two-tailed test.

The lack of differences between lab groups is a further demonstration that labs were well matched in the abilities measured by these tasks. Since optometric tests of this sort are used primarily to identify children with possible learning difficulties, the labs' similarity helps to point out that neither was handicapped more than the other in this particular area.

Comparison of age groups.--Since no differences between the labs were found, the two groups were collapsed and the Older and Younger groups of deaf

children were compared. Table 13 summarizes the relevant data. Generally, there were no differences between the age groups. It should be noted that on most of the tasks the bulk of the scores fell towards the higher end. This indicates that the deaf children with few exceptions function well in visual behavior from an optometric viewpoint.

Comparison of deaf and hearing samples.--In order to study the above point more thoroughly, a control sample of 28 hearing children in grade 3 of an elementary school was given the same optometric tests. The distribution of ratings for the hearing children was compared to a matched sample of deaf children drawn from the larger sample. The result of this comparison is summarized in Table 14. The data confirm the basic similarity in visual functioning between deaf and hearing children and constitute interesting evidence contrary to some speculations that children deprived of hearing would show a great incidence of visual dysfunction. Statistical comparison demonstrated that only on one test did a significant difference emerge, namely on the Fine Motor Task and this difference was in favor of the deaf children.

Comparison of high and low scoring groups.--As mentioned earlier, the optometric tests have been used by schools to discover pupils who may have learning disabilities. In order to test out the validity of its use as a predictor, the ratings of all optometric subtests were totalled for each child except for the acuity and cover subtests. These were rejected because correlations of these scores to the total score were low. On the basis of these total ratings a group of 15 deaf children who scored high on the optometric measures was compared to a group of 15 who scored low. Means were then computed based

Table 13

Percentage of Younger and Older Deaf Children Receiving Optometric Ratings 1-4

Task	Younger (N=23, Mean Age 9.2)				Older (N=33, Mean Age 12.2)			
	1	2	3	4	1	2	3	4
Acuity; near	30	30	-	40	16	19	6	59
Acuity; far	28	6	-	66	13	7	16	64
Cover; near	10	14	10	66	10	13	7	70
Cover; far	10	43	33	14	16	19	44	21
Near Point of Convergence	20	-	30	50	10	6	26	58
Locating	-	14	43	43	3	13	29	55
Tracking	-	19	24	57	6	19	16	59
Book Retinoscopy								
Color	-	26	5	69	7	3	23	66
Brightness	-	26	-	74	6	6	26	62
Motion	-	26	5	69	6	10	19	65
Flexibility	-	31	5	64	7	10	17	66
Gross Motor	-	10	45	55	-	14	31	55
Fine Motor	-	-	38	62	-	-	34	66
Form Boards	15	35	25	25	14	17	31	38
Drawing 1	11	31	27	31	3	15	41	41
2	16	32	42	10	6	28	38	28
3	12	35	53	-	-	15	70	15
4	6	53	35	6	3	9	47	41
5	70	6	24	-	15	36	30	19
6	37	37	21	5	6	44	41	9

Table 14

Percentage of Selected Samples of Hearing and Deaf Children Receiving Optometric Ratings 1-4

Task	Hearing (N=28, Mean age 9.5)				Deaf (N=20, Mean Age 10.2)			
	1	2	3	4	1	2	3	4
Acuity; near	4	7	4	75	20	20	-	55
Acuity; far	4	4	-	92	15	5	15	65
Cover; near	7	7	18	68	20	25	25	30
Cover; far	11	14	50	25	16	-	26	58
Near Point of Convergence	7	-	25	68	5	20	30	45
Locating	-	7	65	28	5	20	30	45
Tracking	4	11	33	52	5	15	15	65
Book Retinoscopy; Color	-	25	21	54	5	16	26	53
Gross Motor	11	22	34	33	26	10	32	32
Fine Motor	10	22	34	34	-	15	25	60
Form Boards	4	18	33	45	21	10	32	37
Drawing 1	11	28	33	28	10	16	58	16
2	4	52	33	11	10	47	6	37
3	-	39	50	11	10	26	58	6
4	-	50	36	14	10	32	32	26
5	11	33	36	20	36	42	6	16
6	11	43	40	6	16	36	32	16

on the total score obtained by the 15 children in each group on five thinking tasks of January, 1971. These tasks were Classification, Conservation, Horizontal Notion, Probability, and Seriation. The comparative results are presented in Table 15. The high scoring group scored better than the low on the thinking tasks with a significant difference ($t = 2.97$, $p < .01$). Mean ages for the two groups, however, did not differ by more than 1 month. This analysis shows that differing performance on optometric measures does indeed point to differing performance on a general measure of thinking. This finding lends some validity to the use of optometric tests as predictors of scholastic performance.

Table 15

Mean Scores on Thinking Tasks for Children Scoring High and Low on Optometric Measures

	Optometric Score (Maximum = 116)	Five Thinking Tasks (Maximum = 35)
High Scoring Group N = 15	104.00	29.26
Low Scoring Group N = 15	78.69	23.80

C. Creativity Testing[5]

(1) General Procedure

The subjects used were 14 deaf children selected from the Language Lab and 14 children selected from the Thinking Lab. Subjects were matched as nearly as possible on variables of age (mean age 9.8 years), sex, and school grade.

The assessment of creativity was based upon tasks taken from two different sources: the Circles and Picture Completion Tasks were from the Torrence Tests of Creative Thinking, Figural Form B (1966) and the Naming Square Things Task was taken from Wallach & Kagan.[6] The Torrence tasks were given according to directions in page 3 of the administration manual with the following exceptions: instructions were shortened and modified so as to be given in Sign Language, examples of the task items were introduced to complement and explicate the abbreviated instructions, and finally all time limits were doubled. The Torrence items were scored according to the instructions outlined in the directions manual. The administration and scoring of the Wallach & Kagan task approximated their instructions with the exception that the administration was done in a group situation rather than on an individual basis.

A total creativity task score was computed for each child for originality, fluency and flexibility: originality defined as the number of unique responses given by one child in response to an item, fluency defined as the number of appropriate responses given by one child in response to an item, and flexibility defined as the number of different categories (classifications) given by one child

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[5] Report by Donald Devers.

[6] Modes of Thinking in Young Children. New York: Holt, Rinehart & Winston. 1965.

in response to an item. These three scores are not additive to yield a single creativity task score. Prior research has demonstrated, however, that originality, fluency and flexibility scores are significantly intercorrelated with each other to comprise a single dimension of creativity. All creativity tasks were administered consecutively to small groups of seven on the same day, by the same experimenters (one male and one female, both sufficient in Sign Language). The Thinking Laboratory had some practice and instruction over the course of the two weeks prior to testing in divergent thinking--particularly stressing uniqueness of thought, quantity of thought, and variability of thought.

(2) Results and Discussion

Mean scores were obtained for all three variables of creativity task scores for both groups. These are reported in Table 16. It is apparent that the Thinking Lab's performance on all three creativity task score variables

Table 16

Mean Creativity Test Scores for Labs

Labs	Creativity Scores		
	Originality	Fluency	Flexibility
Language N=14	16.5	31.4	16.4
Thinking N=14	21.4	37.4	20.4

was consistently higher than those for Language Lab. An F test (2 x 3 analysis of variance) was carried out to test if these differences were significant. The results ($F = 6.27$, $p < .05$) indicated that the difference between overall performance of the labs was significant, taking all three aspects of the creativity task scores together. There were also a significant difference between the three aspects of creativity ($F = 79.45$, $p < .01$). When each aspect of creativity was taken individually, the differences between lab scores were not significant.

This finding concurred with prior studies in suggesting that creativity is a single dimension based upon aspects of originality, fluency, and flexibility and that no aspect taken alone is sufficient for defining creativity ability. It can be inferred that the significant difference in performance between labs is based upon the divergent thinking activities introduced in the Thinking Lab prior to the assessment of creative ability. The inclusion of a pretest would have offered stronger support in terms of comparing pretest performances, posttest performances, and posttest pretest differences. It can also be inferred that for a deaf population, instruction in thinking serves on the whole as a more stimulating environment for creative thought than does language instruction.