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A COMPARISON OF THE RELATIVE REINFORCEMENT VALUE OF RESPONSE-CONTINGENT VISUAL AND AUDITORY STIMULI IN A MULTIPLE-CHOICE LEARNING TASK WITH INSTITUTIONALIZED RETARDATES

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A COMPARISON OF THE RELATIVE REINFORCEMENT VALUE OF RESPONSE-CONTINGENT VISUAL AND AUDITORY STIMULI IN A MULTIPLE-CHOICE LEARNING TASK WITH INSTITUTIONALIZED RETARDATES

A Thesis

Presented to

the Faculty of the Department of Psychology

and Counselor Education

Kansas State College of Pittsburg

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Psychology

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by

William Robert Grimes

January 1969

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Henry Leland for his guidance throughout this investigation; Dr. Dan Smith, who provided advice on language and analysis of the data; Dr. H. P. Rumford, thesis advisor and thesis committee chairman, who made a number of important suggestions; Dr. Robert Steige and Dr. Robert Noble, thesis committee members; Dr. James Crossen and Dr. Fred Girardeau, who offered advice during the formative stages of the thesis; my sisters Miss Jean Grimes and Miss Martha Grimes, who helped in preparation of the manuscript; Mr. Morris Shrago, who offered valuable advice; and my wife, Darlene, who provided artwork and assistance with preparation of the manuscript and who, along with my son Douglas, provided encouragement and inspiration during the long hours of preparation of this thesis.

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ABSTRACT

The purpose of this experiment was to determine if simple auditory and visual sensory stimuli were effective reinforcers with mentally retarded children and, if so whether one stimulus was superior to the other. In order to make this determination, a group of eighteen female patients between the ages of seventeen and twenty-seven, having IQ's ranging between 37 and 98, and classified as functioning in adaptive behavior level-III, were assigned by random sampling techniques to three equal groups to participate in a multiple-choice learning situation. The groups of subjects were exposed either to one of the two sensory stimuli (light flash or buzzer) after each correct response or, in the case of the control group, the subjects received only knowledge of results as a possible reinforcer.

The following null hypothesis was formulated prior to the experiment. There will be no significant difference between the number of errors committed during the learning task by the groups receiving response-contingent sensory stimuli and the number of errors committed by the control group.

The Friedman Two Way Analysis of Variance and the Mann-Whitney U Test were used to determine if there was a significant difference in amount of learning between any of the three groups as measured by number of errors committed per group over all trials. The group receiving response-contingent auditory stimuli was found to be significantly superior in amount of learning only to the group receiving response-contingent visual stimuli; although a trend was seen toward a difference favoring the auditory group over the control group and the control group over the visual group. It was therefore concluded that the present study was unable to demonstrate that response-contingent sensory stimuli provided more reinforcement effect than did mere knowledge of results provided in the control condition; therefore, the data did not justify rejecting the null hypothesis at the .05 level of confidence. It

was suggested that the findings of this study be considered indeterminate rather than negative because a number of possibly confounding variables may have obscured any real differences between the groups.

CHAPTER I

THE PROBLEM, LIMITATIONS, AND DEFINITIONS OF TERMS

During the continuing search for additional reinforcing agents to be used in both experimental and pedagogical learning situations, researchers have demonstrated, in several species, a phenomenon they describe as *sensory reinforcement* (Kish, 1966). Although research in the area of sensory reinforcement has been conducted for several years, most of this has been accomplished with lower organisms, and very little has been carried out on either normal or retarded human populations.

I. THE PROBLEM

Statement of the problem. The purpose of the present experiment is to determine if simple auditory and visual sensory stimuli are effective reinforcers with mentally retarded children and, if so, whether one stimuli is superior to the other.

Importance of the study. There has been a great increase in the use of operant techniques with retarded children in recent years both in behavior modification situations (Ellis, 1966) and in more traditional classroom settings. One consequence of this trend is an increased awareness among researchers of the need for a greater variety of stimuli having powerful and long-lasting reinforcement effects. Although there are many agents that are widely used as reinforcers with the retarded, each of them has certain disadvantages that places a limit on its usefulness in given situations, e.g., one may produce too rapid satiation, or another may take too much time or be too complicated to administer effectively in any but the most optimal conditions.

Several researchers in the field have written regarding this problem; Watson, Lawson, and Reed (1966), for example, have stated that:

> Effective reinforcement seems to be a particularly pressing problem, and one of great interest in its own right as well as for its practical potential. MRs do seem to differ from normals in the kinds of reinforcements that are most effective--whether this is due more to institutionalization or to retardation itself is not entirely clear yet. What is clear is that researchers have only begun to discover truly effective, long-lasting reinforcers. Until these are better developed, certain important long-term learning research is going to be seriously hampered.

A similar view is expressed by Ferster and Demeyer (1962) in a review of experiments using operant reinforcement techniques with normal, retarded and psychotic children:

> The reinforcers used have included trinkets with nursery school children . . .; pennies with grade school children . . .; and candy with feeble-minded and psychotic children. In many of these experiments, the authors report large satiation effects, inability to sustain the performance of every subject, necessity of using brief experimental sessions and frequently weak performances, all presumably arising from a reinforcer that is not sufficiently durable.

An area in which sensory reinforcement might be very useful if proven effective is with auto-instructional devices or "teaching machines." A number of researchers, e.g., Hull (1943), Perin (1943), and Wolfe (1951), have determined that a reward is most effective when delivered immediately, i.e., the strength of the reinforcement is inversely related to the time between the response and the presentation of the reinforcing stimulus. Constructors of teaching machines rely upon this principle for a good deal of their effectiveness, and depend upon immediate confirmation, or knowlege of results, to reward correct responses. Knowledge that an answer is correct is usually adequate reward for older and more intelligent children and adults, but is of dubious value with the retarded and very young normals. It would seem advantageous, therefore, to construct a new teaching machine, or a reward mechanism that could be used with currently available teaching machines, that is capable of dispensing primary reinforcers. However, the use of conventional primary reinforcers such as candy with a teaching machine presents a number of problems: typical food dispensers may be too cumbersome for use by

a large number of students in a regular classroom; too much time may elapse between response and ingestion of the candy reward, and the pupil's pausing to eat the candy ingerferes with the progression of the programmed material.

Conversely, however, most of these problems might be avoided by using response contingent sensory stimuli as reinforcers. Unlike a separate and perhaps bulky food dispenser, the light or auditory sensory reinforcer (bell, buzzer, etc.) would require very little space and could be built directly into the machine front panel. In addition, because electronically produced sensory reinforcement may be presented contiguously with the response and directly to the senses, any time delay between response and reinforcement can be avoided, and the reinforcer may be presented without interfering with the programmed material.

Thus far, the discussion has concerned potential areas of application if response-contingent sensory stimuli are found to be effective reinforcers with the retarded. This question has yet to be answered, however, because so few studies using sensory stimuli have been accomplished utilizing humans and, especially, human retardates. In fact, in a recent review of types of reinforcement used with the retarded, Watson (1967) failed to mention a single study in which sensory stimuli were used as reinforcers. The present investigator was able to find two studies (Baumeister and Ward, 1967; Stevenson and Knights, 1961) using retarded children, but one of these does not fully qualify as a sensory reinforcement as it has been traditionally defined (see page 5).

Another reason for conducting this experiment is the disagreement in the literature concerning reinforcement value of auditory stimuli. Whereas visual stimuli have been shown to have reinforcing effects in many areas of application, studies on auditory stimuli are contradictory. Symmes and Leaton (1962), for example, were unable to demonstrate any reinforcing effect in auditory stimuli used with rats.

Barnes and Kish (1961), however, demonstrated that auditory stimuli can be reinforcing with reinforcement value being related to intensity and frequency.

Consequently, the reasons for undertaking this study are to determine if sensory stimuli of the type found to have reinforcing capabilities with other species are also effective with the human retardate and, if so, to ascertain if stimuli presented auditorily exert greater reinforcing effect than stimuli presented visually.

Hypothesis. The following null hypothesis was stated prior to the study: There will be no significant difference between the number of errors committed during the learning task by the groups receiving response-contingent sensory stimuli and the number of errors committed by the control group.

II. DEFINITIONS OF TERMS

Adaptive behavior; Adaptive behavior level-III. The term adaptive behavior is used to describe the effectiveness with which the individual copes with natural and social environmental demands. Children placed in adaptive behavior level-III are described as ". . . capable of limited social and economic functioning in a noncompetitive or sheltered environment, but will be dependent upon some general control and support." (Leland, 1964).

Control group. The control group is a group of subjects used in an experiment that is made as nearly like the experimental group as possible except that it is not administered the treatment of interest.

Experimental group. The experimental group is the group in which the treatment of interest is administered. In this study there were two experimental groups: Experimental group number I had the introduction of response-contingent auditory stimuli as the treatment of interest; Experimental group number II had the introduction of response-contingent visual stimuli as the treatment of interest.

Reinforcer. The concept of reinforcement forms an integral part of most

contemporary theories of learning, e.g., Hull (1952), Skinner (1958), and although there is considerable disagreement concerning the exact nature of reinforcement (for example, whether or not drive reduction is involved), few would argue with the following definition of a reinforcer: "A reinforcer is a stimulus event which, if it occurs in the proper temporal relation with a response, tends to maintain or increase the strength of a response or of a stimulus-response connection." (Deese and Hulse, 1967).

Kish (1966) has stated that, traditionally, events capable of exerting reinforcing effects could be placed into four broad categories: (1) those substances such as food or water which reinforce because of their relation to some organic need condition (primary positive reinforcement); (2) the removal of aversive stimuli such as shock (primary negative reinforcement); (3) something which has reinforcing effect because of its prior association with a primary positive reinforcer (secondary positive reinforcement); and, (4) a stimulus which, upon its removal, has reinforcing effect because of its prior association with a primary negative reinforcer (secondary negative reinforcement).

Sensory reinforcement. Kish (1966) defines sensory reinforcement in the following manner:

> Sensory reinforcement will be used to refer to a primary reinforcement process resulting from the response-contingent presentation or removal of stimuli of moderate intensity which cannot be subsumed under classes 1, 2, 3, and 4.

It should be made clear that, although not explicitly stated in the definition, the term sensory reinforcement applies only to those stimuli of a quite simple nature such as a single light flash or a clear tone of unvarying frequency and amplitude, and not to stimuli such as music, voices, illuminated pictures, or other more complex stimuli that may have secondary reinforcement value.

White noise. White noise is a "sound effect of a number of random sound

waves presented simultaneously." (Chaplin, 1968).

III. LIMITATIONS OF THE STUDY

An important limitation of this study derives from the fact that the subjects comprising the experimental sample were all patients from an individual cottage in a single state institution for the mentally retarded. Because each institution has its own unique ambience, including, usually, specialized training programs which impart to the patients experiences that other groups might not have, one must be very cautious attempting to generalize the results of this study to the entire retarded population.

The fact that the subjects were all female is another limitation of the study that must be considered when attempting to generalize the results.

It is also important that the findings of this study be applied only to visual and auditory sensory stimuli of a similar nature to that used here, i. e., it should not be assumed that all lights or sounds are similar in effect, even when applied to a similar population.

CHAPTER II

REVIEW OF THE LITERATURE

Perhaps the first to investigate the reinforcing effects of visual sensory stimuli, usually called light-onset reinforcement, was Girdner (1953) who, in order to test the hypothesis that animals engage in exploratory behavior to expose themselves to novel stimuli, devised an experiment in which a rat in a Skinner-box could turn on a light by pressing a lever and thereby expose itself to the visual stimulation. His prediction was borne out when rate of emission of the lever-pressing behavior increased upon reinforcement with the light. Other studies of a similar nature have also demonstrated the reinforcing effect of response contingent visual stimulation with rats (Kish, 1955; Marx, Henderson, and Roberts, 1955).

Other studies, such as those by Sterritt (1966) and Meyer (1967) have demonstrated that light-onset stimuli have reinforcing capabilities across species. Sterritt discovered that chicks raised in dim light would peck at a higher rate for a reward of exposure to ten seconds of bright light. Meyer used two light intensities and three ratio schedules with chicks and found that although light proved reinforcing at all intensities and schedules, it was most effective at the strongest intensity and lowest ratio.

As mentioned in Chapter I, there has been some disagreement concerning auditory reinforcement. Whereas light-onset has been shown to have reinforcing effects in nearly all areas of application, studies in the area of auditory reinforcement have generated a great deal of conflict concerning the reinforcing effect of auditory stimuli across species.

Symmes and Leaton (1962), for example, studied the effect of auditory stimuli on a group of thirty-three rats. They were unable to demonstrate any reinforcing properties in a pure tone, white noise, or a warbling tone presented at fifty and

seventy decibels.

Barnes and Kish (1961), in a study involving one hundred mice, tested the reinforcing properties of auditory stimuli presented in ten frequencies ranging from seven hundred to sixteen thousand cycles per second, five intensities ranging from forty-five to ninety-five decibels, and two levels of pure tone. They determined that, whereas the lower frequencies and intensities of response-contingent pure tones did maintain higher response rates than non-contingent controls, the higher frequencies and intensities tended to have a depressive effect upon rate of responding. They also found, however, that even the lower frequencies and intensities of auditory stimuli were very weak reinforcers in comparison with response-contingent illumination. A possible explanation of this low reinforcing effect was that the tones used were too simple. This led Baron and Kish (1962) to devise an experiment with mice wherein they were able to compare the reinforcing properties of a continuous pure tone, an intermittant pure tone, and a complex sound consisting of three pure tones presented in rapid succession. Contrary to expectations, they found that, although all tones led to a decrease in response rate, the complex tones were responsible for a greater decrease than the simpler, pure tones.

The preceding studies appear to indicate that, not only is light a far better reinforcer than sound, but also that sound is sometimes an aversive stimulus and a hinderance to learning.

Other studies on different populations suggest that auditory stimuli may be effective reinforcing agents. For example, Butler (1957), in his research on exploratory drive in monkeys, demonstrated that rhesus monkeys would learn a position discrimination response in order to receive a reward of hearing fifteen seconds of sounds picked up by microphone from the monkey colony area.

In another study, Butler (1958) reported on the efficacy of both visual and auditory stimuli as reinforcers with monkeys by rewarding them with lighted pictures

(monkey, dog, empty cage), and tape recorded sound (feeding sounds, single monkey sounds, white noise, rage sounds, and dog sounds). He noted that although the majority of the sounds and pictures were effective reinforcers, the dog picture, dog sounds and rage sounds had no reinforcing properties.

Although Kish (1966) referred to the studies by Butler as illustrative of the primary reinforcing effects of auditory stimuli with primates, Kish stated that many of the stimuli used by Butler probably had secondary reinforcing properties.

The scant number of studies reported on sensory reinforcement with humans do little to resolve the question of whether response contingent visual and auditory (sensory) stimuli have reinforcing properties when applied to the human population. In addition, the present researcher has found no studies reported on humans where a comparison has been made between the reinforcing effects of visual and auditory stimuli with the same population.

One of the first studies reporting the use of sensory stimuli with humans was that by Terrell and Kennedy (1957) who used five groups of children to study the relative effectiveness of five different reinforcement conditions. One group received a light flash as reinforcement; another group received a piece of candy for each correct response; a third group received a token which could later be traded for a piece of candy; and the other two groups received either verbal praise for a correct response or verbal reproof for an incorrect response. Candy proved to have the greatest reinforcement value, but there was little difference between any of the other reinforcement conditions. One cannot discern from this study whether the light flash (or, in fact, any of the stimuli other than the candy) had any reinforcing properties for the authors failed to provide a control group.

This criticism of lack of control group applies also to another study by Terrell (1958) in which he investigated the relative effectiveness of four different reinforcement conditions, again using normal children as subjects. In one condition, each

correct response was followed by a flash of light only, and in the other three conditions a light flash after each correct response was accompanied by (1) a piece of candy, (2) a verbal statement to the child that he would receive a piece of candy later, and (3) a token which could be turned in for candy after the experiment. The results of this study were very interesting in that light paired with verbal promise of a later candy reward was a much weaker reinforcer than the other three conditions which were approximately equal in effect. It appears that the light plus verbal statement may have actually interfered with the learning process somehow in that the children received more stimulation in this condition than in the light only condition, yet they learned at a slower rate.

Social class, a variable which is sometimes considered in learning experiments, was examined in a study by Terrell, Durkin, and Wiesley (1959). They utilized children drawn from middle and lower class families in order to test the hypothesis that a tangible reinforcer (candy) plus a light flash presented simultaneously after each correct response would have greater reinforcing effect with lower class children than would a light flash alone. The results of this study confirmed this hypothesis: the candy and light condition was more effective with lower class children, but with middle class children there was no difference in reinforcement effect between the candy-light condition and the condition where a light flash was presented alone. This was interpreted by the authors as a reflection of both the economic differences between the two classes which made candy a more highly valued item for poorer children, and the differing value systems where "being-right" was an important middle-class goal and, subsequently, information to that effect a powerful reinforcer. Still, as no control group was used, it is impossible to tell whether the light was in itself reinforcing or whether it served merely as a signal indicating correctness of response.

As mentioned in Chapter I, the present investigator was able to find only two studies using retarded children (Baumeister and Ward, 1967; Stevenson and Knights, 1961), and the stimuli used in the second of these does not fully qualify as sensory reinforcement as it has been defined for this study.

A study by Baumeister and Ward (1967) does, however, appear to verify the reinforcement properties of an auditory stimulus. Baumeister and Ward studied the effects of sensory and traditional rewards on the reaction times of retardates. One group was rewarded with praise, another group with the sound of a bell, and a third group, used as a control, recieved no reinforcement. The praise, bell, and money-bell groups all experienced significant increase in reaction speed, but the control group decreased their speed of reaction (increased reaction time). There were no significant differences in reaction times between the praise and money-bell groups or between the bell and praise groups. The money-bell group, however, did produce significantly faster reactions than did the bell only condition.

In the second study using retarded children, Stevenson and Knights (1961) compared normal and retarded children on a simple motor task in order to test the hypothesis that visual stimuli would maintain its reinforcing effects for a longer period of time with the retarded than with normals. This prediction was borne out by the results of the study. The visual reinforcement used here was not pure sensory reinforcement, however; instead, the investigators used pictures of animals which they illuminated from behind. These reinforcers, then, probably carry some additional associations for each child which he would not experience when presented a simple light stimulus.

And, finally, Edwards and Filby (1963), in a study related to the development of automated teaching methods to test and teach form discrimination to aphasics, used a one second flash of colored light as a reinforcer. The study involved adult aphasics as subjects in a matching-to-sample discrimination task. The

main goal of the study was to compare aphasic learning ability with that of normals. Although there was no significant difference between the two groups on the task described, it was reported that the light generally appeared to be an adequate reinforcer. The authors did mention that the light flash seemed to lose its effect toward the end of the program of one hundred and eighteen trials.

It appears, therefore, that a number of deficiencies exist in the collected data on sensory reinforcement with humans, and especially with the retarded. This researcher, for example, has found no studies reporting on the reinforcing effects of simple visual sensory stimuli with the retarded (pictures are considered to have secondary reinforcing properties) and, in addition, only one was performed with a control group, and none of the six compared the relative effectiveness of auditory and visual reinforcers with the same population.

The purpose of the present experiment is to determine if simple auditory and visual sensory stimuli are effective reinforcers with mentally retarded children and, if so, whether one stimulus is superior to the other. This study was accomplished by a learning situation wherein presentation to the subject of visual stimuli, auditory stimuli, or no stimuli (control condition) was contingent upon making the correct choice in a multiple-choice situation.

CHAPTER III

METHOD

Subjects. The subjects were eighteen female mentally retarded patients on the same cottage at Parsons State Hospital and Training Center, a state institution for the retarded. All had been classified at adaptive behavior level-III (Leland, 1964). Their ages were between seventeen and twenty-seven years old with their average age 20.4 years. Their IQs were between 37 and 98 as measured on the Draw-A-Man test (Goodenough, 1926) that was administered and scored by this investigator.

Apparatus. The response mechanism (Appendix Figure 1, a and b) was an eight inch by ten inch Pressey-type punchboard (Pressey, 1950) modified so that a correct answer would close an electrical circuit connected to either a buzzer or light reinforcer. The punchboard contained five rows of one-fourth inch holes, four holes to a row. A one-eighth inch rim around each hole was painted either red, green, yellow, or black to correspond to the color-coded stimulus cards. The punchboard was constructed of one-fourth inch hardboard with a space between the front and back that allowed insertion of one of the three answer keys. The answer keys were constructed of masonite with holes drilled to allow passage of the stylus through the keys to make contact with the metal plate in front of the back-board. The keys could each be inserted into the punchboard in four different ways, and the holes in the keys were arranged randomly to prevent position responses. The metal plate in front of the backboard formed part of the electrical circuit which was completed when touched by the stylus. Answers were recorded on a piece of six inch by eight inch paper inserted between the face of the punchboard and the answer-key. A large hole in the paper caused by the stylus passing completely through indicated a correct response, and a small hole caused by only the tip of

the stylus puncturing the paper indicated an error.

The stylus was constructed of a three-sixteenth inch pointed steel rod which had a wooden handle covering four of its six inches of length. The steel was connected by electrical wire to a plug connection in the punchboard.

The main body of the apparatus was constructed in the form of a suitcase measuring sixteen inches by twenty-four inches by eight inches. The visual reinforcer, a red light made from a three inch diameter round red plastic safety reflector, was mounted flush in the white-painted lid of the case. Illumination was provided by a standard six volt automobile tail-light bulb mounted inside the lid behind the reflector. The case itself contained a U.S. government surplus interval timing unit which was wired directly to the 110 volt power source. The timer was connected in turn to a six volt transformer which powered both buzzer and light. These components were covered by a panel which held the on-off switch, the time adjustment knob for the timer, and a switch which directed current to either the light, the buzzer, or neither. During operation, the lid was removed and put in a position which placed the light-reinforcer directly in front of the subject and served to conceal the main body of the apparatus.

The stimulus materials were pictures of girls involved in five different problem situations of a social nature. Each stimulus picture was accompanied by four smaller pictures illustrating different possible responses to the problem in the larger card. The drawings were in black pencil on white cards measuring nine and one-half inches by twelve inches for the stimulus cards and five by six inches for the response cards. These pictures are illustrated in the appendix.

Since many of the subjects could not read, it was necessary to color-code the answer pictures to match correspondingly colored holes in the punchboard. However, in order to avoid color-determined responses, color was not placed directly on the cards; instead, the cards were placed on eight and one-half inch by

eleven inch colored squares of cardboard on the table in front of the subject. The positions of the pictures, and hence their color, were assigned randomly for each trial.

The experiment was conducted in a room that had been partially soundproofed, so extranious noise was minimal. The room measured eleven feet by twelve feet and contained a twenty-six inch high rectangle table and two plain chairs.

Procedure. The eighteen subjects were assigned to the three reinforcement conditions in a randomized block design. The subjects were first ranked in descending order according to I.Q. The upper three subjects were assigned to the first stratum, the second three subjects to the second stratum, etc. . . ., until six strata were formed. Then, random sampling from each stratum insured that only one of the subjects from each stratum was assigned to each reinforcement condition.

Before starting the actual study, the subjects were given instruction and training on use of the apparatus and were familiarized with the type of material they would be asked to learn later. The subjects were brought into the room individually and asked to sit in a chair facing the table upon which the apparatus had earlier been arranged. The experimenter then sat in a chair at the side of the table and gave the following instruction; "This is a machine which I would like to use to find out how quickly you can learn some things. I will first show you a big picture which I want you to look at carefully (showed subject picture of cup).[1] Now, here are four smaller pictures (laid the pictures on the colored cardboard). One of them is like the big picture, but three of them are different--you point to the one which is just like the big picture." If the subject failed to point, or

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[1]A simple matching-to sample task was used for the first illustration in order to allow the subjects to concentrate their attention on learning the apparatus and procedure.

pointed to the wrong one, the experimenter showed her the correct picture and asked the question again until the subject pointed it out correctly. Upon pointing to the correct picture, the subject was given these additional instructions: "Good, you pointed to the right picture, now let's do it again (pictures were rearranged and the task repeated). Now, instead of pointing to the picture, I want you to show me the picture you mean in a different way. See, the picture you said was the right one is on the red card. Now, do you see this punchboard? One of the holes has a red circle around it. I want you to show me you picked the red card by taking this thing (stylus) and pushing it into the red hole like this." At this point, it was usually necessary to give individual instructions, varied somewhat for each subject. Some subjects had difficulty with the apparatus, and it was necessary to rephrase the instructions or repeat them several times. Only after the subjects had a thorough knowledge of the operation of the apparatus, as demonstrated by four successive correct responses, were they presented with a task similar in nature to those in the actual study (all tasks up to this time had been matching-to-sample). This task consisted of a large picture showing a boy going onto a playground where a second boy was playing basketball. The four small pictures show (1) the boys fighting, (2) the first boy throwing rocks at the second boy, (3) the first boy running away with the basketball, and (4) both boys playing basketball in a friendly manner. The subjects were given the following instructions: "Here is a picture of a boy going onto a playground where another boy is playing basketball. Do not try to find a little picture that looks just like the big one because there isn't any. Instead, I want you to find a little picture that shows what the boy should do next. When you find the right picture, show me which one it is the same way you did last time." The subjects were tested on this set of pictures and another of the same type until it was clear they understood the nature of the task and could give the

correct answers for four consecutive presentations of the pictures. When all of the subjects had met this criteria, the actual study was begun.

The subjects were seated as in the training period with the punchboard directly in front of them on the table. The lid of the apparatus containing the red light was placed two feet, six inches from the front edge of the table directly before the subject. The main body of the apparatus was behind the lid and could not be seen by the subject. The colored cards upon which the pictures would be placed were in the space between the lid and the punchboard, with a space above the colored cards for the placement of the large stimulus card. The experimenter was seated at the side of the table where he could change the pictures without disturbing either the subjects or the apparatus.

The subjects were given the following general instructions: "I am going to show you some more pictures. As before, there is one big picture and four little pictures. You look at the big picture first, then find the little picture that shows what should happen next. You show me which is the right picture by punching the 'thing' in the same colored hole, just like you did before. If the one you choose is not the right one, keep trying until you find the one that is."

The experimenter then began to place the pictures in their positions on the table and gave the following instructions to the subjects for each set of pictures:

Picture no. 1. "This is a boy and girl going into a restaurant. Which little picture shows what should happen next?"

Picture no. 2. "This is a girl getting dressed in the morning. Which little picture shows what she should wear?"

Picture no. 3. "This is a new girl coming into the cottage. Which little picture shows what should happen next?"

Picture no. 4. "These girls are teasing this other girl. Which little picture shows what should happen next?"

Picture no. 5. "This is a girl coming into the cottage. Which little picture shows what she should do next?"

If the subject failed to respond or asked for further instructions, she was told to "Look at the big picture, then find the little picture that shows what should happen next. Then make a punch in the hole that is the same color as the picture you chose." If the subject started to make a punch in the wrong row on the punchboard, the correct row was pointed out to her. The order of presentation of the five picture sets was determined by consulting a table of random numbers as were the positions of the correct response cards.

The timer was set to provide visual or auditory reinforcement of one second duration. This time was kept constant for all subjects in either reinforcement group. Neither the buzzer nor the light had provision for regulation of intensity. Both appeared subjectively to be of moderate intensity, clearly audible and visible, but not irritating in any way. Arrangement of the apparatus was kept constant for all groups, including the control group.

Two consecutive errorless trials per set were established as criterion of learning. If an error was committed on one set, the subjects would continue to answer all sets until criterion was reached. If a subject failed to reach criterion in twenty trials, the session was terminated.

One week after the first session, the subjects were retested on the same materials. There was one trial per picture-set, and the score recorded was the number of correct responses on that one trial.

Non-parametric statistical tests were used to analyze the data because all of the assumptions (such as normality of the data) underlying use of parametric tests were not met in this study. The conditions which must be satisfied before parametric tests may be used have been described by Siegel (1956), and include the requirement that observations be independent, that observations be drawn from normally distributed populations which have either the same variance or a known ratio of

variances, and that, in the case of the analysis of variance (F test) the means of these otherwise satisfactory populations "must be linear combinations of effects due to columns and/or rows. That is, the effects must be additive."

Non-parametric tests do not require such rigid assumptions to be met, however, and are therefore more appropriate for the analysis of this experiment.

The Friedman Two-Way Analysis of Variance (Siegel, 1956) requires only that there be three or more matched samples in at least an ordinal scale, and the Mann-Whitney U Test is used under the assumption that ordinal measurement has been achieved on the two independent groups to be tested. The only assumption underlying the use of the Spearman Rank Correlation Coefficient (Siegel, 1956) is that both variables in the correlation be measured in at least the ordinal scale.

The Friedman Two-Way Analysis of Variance (Siegel, 1956) was used to determine if the three reinforcement groups were at approximately the same level when the learning task began, and if they differed in respect to the amount of learning, as measured by number of errors, and in respect to retention of the material, as measured by number of correct responses per group in the retest. If the groups were shown to differ in knowledge of the material before the learning task started, in amount of learning, or in retention, the Mann-Whitney U Test (Siegel, 1956) was employed to determine which group was responsible for the overall difference.

In order to extract additional information from the data, several other tests were performed as a supplement to the main body of the study. The Spearman Rank Correlation Coefficient (Siegel, 1956) was employed to test the correlation between amount of learning and I.Q.s, amount of learning and retention, and I.Q.s and retention.

CHAPTER IV

RESULTS OF THE STUDY AND DISCUSSION

Results. The first measurement performed on the data was to count the number of errors (incorrect choices in a multiple-choice situation) produced by each group on the first trial of the learning task; these errors were made prior to initial reinforcement (Table I). This data was then used in the calculation of the Friedman Two-Way Analysis of Variance. This measure was used to test whether there was a significant difference in number of errors on the first trial between any of the three groups; i.e., were the three groups closely matching in pre-experimental knowledge of the material to be learned? If it was found that one group was significantly superior or inferior to the others in knowledge of the task before introduction of the response-contingent stimuli, the findings of the study would have been very questionable, forcing a revision of the experimental method. Calculation of the Friedman Two-Way Analysis of Variance (Siegel, 1956, p. 32) demonstrated a X_r^2 of 4.486 which was not significant at the .05 level of confidence (a X_r^2 of 6.33 is needed to be significant at the .05 level). (Table II, p. 23.)

TABLE I

NUMBER OF ERRORS COMMITTED IN
EACH REINFORCEMENT CONDITION
ON FIRST TRIAL

	REINFORCEMENT CONDITION		
SUBJECT NUMBER	CONTROL	BUZZER	LIGHT
	NUMBER OF ERRORS		
1	7	4	6
2	7	4	6
3	7	3	4
4	2	12	8
5	8	7	10
6	6	3	5

TABLE II

FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE: DIFFERENCES BETWEEN GROUPS ON FIRST TRIAL

	REINFORCEMENT CONDITION		
SUBJECT NUMBER	CONTROL	BUZZER	LIGHT
	RANKS		
1	3	1	2
2	3	1	2
3	3	1	2
4	1	3	2
5	2	1	3
6	3	1	2
SUM OF RANKS	15	8	13

$X_r^2 = 4.486$

$p = > .05$

Having determined that the three groups were at an approximately equal level at the beginning of the learning task, the next step was tabulation of the total number of errors committed in each reinforcement group over all of the experimental trials. Experimental group number I, the group receiving auditory reinforcement in the form of a buzzer sound, made the fewest number of errors (N = 390), while experimental group number II, the group presented with visual stimuli in the form of a light flash, committed the greatest number of errors (N = 652). These values are shown in Table III.

The Friedman Two-Way Analysis of Variance was again employed to determine if there was a significant difference in amount of learning between any of the three groups as measured by total number of errors per group over all trials. This calculation demonstrated a X_r^2 of 6.49 which is significant at the .05 level of confidence (Table IV, p. 26).

The Friedman Two-Way Analysis of Variance, although able to reveal whether there is a significant variance of one or more of the groups from the others, it cannot pick out which one of the three groups is responsible for the variance. To determine the variant group or groups, the Mann-Whitney U Test, which compares the groups two at a time, was employed.

The results of the Mann-Whitney U Test are presented in Table V. Upon consulting the table it is evident that there is no significant difference between the control group and the buzzer group (a U of 7 is needed to be significant at the .05 level) or between the control group and the group presented with a flash of light. It is, therefore, concluded that the data do not give evidence which justify rejecting the Null hypothesis of no significant differences between the number of errors committed during the learning task by the groups receiving response-contingent sensory stimuli and the number of errors committed by the control group.

TABLE III

NUMBER OF ERRORS PER SUBJECT WITHIN GROUPS ON ORIGINAL LEARNING TASK

	REINFORCEMENT CONDITION		
SUBJECT NUMBER	CONTROL	BUZZER	LIGHT
	NUMBER OF ERRORS		
1	19	11	55
2	93	20	84
3	54	5	50
4	11	54	152
5	40	34	151
6	173	15	160
TOTALS	390	139	652

TABLE IV

FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE: DIFFERENCES BETWEEN GROUPS IN NUMBER OF ERRORS OVER ALL TRIALS

	REINFORCEMENT CONDITION		
SUBJECT NUMBER	CONTROL	BUZZER	LIGHT
	RANKS		
1	2	1	3
2	3	1	2
3	3	1	2
4	1	2	3
5	2	1	3
6	3	1	2
SUM OF RANKS	14	7	15

$X_r^2 = 6.49$

$p = < .05$

Although it was not possible to demonstrate a significant difference in amount of learning between the experimental groups and the control group, matching the buzzer group against the light group revealed a difference which is significant at the .002 level.

TABLE V

MANN-WHITNEY U TEST OF DIFFERENCES BETWEEN GROUPS ON LEARNING TASK

SOURCE	U	P
CONTROL X BUZZER	9	.09
CONTROL X LIGHT	10	.12
BUZZER X LIGHT	1	.002

An alternative method of viewing the data is presented in Table VI which shows the number of subjects in each group that reached the criterion score of two consecutive trials without error. This table reveals essentially the same balance between groups as does Table III, i.e., all six subjects in the Buzzer group reached the criterion score, whereas only three of six subjects in the Control group and one of six in the Light group can be considered to have learned all the material.

TABLE VI

SUBJECTS REACHING CRITERION PER GROUP

	CONTROL	BUZZER	LIGHT
Number Ss Reaching Criterion	3	6	1
Number Ss Not Reaching Criterion	3	0	5

The number of correct responses for each individual and each reinforcement group on retest one week later is presented in Table VII. The results of this phase of the study are quite similar to those presented in Tables III and VI. Although the Buzzer group appeared to register the best performance, followed in turn by the Control group and the Light group, the differences between the groups were not statistically significant. Unlike the analysis of the original learning task, calculation of the Friedman Two-Way Analysis of Variance (Table VIII, p. 30)demonstrated a X_r^2 of 3.163 which failed to reach significance at the .05 level of confidence (a X_r^2 of 6.00 is needed to be significant at the .05 level).

TABLE VII

NUMBER OF CORRECT RESPONSES
PER GROUP ON RETEST

	REINFORCEMENT CONDITION		
SUBJECT NUMBER	CONTROL	BUZZER	LIGHT
	NUMBER CORRECT ON RETEST		
1	3	4	4
2	4	5	1
3	0	4	0
TOTAL	7	13	5

TABLE VIII

FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE:
DIFFERENCES BETWEEN GROUPS ON RETEST

	REINFORCEMENT CONDITION		
SUBJECT NUMBER	NONE	BUZZER	LIGHT
	RANKS ON RETEST		
1	1	2.5	2.5
2	2	3	1
3	1.5	3	1.5
SUM OF RANKS	4.5	8.5	5.0

The results of retesting the subjects one week later cannot be considered as reliable as the results of the original learning task because three subjects were lost from each group in the time between cessation of the original learning task and the retest.

Finally, as a complement to the main body of the study and in order to provide additional descriptive statistics, Spearman Rank Order Correlation Coefficients (Table IX) were obtained on learning and I.Q. (number of errors x I.Q.), retention and I.Q. (number correct on retest x I.Q.), and learning and retention (number of errors x number correct on retest).

There was only a negligible positive correlation (.275) between learning and I.Q. which was not significant at the .05 level (r of .399 needed for .05 level of confidence).

The correlation between retention and I.Q. was also very low (.33), and also not significant at the .05 level. (r of .600 needed for .05 level of confidence).

On the other hand, however, a correlation coefficient of .81 was obtained between learning and retention. This relationship was found to be significant at the .01 level of confidence. (r of .783 needed for .01 level of confidence).

Discussion. The purpose of this experiment was to determine if simple auditory and visual sensory stimuli were effective reinforcers with mentally retarded children and, if so, whether one stimulus was superior to the other.

It was not possible to obtain an unqualified demonstration of the phenomenon of sensory reinforcement in this study because neither of the groups presented with response-contingent sensory stimuli performed significantly better on the learning task than did the control group.

TABLE IX

SPEARMAN RANK ORDER CORRELATION COEFFICIENT

MEASURES	r_S
LEARNING X I.Q.	.273
LEARNING X RETENTION	.81*
RETENTION X I.Q.	.33

*p = .01

It may be hypothesized that the failure of the study to demonstrate clearly the reinforcing properties of response-contingent sensory stimuli was possibly related to failure of the sensory stimuli to reinforce responses to a significantly greater degree than natural or other reinforcers in the situation possibly operating concurrent to the sensory stimuli. For example, the experimenter may have served as an uncontrolled social reinforcer which made "being-right" a more powerful reinforcer than correctness of response would have ordinarily been. This social reinforcement may have served to increase the learning level of the subjects to the point where additional sensory reinforcement could add very little to the performance level.

Another possibility that might be considered is that the experimental surroundings, presence of the experimenter in the testing room, the learning apparatus, etc. . . ., may have served as discriminative stimuli for responding by all subjects; i.e., the learning environment may have served as a cue or indicator to the subjects that they should perform well on the task.

In the two previous examples, the relatively short training session (one to two hours per subject) may have precluded subject adaptation to the situation and subsequent "leveling off" in the response variable measured. If the training sessions were considerably longer, the subjects might have become habituated to the experimental surroundings, thereby negating any transitory increase in responsiveness.

It is also possible that knowledge of results and kinesthetic feedback provided by operation of the punchboard were reinforcing for the subjects. Skinner, (1954) for example, has remarked that mere manipulation of teaching machines has been found to be an effective reinforcer. If such is the case in the present study, it is possible that the reinforcement provided by knowledge of results and manipulation of the apparatus was sufficient to obscure the possible facilitative effects of sensory reinforcement.

It might be mentioned that, although not statistically significant, there does appear to be some evidence to demonstrate sensory reinforcement. As shown in Table III, all members of the Buzzer group reached the criterion of two consecutive errorless trials, whereas only three of the control group and one of the Light group reached criterion. In addition, although it was not possible to demonstrate a significant difference between the Buzzer group and Control group in number of errors committed over all trials of the learning task, there was a distinct trend in the direction of significance ($p = .09$) favoring the Buzzer group.

Thus far, the discussion has been concerned with factors relevant to the inability of this study to demonstrate the superiority of sensory reinforcement, over natural or "uncontrolled" reinforcers in the control condition. Fortunately, it is possible to relate somewhat more positive findings when comparing the relative effectiveness of visual and auditory stimuli.

For example, a significant difference was demonstrated between the Buzzer group and the Light group with the Buzzer group achieving a significantly higher amount of learning than the Light group. These findings were in contradiction to the only other reported study that compared the reinforcement effects of pure auditory and visual stimuli (Barnes and Kish, 1961). The fact that the findings of the present study are in contradiction to the findings of Barnes and Kish (1961), who utilized mice, is not particularly unexpected, for other researchers (Symmes and Leaton, 1962; Baron and Kish, 1962) have also found sound to be an effective reinforcing agent.

There are several possible explanations for the greater achievement of the Buzzer group as compared to the Light group. For example, the buzzer sound may have been more of an environmental change than the light-onset and therefore a "stronger" stimulus in relation to other environmental events. Conversely, if the

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study had been conducted in a darkened room, the Light group might have achieved the greater amount. In addition, it was not possible to equate the buzzer and light in any dimension other than duration. The possibility exists, therefore, that a light of a different color, size, intensity, or shape might have an entirely different effect. One of the most likely explanations of the poor reinforcement value of the light-onset is the fact that there was a slight delay between the subject's response and her observation of the light stimulus--the subject had to raise her eyes from the punchboard to see the circle of light on the panel before her. This possibility is given credence by the findings of those researchers (e.g., Perin, 1943; Wolfle, 1951) who have demonstrated that, up to a point, the strength of a reinforcer is inversely related to the length of time between response and presentation of the reinforcing stimulus. Consequently, the light might have possibly demonstrated reinforcing properties had it been placed directly on the punchboard so the subject would have seen it immediately upon response.

And, finally, simple observation of the data portrayed in Tables III and VI, which reveals a tendency of the Control group to perform better than the Light group, leads this experimenter to suspect that onset of the light may have resulted in attenuation of any natural or uncontrolled reinforcement similar to that hypothesized to be contingent upon correct response in the control condition.

There is some additional evidence to support the suggestion that the Control group tended to perform at a higher level than did the Light group. One of the subjects in the Control group performed so poorly on the learning task (173 errors) that she was considered a deviant subject in comparison with the other subjects in the group, i.e., the subject was considered to have violated the matching achieved among the other subjects in the group. Re-calculation of the Mann-Whitney U Test (the test most likely to have been influenced by this deviant score), after substituting for the deviant score the mean error score of the other five subjects (43)

resulted in a U of 4 and a p of .013 when comparing the Control group with the Light group. Comparing the Control group and the Buzzer group failed to demonstrate a significant difference at the .05 level ($U = 10$; $p = .120$).

These re-calculations of the Mann-Whitney U Test, using an adjusted error score to compensate for the deviant performance of a single subject, should be used as a supplement to, rather than a substitute for, the original calculation. Although it is strongly suspected that an uncontrolled subject variable (such as an unknown sensory defect) was responsible for the subject's grossly defective performance, the slight though real possibility that the difference may have been a consequence of reinforcement value compels retention of the original calculation as final arbiter of any discussion of relative group standing.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this experiment was to determine if simple auditory and visual sensory stimuli were effective reinforcers with mentally retarded children and, if so, whether one stimulus was superior to the other.

In order to make this determination, a group of eighteen female patients between the ages of seventeen and twenty-seven, having I.Q.s ranging between 37 and 98, and classified as functioning in adaptive behavior level-III (Leland, 1964), were assigned by random sampling techniques to three equal groups to participate in a multiple-choice learning situation. Each group of subjects was exposed to one of the two sensory stimuli (light flash or buzzer) after each correct response or, in the case of the control group, the subjects received only knowledge of results as a possible reinforcer.

The stimulus materials were large pictures of girls involved in five different problems of a social nature. The subjects chose one of four smaller pictures as the correct solution to the problem and indicated this choice by punching with a metal stylus the appropriate color-coded hole in a Pressey-type punchboard (Pressey, 1950). The punchboard and stylus were wired to an apparatus which produced the reinforcement conditions--either the light or buzzer; in the control condition, passage of the stylus through the paper provided neither the light nor buzzer.

The following null hypothesis was formulated prior to the experiment: There will be no significant difference between the number of errors committed during the learning task by the groups receiving response-contingent sensory stimuli and the number of errors committed by the control group.

As descriptive statistics, Spearman Rank Order Correlation Coefficients (Siegel, 1956) were obtained on amount of learning and I.Q. (.273), amount of

learning and retention (.81*), and retention and I.Q. (.33).

The Friedman Two-Way Analysis of Variance (Siegel, 1956) was used to determine if the three groups were at approximately the same level when the learning task began and if they differed in respect to amount of learning, as measured by errors, and in respect to retention of the material as measured by number of correct responses per group in the retest. If the three groups were shown to vary in any of these dimensions, the Mann-Whitney U Test (Siegel, 1956) was employed to determine which group was responsible for the overall difference.

During the learning task, the criterion score of two consecutive errorless trials was reached by more subjects in the Buzzer group than either the Light group or Control group, and the Buzzer group committed fewer errors over all trials in the learning task than did either of the other two groups. However, the Buzzer group was found to be significantly superior in amount of learning only to the group receiving light flash as a reinforcer. Although a definite trend was seen toward a difference between the Buzzer group and the Control group, the data did not justify rejecting the null hypothesis at the .05 level of confidence. In addition, there was a tendency of the data to indicate that the Control group accomplished a higher level of learning than the Light group; however, it was not possible to demonstrate a statistically significant difference between the two groups.

There were no significant differences in retention among the three groups when retested one week after cessation of the initial learning period.

Conclusions. In any experiment which reports partially negative findings accompanied by a number of possible mitigating factors that may have distorted the experimental results, there is a valid question of whether the findings should be considered negative or simply indeterminate.

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*Significant at .01 level of confidence

From this experimenter's point of view, the primary conclusion to be drawn from this study is that it is still unclear whether response-contingent sensory stimuli are effective reinforcers with the retarded. Although the data demonstrated no statistically significant differences between the reinforcement groups and the control group, the possibility that confounding influences may have obscured any real differences leads this experimenter to the conclusion that further research in the area is called for with appropriate steps being taken to control the possible confounding factors.

For example, it is deemed advisable that in future research the subjects be familiarized with the experimental room and apparatus in order to diminish any possible feedback from the novel situation.

The experimenter should be out of the room if at all possible to eliminate any possible social reinforcement.

The sensory stimuli should be standardized by utilizing pure tone and light, and the light source should be near the response mechanism in order to avoid delay between response and reinforcement.

The present study was able to demonstrate positive results in the second half of the stated problem, i.e., was response-contingent sensory stimuli more effective when presented in one sense modiality than when presented in another? The observed data indicated that more learning occurred from response-contingent auditory stimuli than from response-contingent visual stimuli in the present study.

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APPENDIX

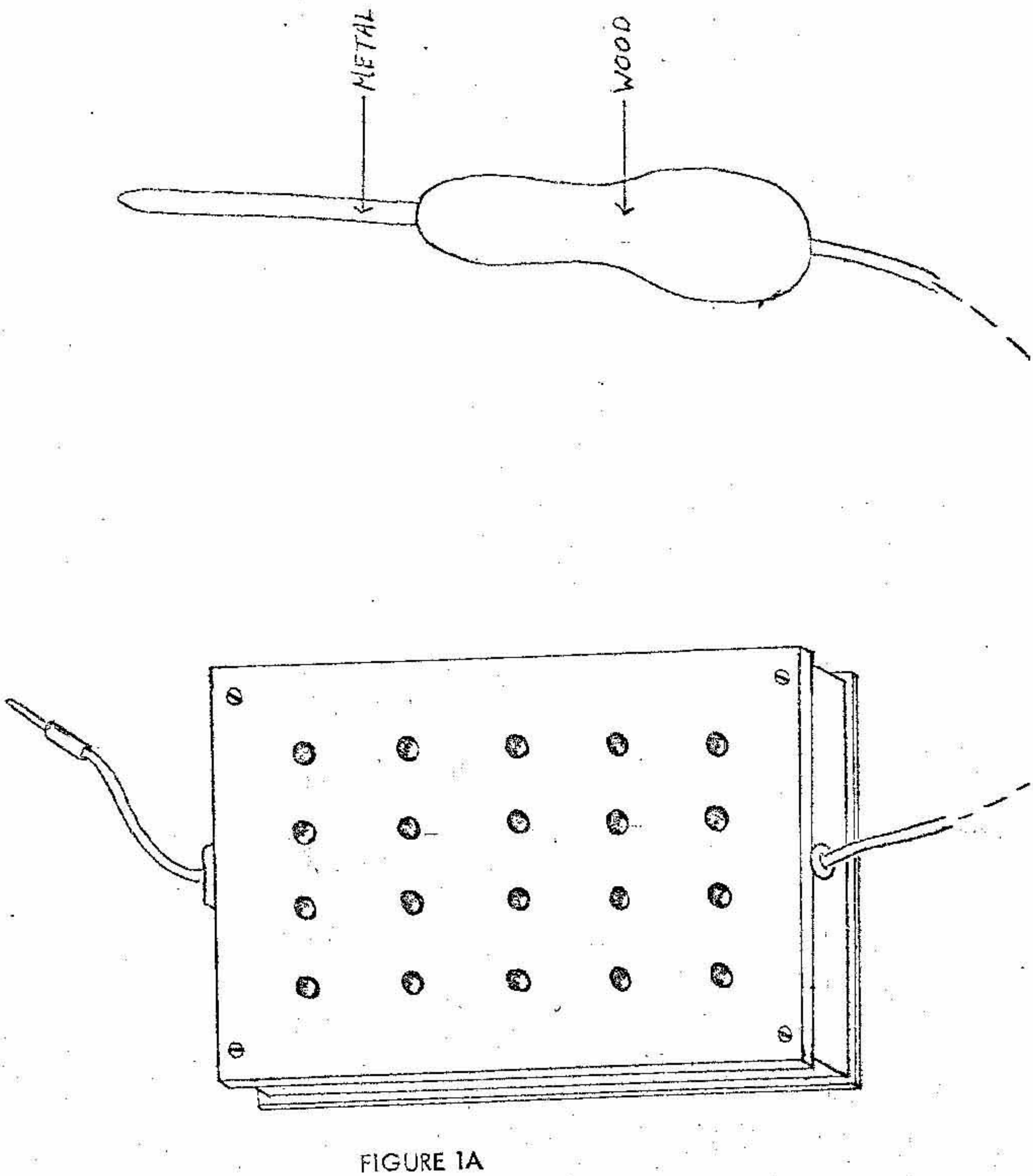


FIGURE 1A

PUNCHBOARD

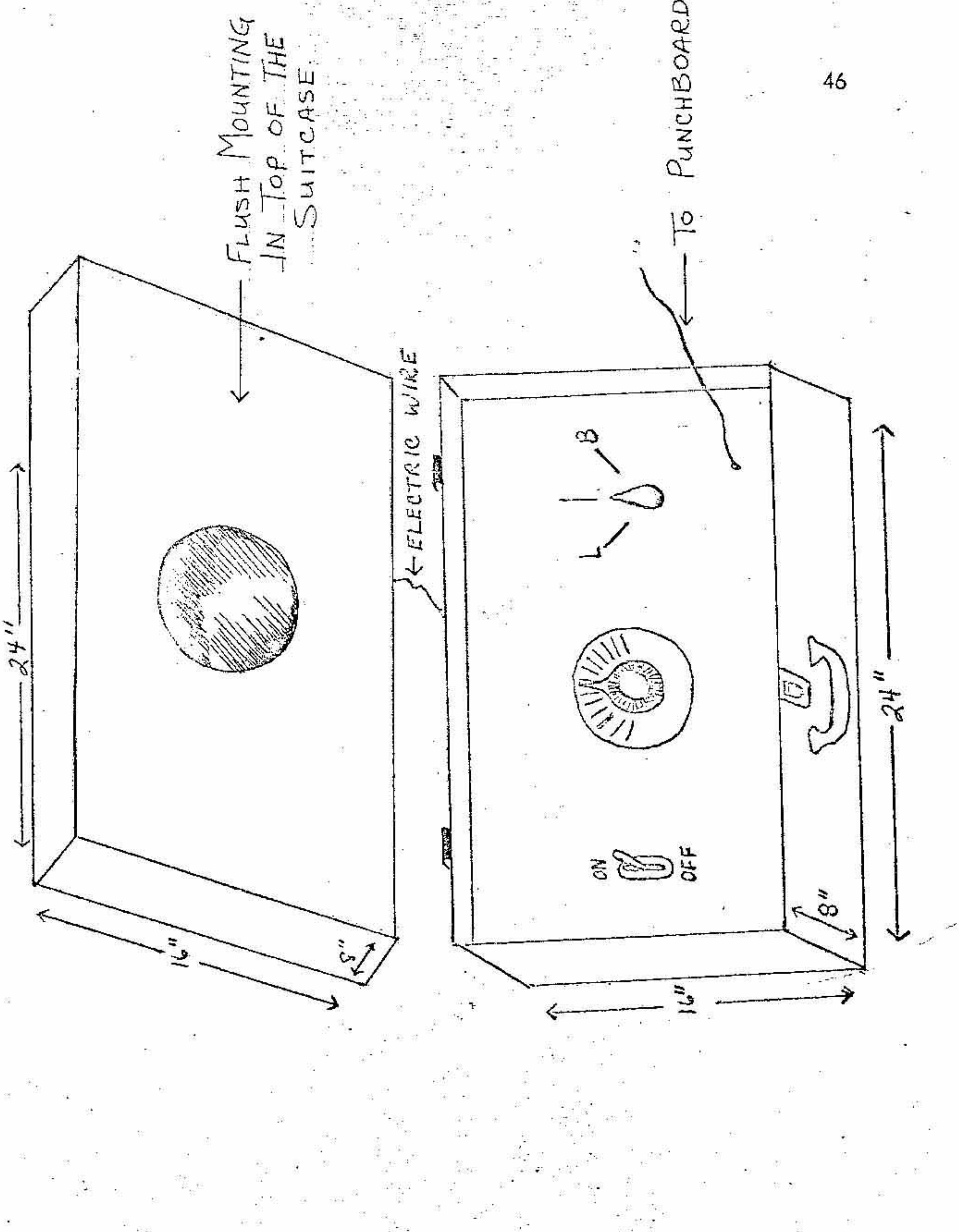
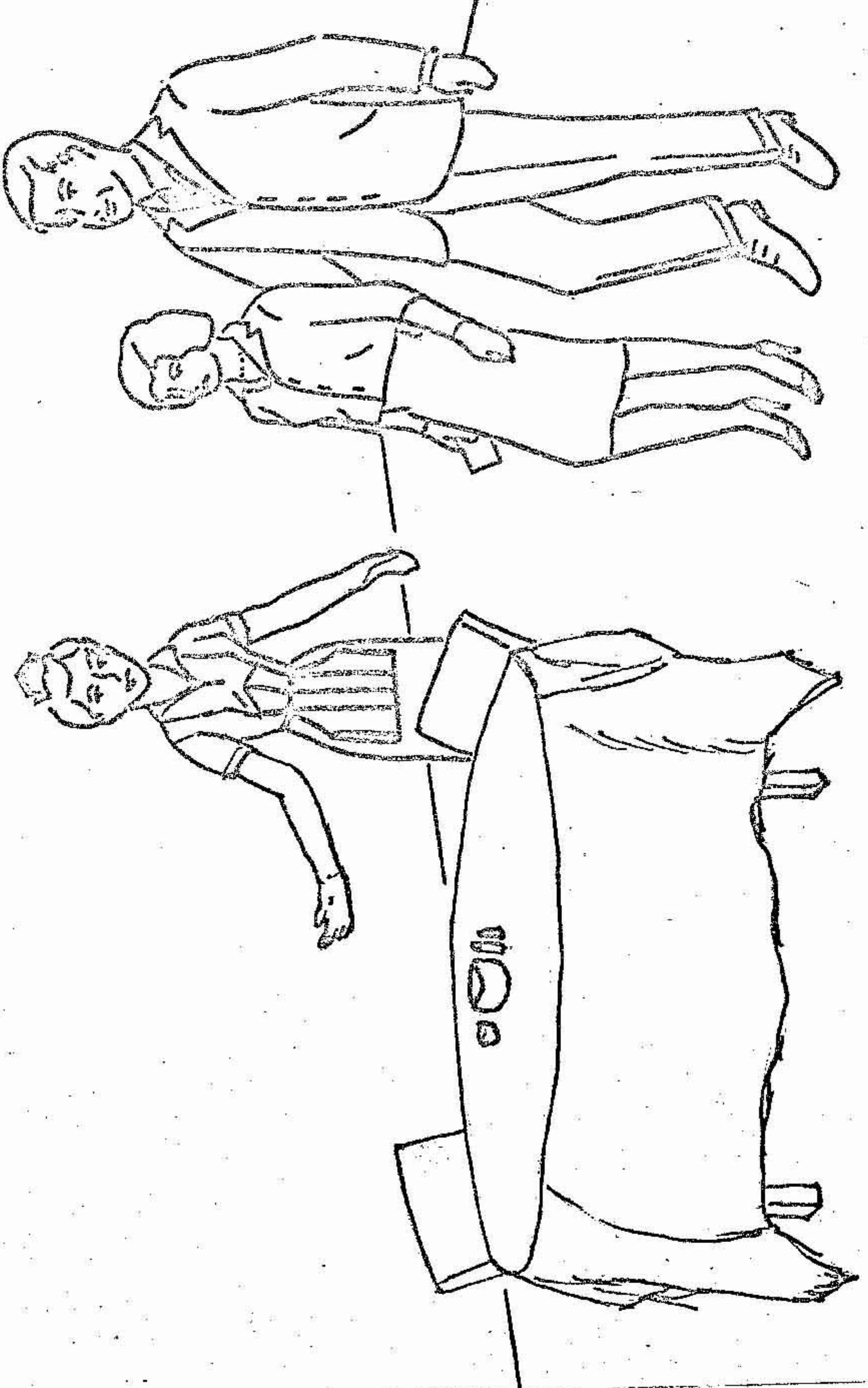


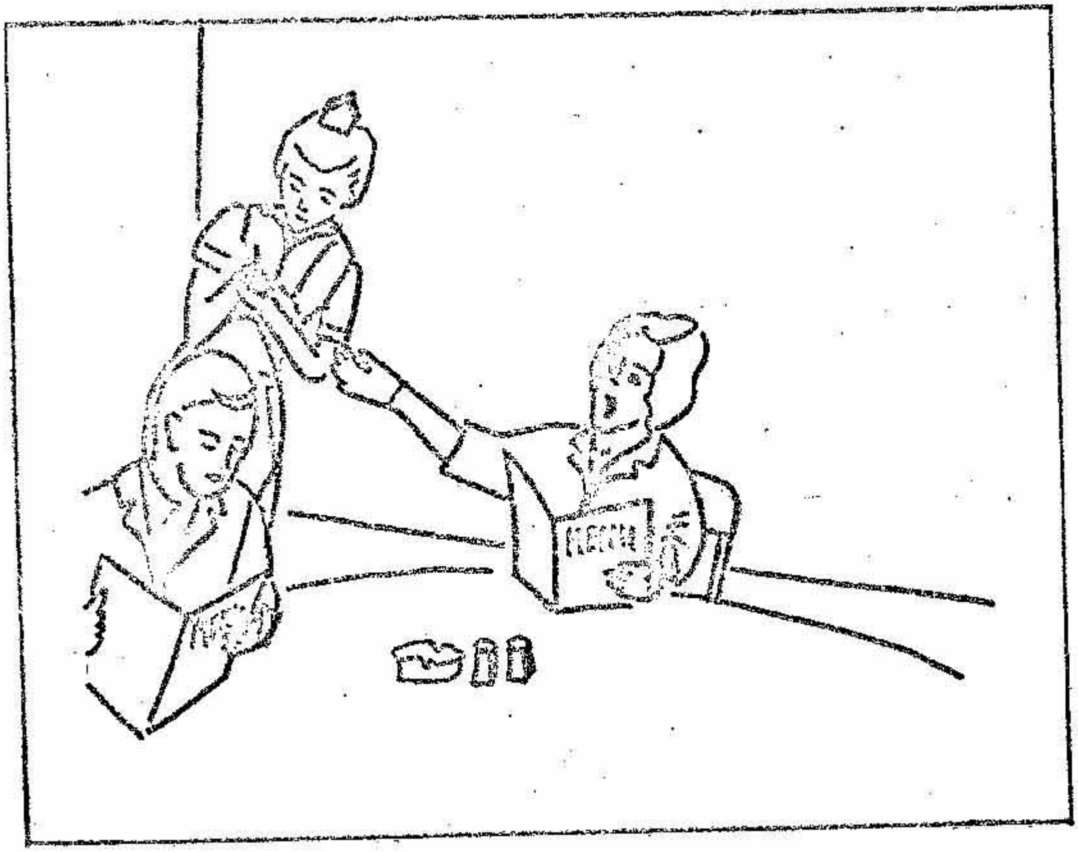
FIGURE 1B

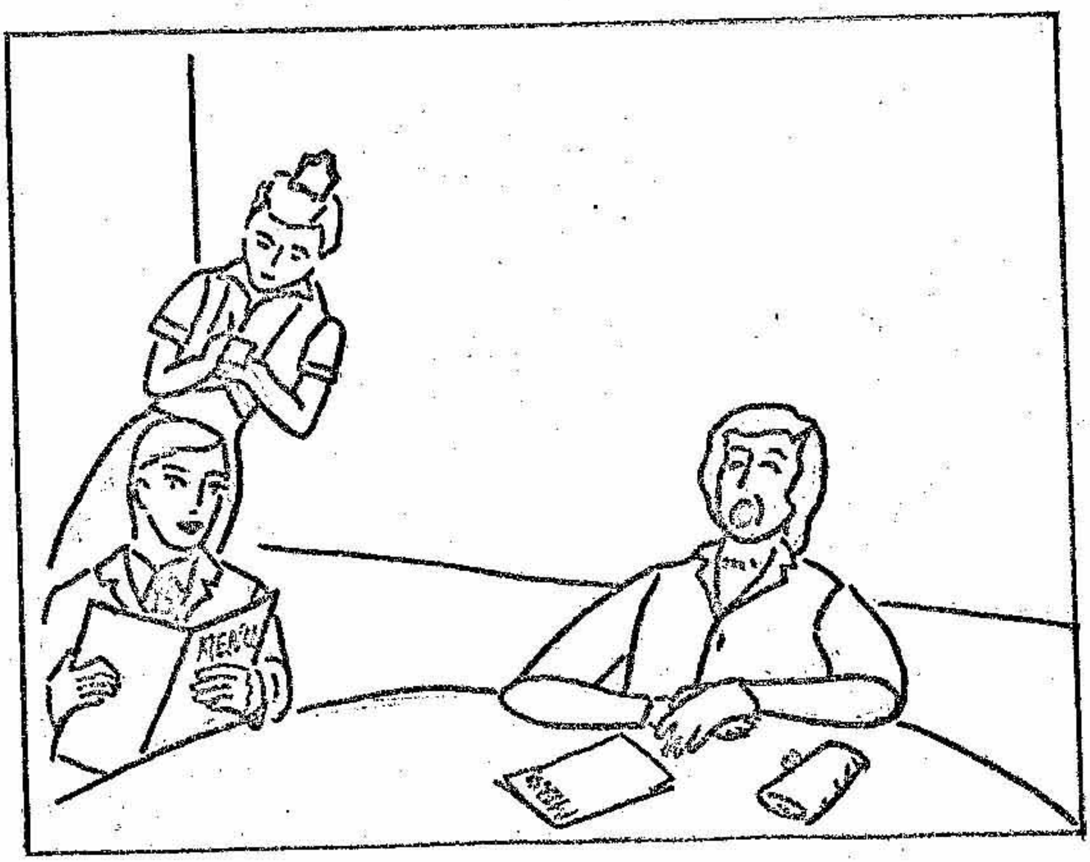
REWARD MECHANISM



STIMULUS PICTURE NUMBER 1

RESPONSE CARDS TO PICTURE NUMBER 1





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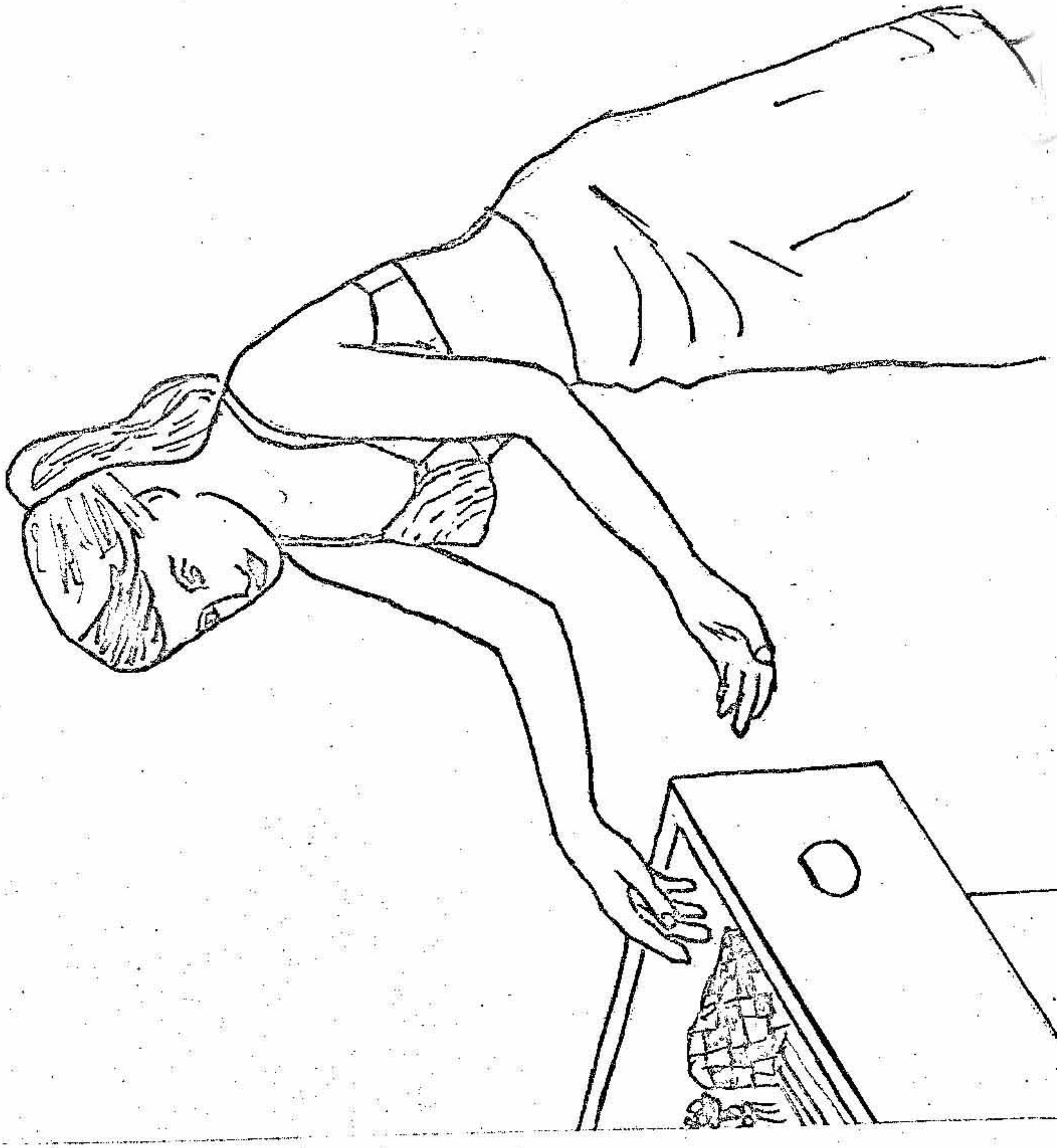

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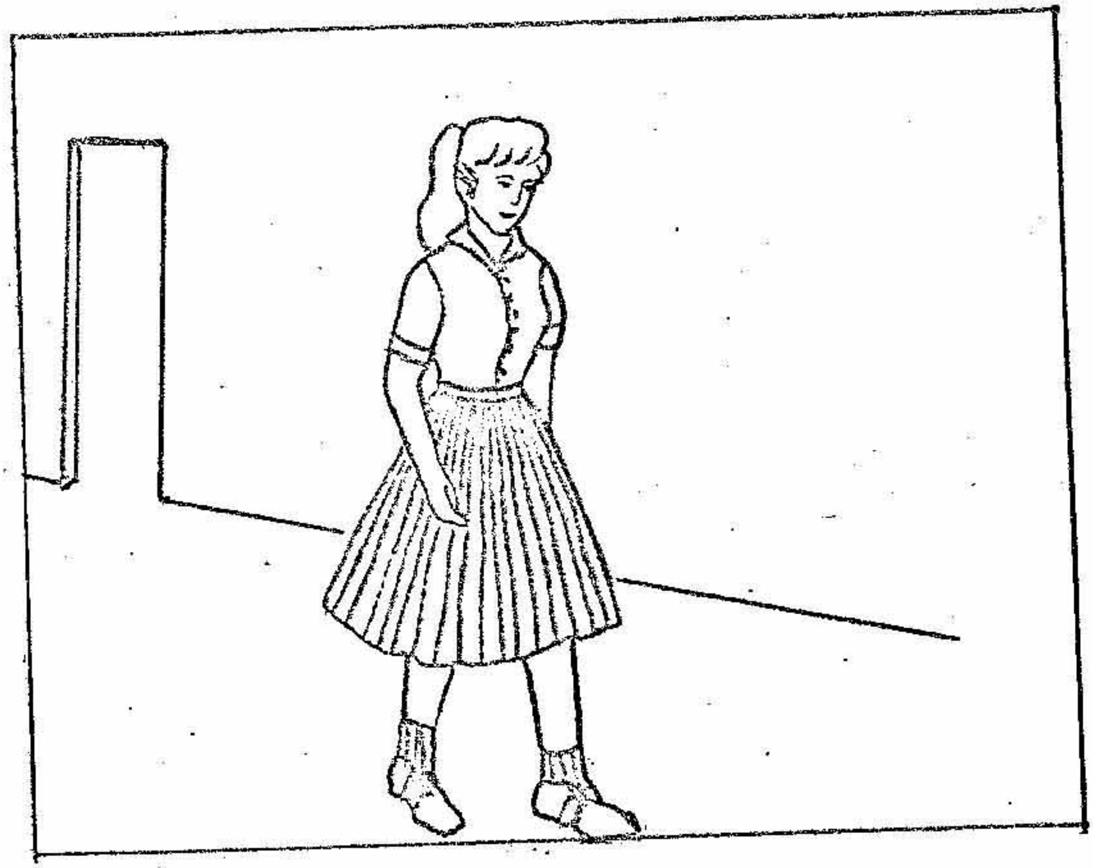

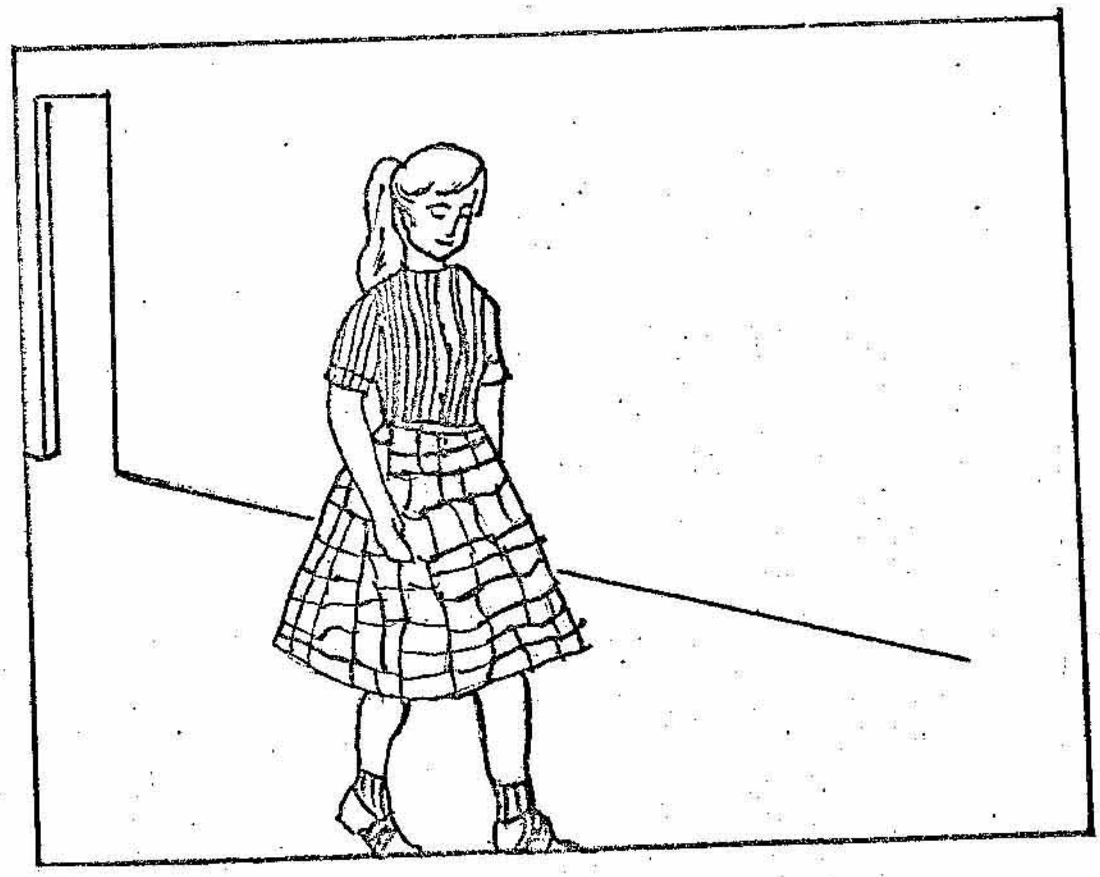

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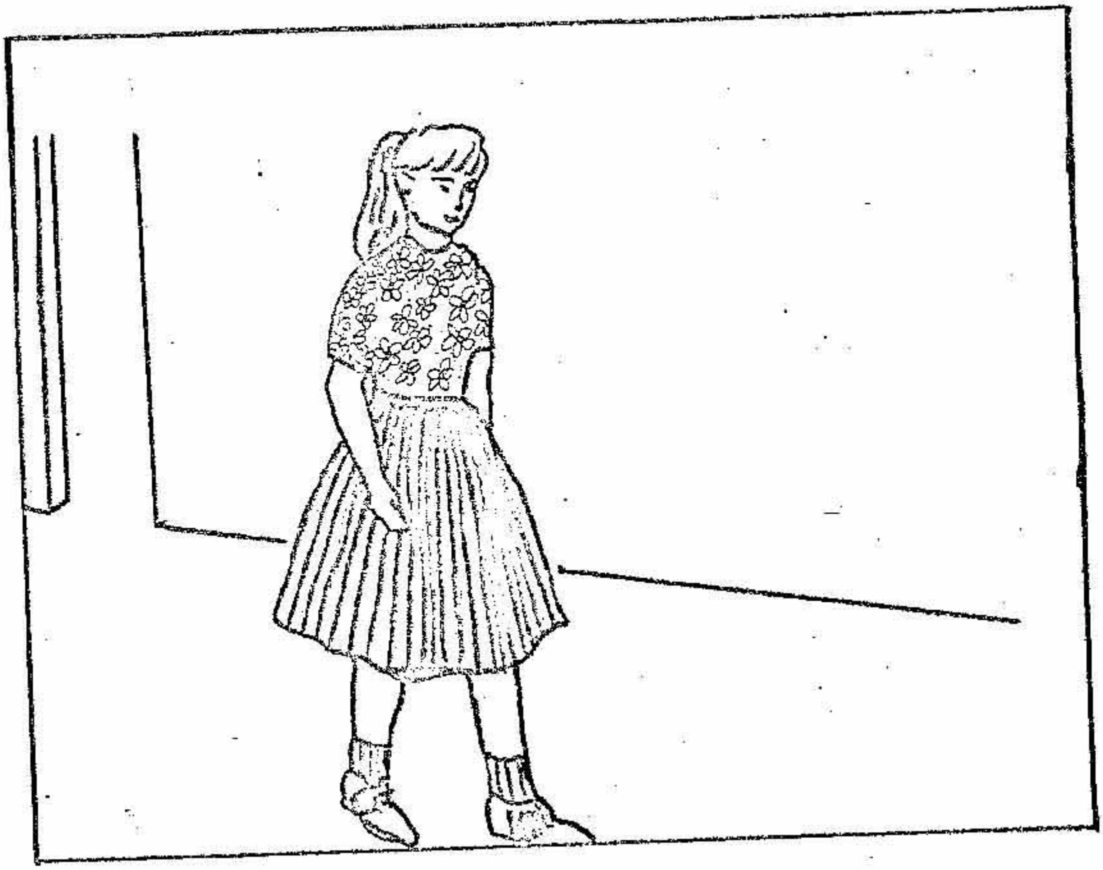

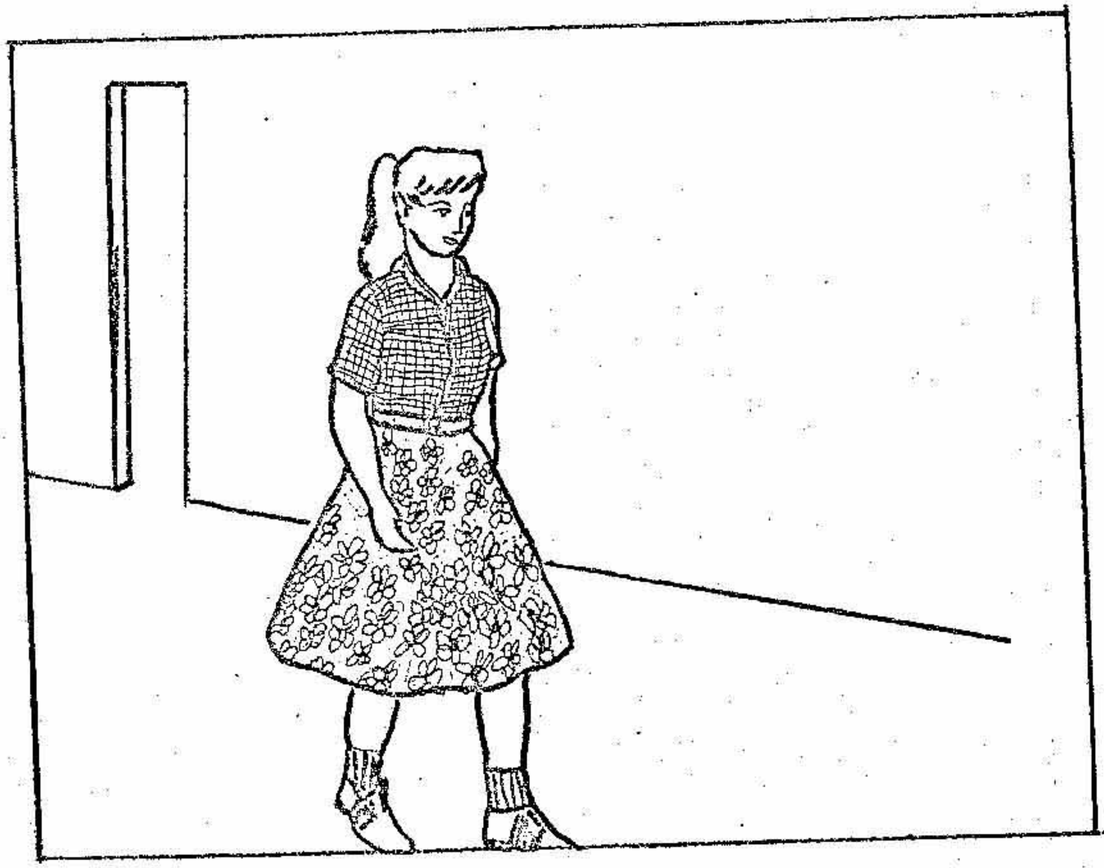

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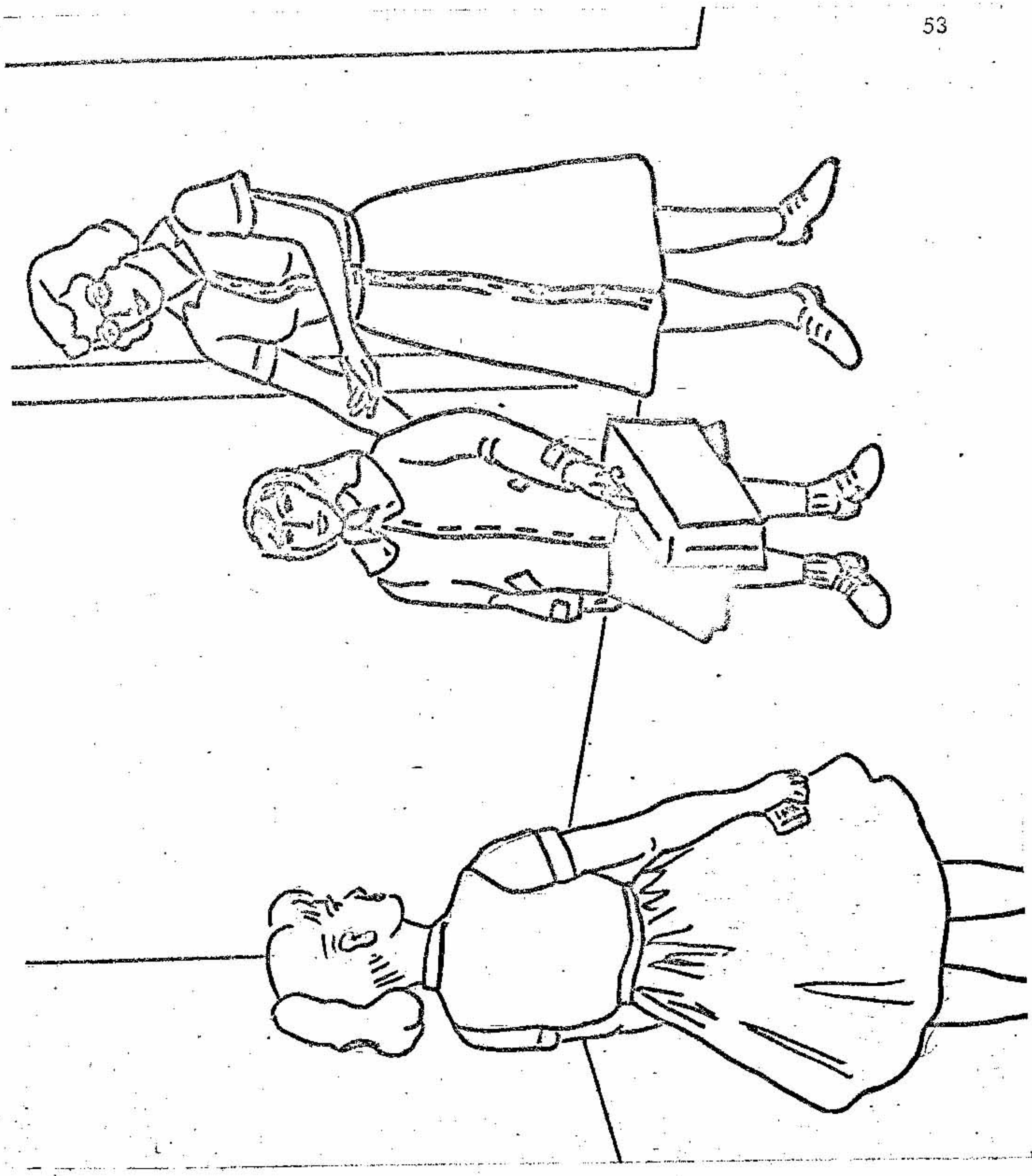

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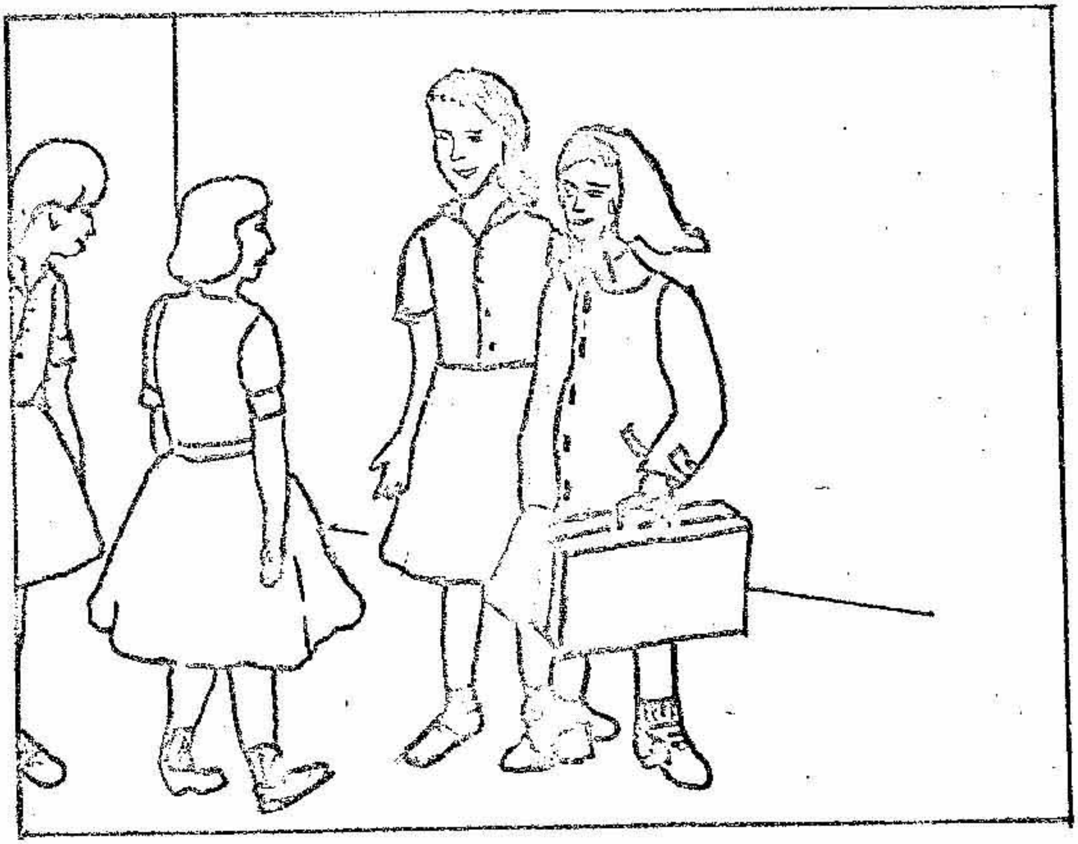

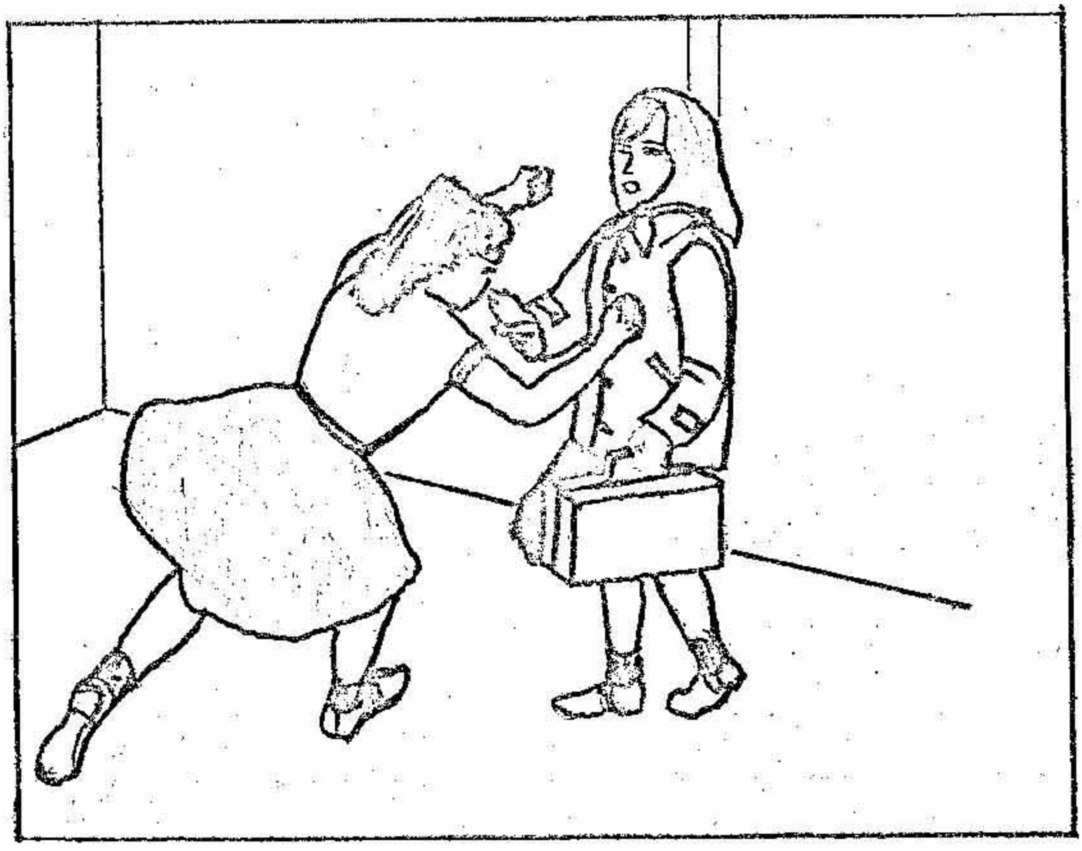

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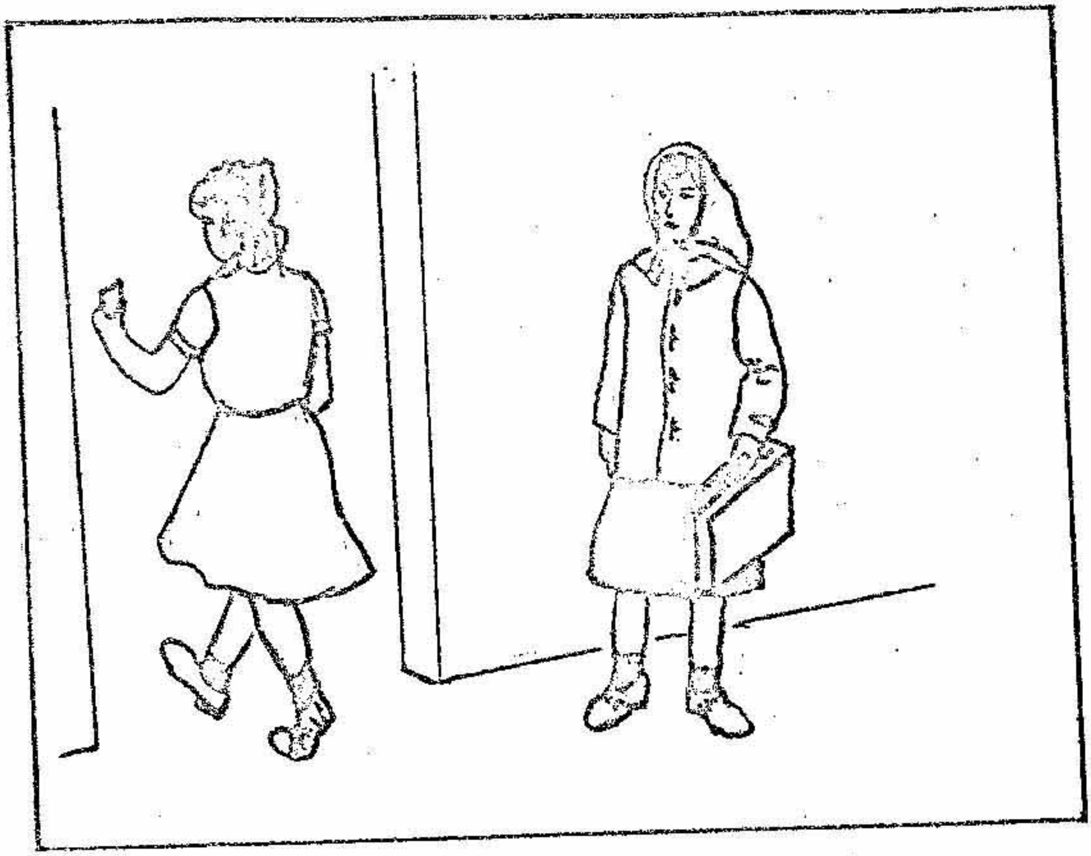

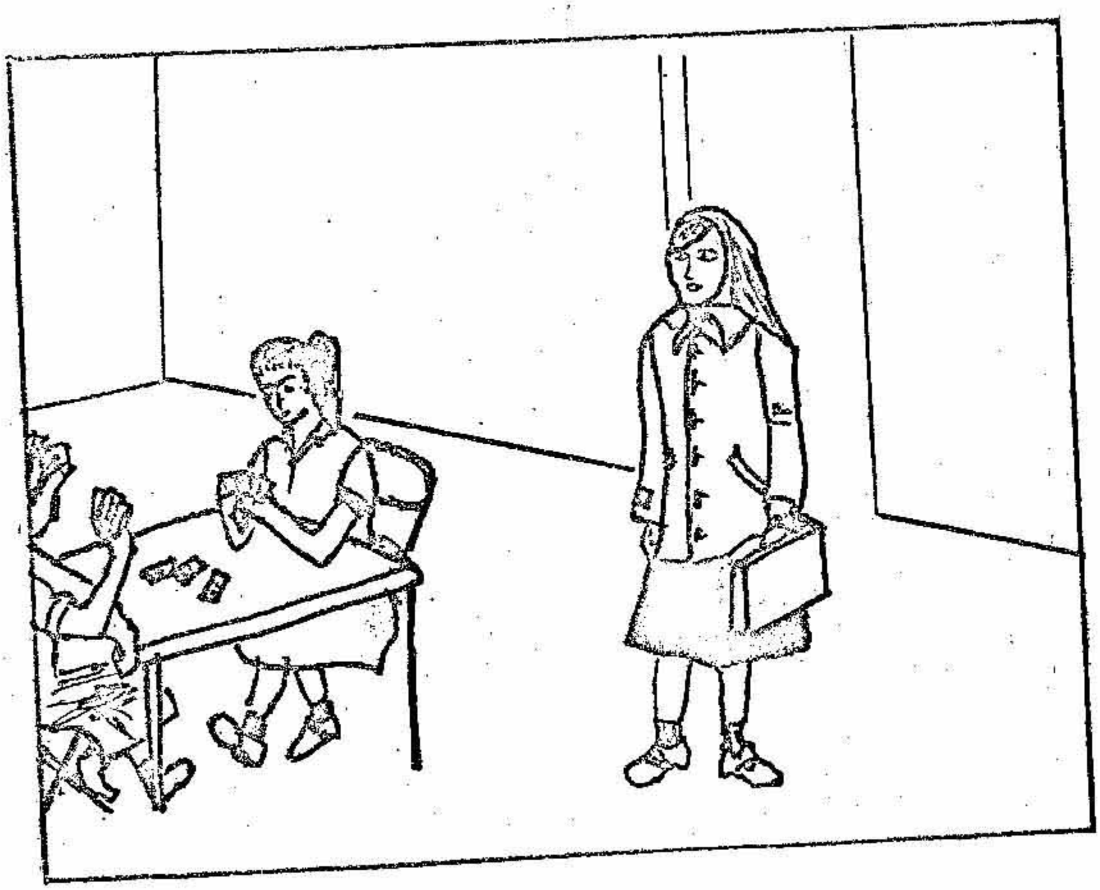

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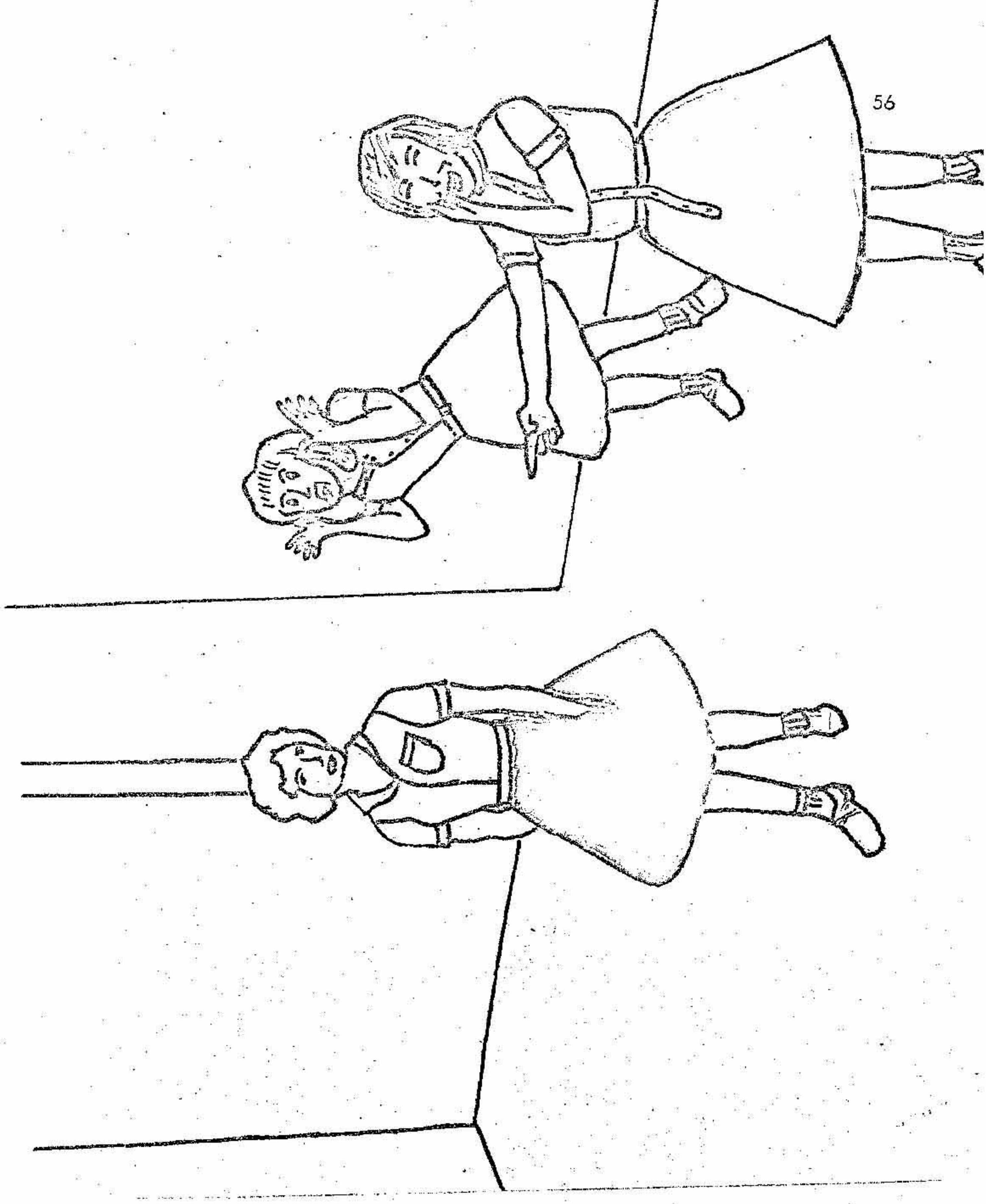
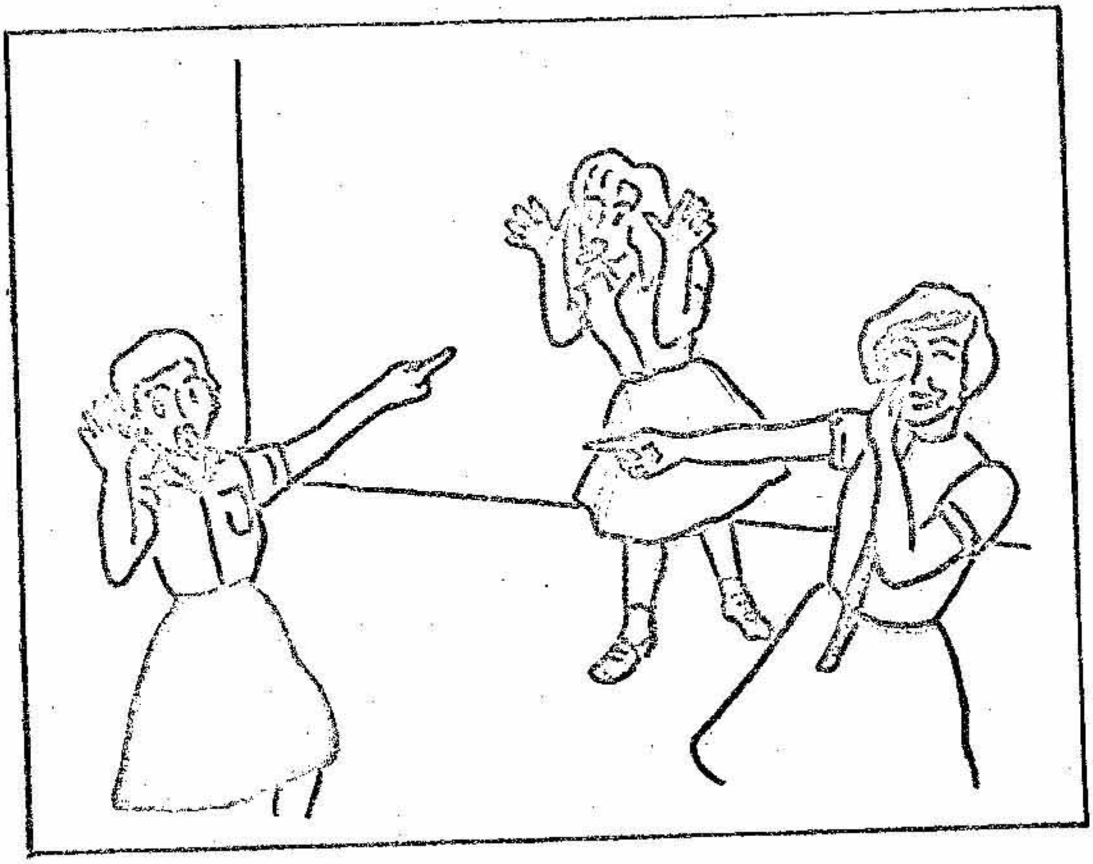
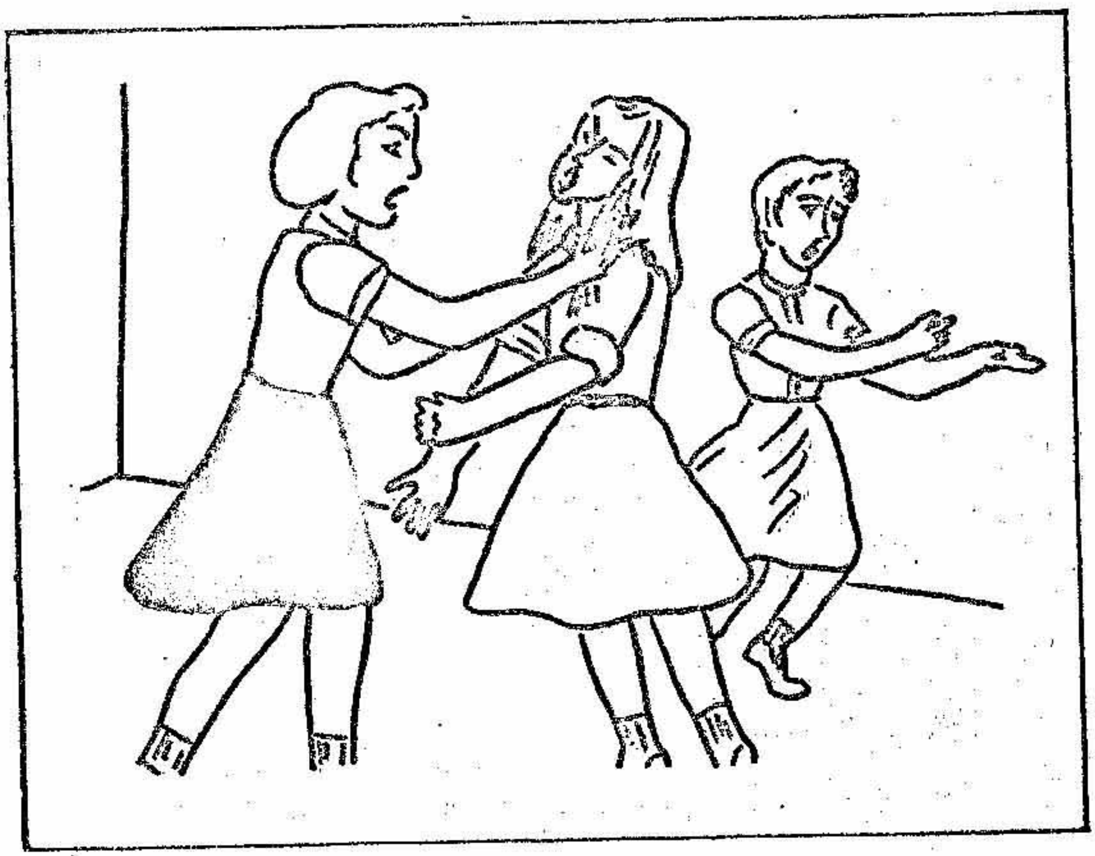


STIMULUS PICTURE NUMBER 4





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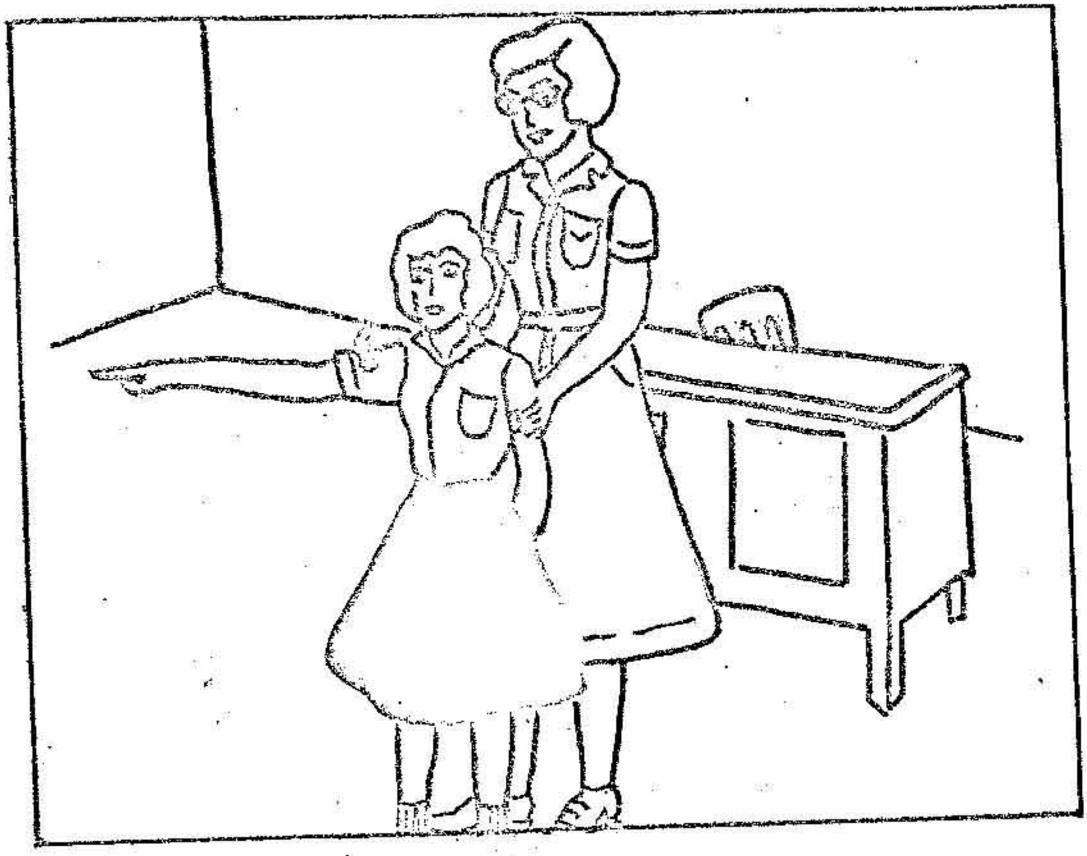

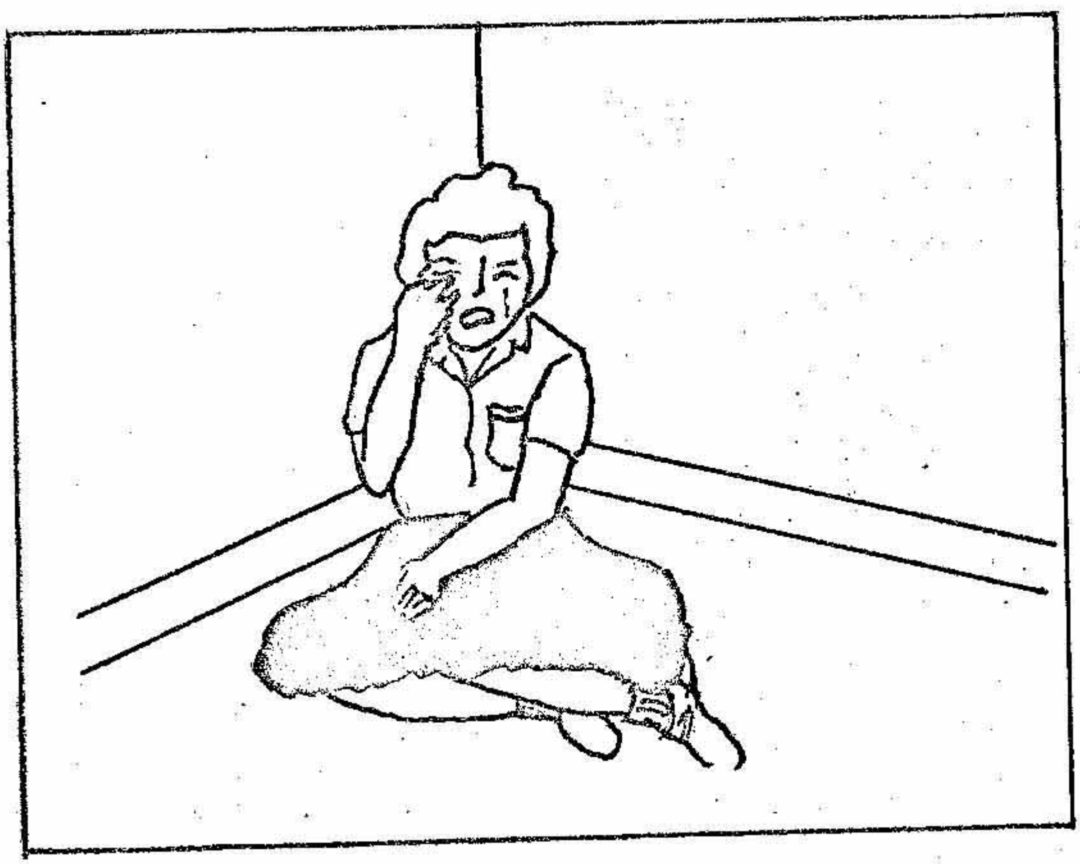

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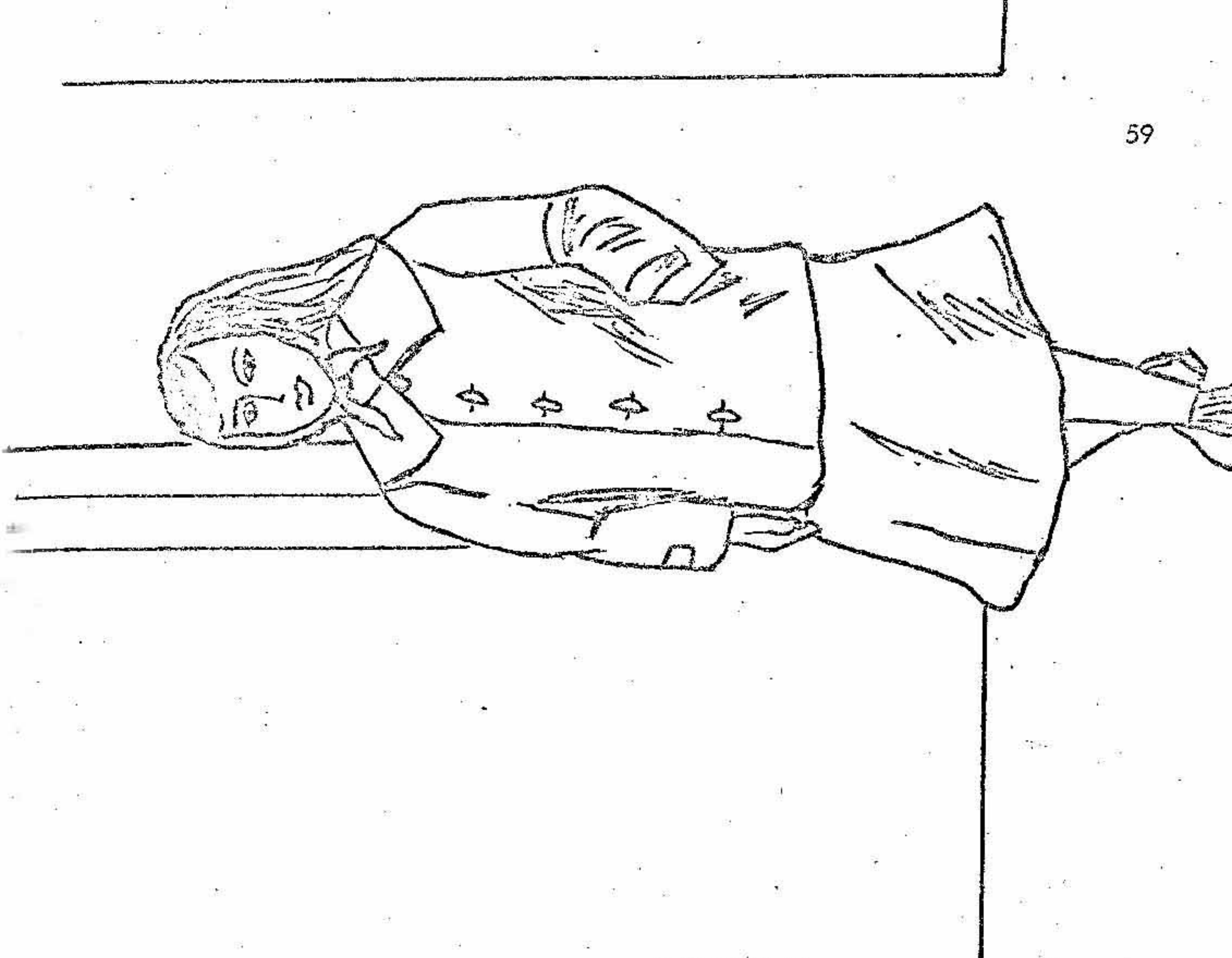
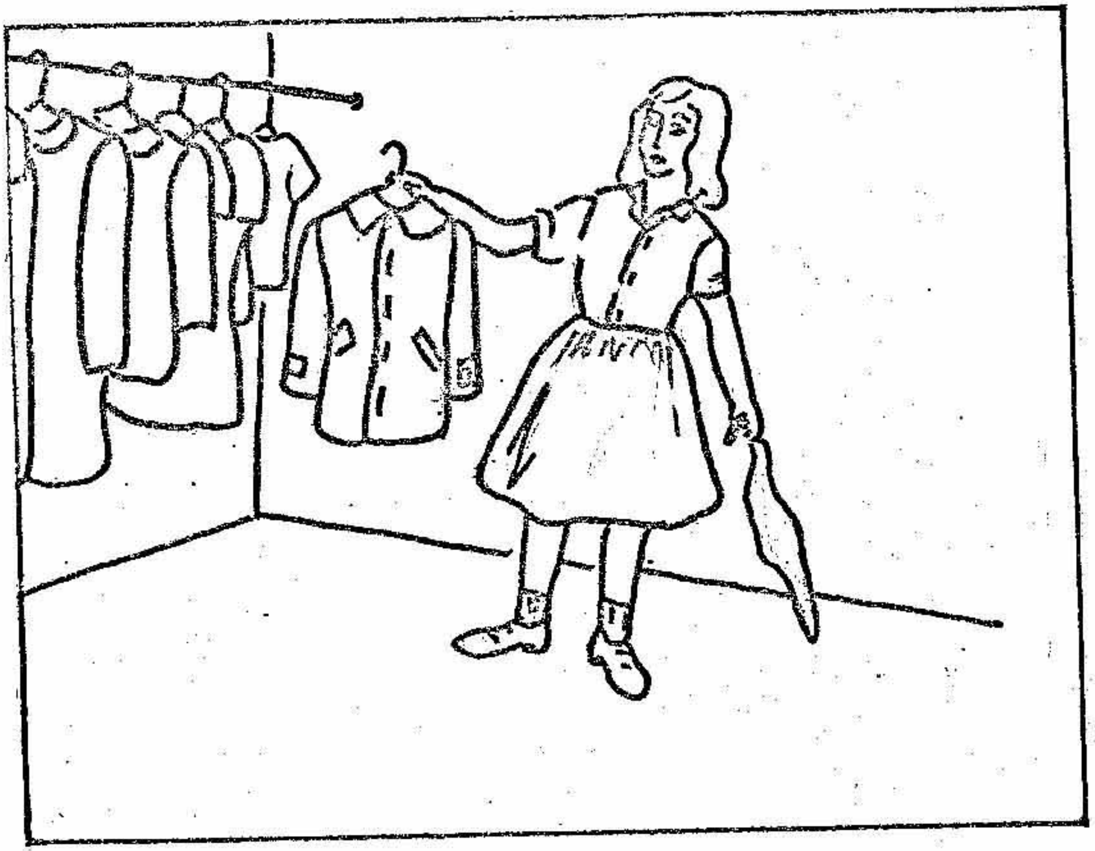


STIMULUS PICTURE NUMBER 5



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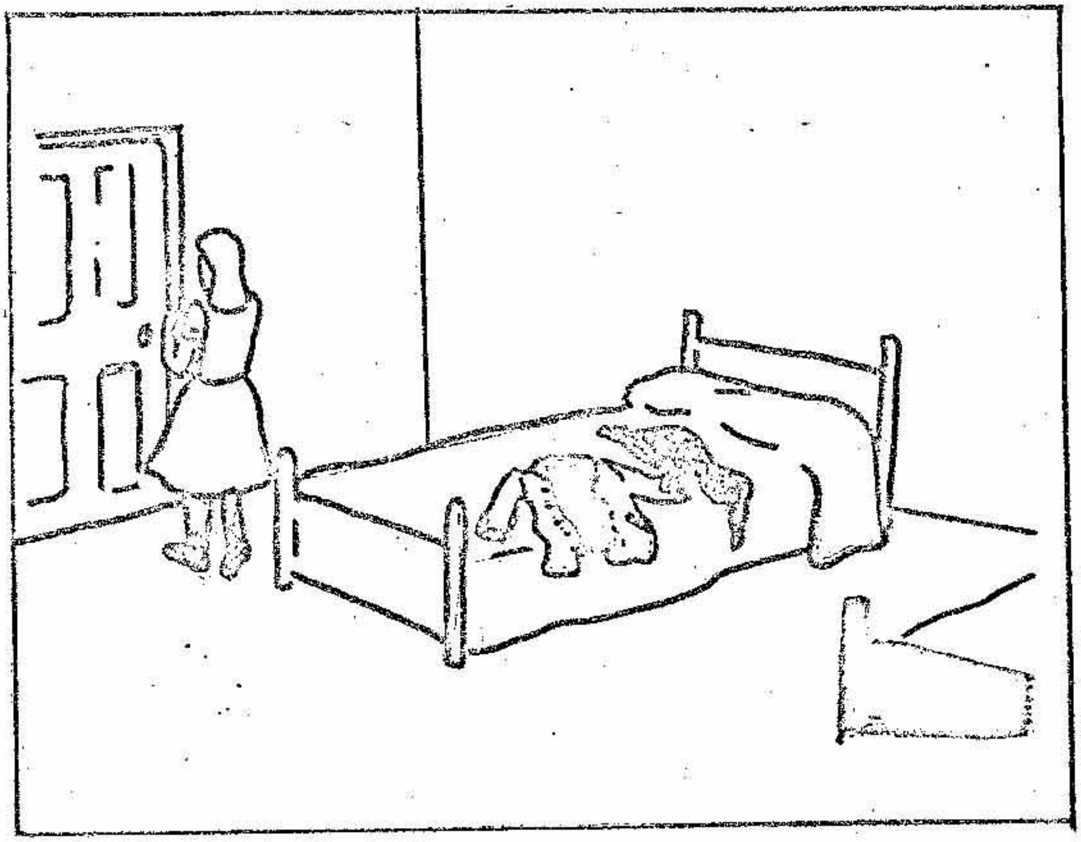

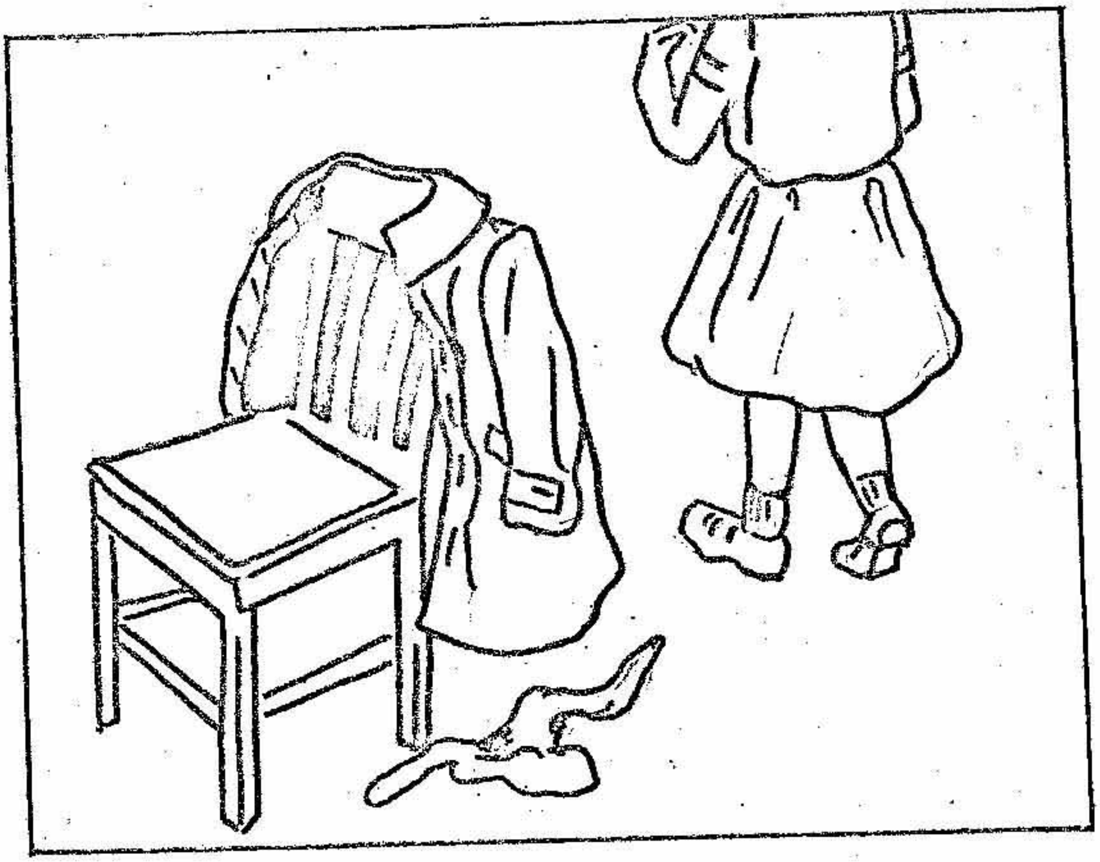

RESPONSE CARDS TO PICTURE NUMBER 5