THE FUNCTION OF INSTRUCTED SPEECH IN YOUNG CHILDREN'S PERFORMANCE OF A TASK PRESENTED BY INSTRUCTIONS

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ABSTRACT

THE FUNCTION OF INSTRUCTED SPEECH IN
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TASK PRESENTED BY INSTRUCTIONS

By

Dorothy Hostetter

The present study attempted to replicate Luria's findings regarding verbal regulation of the ball-squeezing response in a single signal task as well as to assess the effects of training on young children's performance of this task. It was hypothesized that verbal regulation could occur only if verbal training were given, and that the ball-squeezing response would be performed successfully without the addition of verbal responses if motor training were given.

On three criterion tests, subjects performed verbal responses alone, motor responses alone, and verbal and motor responses together. After the criterion pretests were given, subjects received either verbal or motor training or no training and then were tested again.

The predicted differential effects of verbal and motor training did not occur. But a general effect due to training was observed in the improvement in performance from pretest to posttest by the trained groups in comparison to the control group.

Under instructions to make both a verbal and a motor response to each signal, correct motor responses increased significantly from pretest to posttest, but there was no improvement in the performance of motor responses alone. Although the addition of verbal responses appears to have facilitated motor performance, the function of verbal responses in this task is unclear because correct motor responses occurred with extra verbal responses and verbal omissions as well as with correct verbal responses. The combined verbal-motor response was more difficult than single verbal or motor responses, and verbal performance especially was inhibited rather than facilitated by making two responses on each trial.

The general superiority of the verbal response over the ball-squeezing response which Luria found was not observed in the present experiment except in one of the three experimental replications. Superior verbal performance by these subjects did not lead, however, to superior performance in the combined verbal-motor task.

Some evidence for the interaction of verbal and motor responses was seen in the fact that on the combined posttest, correct motor responses occurred most frequently with correct verbal responses, and that extra motor responses occurred most often when the verbal response was omitted on both combined tests.

Although training appeared to be quite similar to the criterion tests, the correlation of training and posttest scores was lower than the correlation of pretest and posttest scores. The control group was less consistent from pretest to posttest than the trained groups were, implying that training contributed in a general way to consistency in performance across test repetitions. Free play appeared to be less interesting than training and may have failed to maintain the subjects' interest through the course of the experiment.

Performance on an extra test, given to subjects in the second and third replications after all other tests were completed, was far superior to performance on the criterion tests. The signals and instructions were basically the same as for the criterion tests, but the response was to put a block into a box rather than to squeeze a ball or say "push." It was suggested that the kind of verbal-motor interaction found by Luria and observed to some extent in the present experiment occurs chiefly in tasks that provide little feedback and are lacking in interest for the subjects. In such tasks overt verbal responses probably increase attention and effort during task performance and also increase feedback.

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By

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INTRODUCTION

In a series of studies Luria (1961) observed that children ages three to four could not coordinate a ball-squeezing response with a light signal unless they said "go" as well as squeezing the ball. When performing in silence, they squeezed the ball correctly for a few signals and then began to squeeze repeatedly without waiting for the light signals. Luria suggested that squeezing the ball stimulated the child's palm and led to perseveration of the motor response rather than termination of squeezing after a single response. By contrast, when children ages three to four were instructed to say "go" in response to light signals, they performed correctly and appeared to enjoy the task. When they were instructed to say "go" and squeeze the ball, extra motor responses did not occur. But whenever verbal responses were eliminated from the task, children reverted to making extra motor responses.

Two stages in the development of the regulatory function of the child's own speech are seen when two light signals are used. If children ages three to four are asked to say "press" and squeeze the ball for one signal and to say "no" and refrain from squeezing for the other signal, they frequently squeeze the ball when they say "no."

Their own speech regulated ball-squeezing on the positive trials presumably because of the impellant or motor aspect of speech rather than the semantic aspect or meaning of the verbal response. When the impellant function predominates, children can perform the discrimination task successfully if they remain silent in response to the negative signals. When the semantic function of children's own speech is developed, they can say "no" to negative signals without squeezing the ball.

There have been several unsuccessful attempts to replicate some of Luria's findings, particularly the distinction between the impellant and semantic functions of the child's own speech. At the same time many studies stimulated by Luria's concept of verbal regulation have investigated the effect of verbal responses, both spontaneous and instructed, in a variety of tasks. The aim of the present paper is to combine information from the related studies of verbal regulation with Luria's insights in order to broaden the concept of verbal regulation.

The failure to replicate Luria's findings has stimulated a search for factors which, though not discussed by Luria, might have influenced the outcome of his experiments. One such factor is training. Luria (1961) mentioned briefly that verbal responses could be performed successfully, especially by children "whose speech had been thoroughly trained in the kindergarten" (p.71). Thus one goal of the present experiment is to investigate the effect of training on the performance of the verbal and ball-squeezing tasks. Two kinds of training were compared: verbal training, which Luria's subjects received in kindergarten, and motor training. Verbal training is apparently necessary for successful performance of verbal responses in a single signal task and for verbal regulation of the ball-squeezing task. Motor training should lead to successful performance of the ball-squeezing response without the addition of the child's own speech. Luria described a training procedure in which children were asked to squeeze the ball and then to put their hands on their knees. After practicing in this way, children made no extra ball-squeezing responses even when they no longer removed their hands from the ball.

The prediction of the present experiment is that verbal training will lead to successful performance when the verbal response is performed with the ball-squeezing response as well as when the verbal response is performed alone because the verbal response will be available to regulate the motor response. But children with verbal training will not be able to perform the motor response correctly in silence. Motor training will lead to successful performance of the motor task alone. But without verbal training children will fail to perform the verbal response correctly either alone or in the combined task.

Studies Related to Verbal-Motor Interaction

A review of studies related to the concept of verbal regulation shed light on the variety of requirements posed by different tasks and the variety of functions of overt verbal responses. Studies involving both spontaneous or private speech and instructed speech were reviewed.

The Relationship of Private Speech to Task Performance

Vygotsky and most subsequent researchers have maintained that although private speech occurs overtly because the child fails to distinguish between himself as listener and others as listeners, it also has a cognitively related function. As children develop cognitively, private speech contains a higher proportion of self-guiding comments, becomes more abbreviated in syntax and increasingly covert (inaudible muttering, and eventually no outward signs). Investigators (Vygotsky, 1962; Kohlberg et al., 1968; Gever et al., 1970) have found that private speech increases with an increase in task difficulty, and that with age the proportion of task oriented comments increases (Kohlberg et al.,1968; Gan'Kova, 1960).

Klein (Kohlberg et al., 1968) found that children who successfully completed a puzzle in solitude produced over twice as many task-relevant speech units as children who failed to complete the puzzle. But Gever et al., (1970) found that although spontaneous speech increased with task difficulty, there was no relationship between the amount of spontaneous speech and performance on a picture sorting task. An analysis of the content of spontaneous speech might have shown that some kinds are related to successful task performance even though the overall amount is not. Flavell et al. (1966) found a relationship between spontaneous rehearsal and performance on a sequential memory task with pictures.

Evidence for the effect of task oriented private speech on task performance is correlational and does not permit any conclusions about cause and effect or about the function(s) of such speech. Task oriented spontaneous speech may fulfill several functions, or it may itself be a result of successful task performance or of some other factor.

The Relationship of Instructed Speech to Tasks Other Than Squeezing a Ball

In addition to spontaneous private speech, the effects of instructed speech have been investigated in at least three tasks: sequential memory of pictures (Keeney et al., 1967), pressing a lever to turn off lights which are no longer visible (Bem, 1967), and a reaction time discrimination experiment (Birch and Eisner, 1968). Each study provides evidence for the effect of overt verbal responses in the performance of another task, and in each study verbal responses functioned differently.

In a sequential memory task involving pictures Kenney et al. (1967) found that training non-rehearsers to rehearse raised their recall scores to the level achieved by spontaneous rehearsers. The experiment actually compared two methods of encoding sequentially presented material for memory, verbal and visual, rather than examining verbal regulation of the motor response (pointing at pictures). In this study, instructed verbal responses aided memory.

Bem (1967) trained children ages three and four to count from one to five lights and then when they were hidden from view to press a lever the correct number of times to turn them off. Training included practice of the counting and lever pressing responses separately, followed by practice of the verbal and motor responses together with a fading procedure. The lights, which were kept in view for practice and covered only during tests, were dimmed gradually during practice of the responses until they were no longer visible. Although all children eventually learned to count correctly with the lights not visible, none performed the combined response correctly until they had practiced it with the fading procedure.

The verbal counting responses may have failed initially to insure correct performance because counting by young children is sometimes performed by rote memory and may not represent a numerical concept. The fading procedure evidently stimulated the transition from counting by rote memory to numerical counting, which helped subjects to determine accurately and later to recall the number of lights, as well as to understand the relationship between the number of lights and the number of lever presses. Eventually subjects performed correctly without counting aloud.

Birch and Eisner (1968) compared combined verbal-motor responses with verbal or motor responses performed separately in a reaction time discrimination experiment with college men. The purpose was to see whether the verbal and motor response systems compete, operate independently or are coordinated. When the verbal and motor responses were performed together, there was less difference between verbal and motor reaction times than when the responses were performed separately, supporting the coordination hypothesis. Although overt verbal responses were not necessary for successful motor performance, they interacted with motor responses when performed with them.

The Relationship of Instructed Speech to the Task Performance of Impulsive and Reflective Subjects

Luria's concept of the verbal regulation of impulsive motor responding stimulated research in self-regulation by impulsive children. Motor impulsivity in the ball-squeezing task is characteristic of all young children, according to Luria, while impulsivity in cognitive style is characteristic of only some children. Nevertheless impulsivity in the ball-squeezing task may be found to be more closely related to cognitive impulsivity than to the immobility of nervous impulses described by Luria.

Impulsivity-reflectivity as a dimension of cognitive style is measured by latency of response and number of errors on the Matching Familiar Figures Test (Kagan and Kogan, 1970). Impulsive children select a figure to match a standard more quickly and make more errors.

Bates and Katz (1970) found that in performing a discrimination task, reflective subjects were better able to regulate their motor behavior verbally than impulsive subjects. Meichenbaum *et al*. (1969) found that impulsive subjects made fewer responses to the negative stimulus in a discrimination task when they said "don't push" aloud than when they performed in silence. Overt verbal responses may have helped impulsive subjects to concentrate their full attention on the requirements of the discrimination task.

The Relationship of Task Performance to After-the-Fact Measures of Task Related Speech

Traugott (1959) and Lombard and Stern (1968) evaluated children's ability to describe a task after they performed it. Traugott found that subjects' descriptions of experimental contingencies in a non-instructed conditioning task improved with the age of the subjects and with their performance of the conditioned response. For older subjects, describing experimental contingencies in the course of learning led to better performance of the conditioned response, possibly because task comprehension was increased.

Lombard and Stern (1968) measured subjects' task related vocabulary after assembling puzzles. The experimenter described the shapes and sizes of puzzle pieces for some of the subjects while they put the puzzles together. These children did not improve in puzzle assembly in comparison with other subjects, but their task related vocabulary which was tested afterward was better. Verbal training in this study did not include a description of how to put pieces together and therefore was not fully relevant to the task.

The Relationship of Verbal Training to Subsequent Task Performance

Lovaas (1961) examined the influence of verbal conditioning, aggressive or non-aggressive, on a later choice of toys. During the first training stage some subjects were reinforced for making aggressive remarks to a dirty doll. These subjects later spent more time playing with an aggressive toy than the non-aggressively trained subjects, and also more in comparison with their own level of performance before verbal conditioning. Thus aggressive behavior was rewarded during verbal conditioning and permitted during later play, demonstrating a general transfer from verbal training to another area of behavior.

In a later series of experiments Lovaas (1964) explored the effect of training in one discrimination task on performance during a subsequent discrimination task using the same stimuli. In the first task subjects were instructed to count rapidly for one light and slowly for the other. In the second task the children were asked to press a lever as well as to count. Subjects pressed the lever faster and counted faster to the "fast" light of the first task. It is likely that since the experimental situation was the same except for the addition of the lever pressing response, the subjects continued to follow the instructions given for the first task, again demonstrating a general transfer of training.

In another study in the same series children ages nine and eleven made lever pressing responses with shorter latencies after saying "fast" than after saying "slow." In an experiment with younger children ages five to six there was no transfer from verbal training to a discrimination task with a manual response. Children failed to perform the manual response unless they were instructed continuously at first.

Lovaas' findings suggest that training in a related task might transfer to the ball-squeezing task.

Instructions to make the trained and untrained responses together should facilitate transfer.

Instructions, Task Comprehension, and Motivation

The issue of task comprehension is often raised in interpreting the outcome of Luria's research. If subjects do not understand the instructions, subsequent failure of the ball-squeezing response is due to lack of comprehension rather than to impulsive motor responding, and the function of verbal responses is different in each case.

Beiswenger (1968a) investigated the effect of the linguistic form of instructions on the behavior of young children ages two through eight to four through six. Nine sets of commands of increasing difficulty were administered in the same order to each child. The dimensions of difficulty were: direct versus conditional commands (response contingent upon visual signal), one versus two kinds of signals, one or two responses, and positive only versus positive and negative elements. As expected, conditional commands were more difficult than direct ones. Performance on the first conditional task was poorest of all. Performance improved in later conditional tasks even though the instructions covered more signals and responses than the first command. Subjects apparently learned to follow complex instructions in the course of the experiment, again demonstrating a transfer of learning.

In this study as well as in other studies reviewed, the motor response did not stimulate response perseveration in the way that the ball-squeezing response apparently does. Motor responses in this and other studies included putting marbles of certain colors into a dish, placing blocks on a shelf, pointing at or sorting pictures, pressing a lever, and assembling puzzles. Some of the responses such as placing a block, marble or picture, provided a record of the subject's response which he could see after the response was completed. Pointing at pictures, pressing a lever, squeezing a ball, and saying "go" do not provide a record of the subject's response, but they do provide differing amounts of feedback.

Bem (1968) proposed that young children sometimes fail to follow instructions because they lack the correct representation of the end state. Instructions initiated activity which corresponded to elements in the instructions but not to the entire command. The task involved two blocks. One was placed on the middle shelf of three shelves, and the other was held by the subject. The instructions were, "Make it so that the (color) block is on top of (under) the (color) block." When the block in the subject's hand was named first, he usually performed correctly. But when the block on the shelf was named first, subjects placed their blocks incorrectly on more than half of the trials. In response to the "object" instructions (block on the shelf named first), the subjects apparently obeyed the preposition (on top of, under) with the block they held regardless of its color.

Comprehension training involved showing subjects a display containing the correct arrangement of blocks after the instruction was given. The subjects then placed their blocks after the display was removed. After comprehension training, subjects successfully placed their blocks regardless of the form of the instructions. They also performed successfully on a transfer task using different words, in which they were instructed to place a truck in front of or in back of another one. Bem contended that subjects learned to translate "object" instructions into descriptions of the desired end state.

The desired end state of the ball-squeezing task, one response for each signal, may not be clear to very young children, and after completion of the task there is no record of their performance by which subjects can judge whether they did what they were asked to do. A demonstration of the desired performance can be observed only while it is occurring, and the interrelationship of signals and responses in sequence may be vague to the subjects.

Birch (1966) tested the motivational, in contrast to the informative, function of a verbal command by repeating the command at three minute or 15 second intervals, or contingent upon the subjects' failure to continue responding (holding a lever down). Performance was the same within each age group regardless of the frequency of the command, fixed interval versus contingent, and repetition of the command versus substitution of a buzzer signal. The only significant effects were age and length of responses. Subjects tended to let up on the lever, especially those 3 1/2 and younger. The initial command appeared to provide sufficient information and motivation for older subjects, but even the repetition of the command every 15 seconds did not maintain the younger subjects' responding. Instructions are apparently effective (when understood) for communicating information to very young children but not for motivating compliance.

Luria apparently had no difficulty in motivating subjects to perform the ball-squeezing task, but motivation proved to be a problem in the present study and probably in other replications as well.

Replications of Luria's Research

Several attempts have been made to replicate Luria's findings, but in general these experiments have failed to demonstrate the kind of self-regulatory function of speech for which they were looking. The experiments differed in some ways from Luria's,and the authors examined only one aspect of Luria's hypothesis without first exploring some of the basic assumptions.

Hypotheses Tested

The replications reviewed (Jarvis, 1964; Beiswenger, 1968b; Joynt and Cambourne, 1968; Miller et al., 1970; Bates and Katz, 1970) were based on Luria's description of the stages of development of the self-regulatory function of speech and apparently accepted Luria's explanation of motor preseveration as the chief problem in the ball-squeezing task.

Luria claimed that the speech of others directs and controls a child's behavior. But the conditions under which children follow instructions have not been investigated. Another critical but untested assumption is that children ages three to four can perform a discrimination task better with a verbal response than with a motor response.

Only Joynt and Cambourne (1968) examined verbal regulation in a single signal experiment. All of the other experiments used a discrimination task, apparently assuming that the basic self-regulatory function of speech would be demonstrated in subjects' responses to the positive signals and that their performance on positive trials would not be influenced by the interpolated negative signals. Response to negative signals under various speech conditions should demonstrate the difference between the impellant and semantic functions of children's speech.

All of the authors cited referred to Reese's (1962) concept of verbal mediation for an explanation of the impellant function of speech. The concept of mediation appears to be based on the assumption that any given link of a behavior chain is necessary and sufficient to lead to the next link. Thus if the verbal response in a combined verbal-motor response is a mediator between the signal and the motor response, the motor response will be performed correctly if and only if the verbal response is performed correctly.

The present experiment used a single signal task rather than a discrimination task. The assumed superiority of verbal over motor performance is examined, as is the necessity of overt verbal responses for success in the ball-squeezing task.

Results

The only general finding among the replications reviewed was that performance in a discrimination task improved as subjects increased in age. Joynt and Cambourne (1968) reported that performance was more closely related to linguistic than chronological age. Only Miller et al. (1970) reported results for the verbal response alone. They found that omission of the verbal response decreased with age, but did not report other verbal errors such as positive verbal responses to negative signals or extra verbal responses to positive signals.

The results reported by Jarvis (1964) and Miller et al. (1970) clearly did not support their interpretation of the self-regulatory function of speech. No interaction was found between age and speech condition. Jarvis also reported that there was no relationship between error scores and the subjects' spontaneous speech for self which was tested on the same occasion. Miller et al., found that children perform best in silence regardless of age, and that they perform very poorly when asked to make a verbal response to both signals. There were more omissions and extra responses when subjects said "yes" only and more responses to the negative signals when subjects said "no" only.

The results reported by Joynt and Cambourne (1968) are similar to Luria's findings except that children in each state of development were older than Luria's subjects, according to linguistic age as measured by the Illinois Test of Psycholinguistic Abilities. Each subject performed all tasks under all speech conditions and in the same order. Rather than reporting errors, the authors grouped subjects according to the speech conditions in which they showed disconnected behavior (squeezing impulsively in an indiscriminate manner or failing to squeeze the ball).

They found that subjects ages (linguistic) two to five to three to seven could succeed only when the experimenter gave them an instruction for each response and when no light signal was used. Subjects ages three to ten to four to nine could perform successfully when their own speech was congruent with the motor response. Subjects ages four to six to five to four succeeded even when their speech and motor responses were incongruent, as well as in the other conditions. The oldest group performed correctly in silence. The order of difficulty is the same as that found by Luria.

By using disconnected behavior as a measure of performance rather than relatively isolated errors made by otherwise competent subjects, the authors may have come closer to measuring the kind of regulation that Luria observed with very young and initially incompetent subjects. In addition to disconnected behavior the authors reported a mean error index for each speech condition on each of three tasks: single signal, discrimination, and single signal with a double response. The data is displayed graphically but is not reported numerically, and no statistical tests are referred to. From the figures it surprisingly appears that performance was better on the discrimination task than on the single signal task, suggesting that some learning took place. In both of these tasks, performance appeared to be poorest when the verbal and motor responses were incongruent.

Beiswenger (1968) found that motor performance improved with age. But since subjects were not instructed to make a verbal response in addition to a motor response, the experiment yields no information on the self-regulatory function of the child's own speech.

Bates and Katz (1970) gave a different instruction requiring a different response on each of 15 trials. The experiment did not use a series of signals or a series of responses directed by a single initial instruction. The authors found the usual age effect. The youngest group performed better under the experimenter's instruction alone than when they were asked to make a verbal response as well as a motor response. No difference in effectiveness between the experimenter's instruction and self-instruction was observed in inhibiting motor responses. Neither was effective for three year olds. The authors reported that reflective subjects, so designated by their performance on the Matching Familiar Figures Test, were better able to regulate their motor behavior verbally than subjects who responded impulsively on the MFF.

Subjects

The age of the youngest subjects averaged three to eleven (Jarvis, 1964), two to nine (linguistic age, Joynt and Cambourne, 1968), four to zero (Beiswenger, 1968), three to two (Miller *et al*., 1970), and three to six (Bates and Katz, 1970). Thus some of the younger subjects in several of the studies were older than the age range estimated by Luria for State Two.

Experimenters usually spent time getting acquainted with the children before testing began but probably no more than 15 minutes (Jarvis, 1968). The instructions were usually demonstrated by the experimenter and up to 21 practice trials were given (Miller et al., 1970). If a child did not perform satisfactorily during practice, he was dropped from the experiment. Thus the ability to follow instructions with a minimum of practice was a prerequisite for participating in these experiments, as was cooperation with a relative stranger in a new situation. Jarvis dropped 17 subjects, 11 of these from the youngest group, nine of whom would not attend to the task or follow instructions. Of the remaining 72, one-third of the children would not separate from their parents who had brought them to the Child Study Center on a weekend day for the experiment. The parents had to sit in the room with their children during the experiment. Miller et al. (1970) dropped 24 subjects for inablity or refusal even to attempt the experimental task or failure to attend to the stimuli on at least 75 per cent of the trials. Thirteen of these were from the youngest group.

Subjects in the present experiment ranged in age from two to five to three to six (X = 3-1). The experiment was conducted in day care centers with children who were accustomed to interaction with adults in addition to their parents. Testing was spread over several sessions, providing opportunity for the children to become acquainted with the experimenter, the general experimental situation and the task. Subjects were dropped from the experiment if they refused on several occasions to accompany the experimenter to the test room (usually one subject at each day care center), but not for refusal of a single test session.

Instructions

Most of the instructions reported were conditional statements containing both positive and negative elements since a discrimination task was used, and sometimes introducing two novel responses in the same set of instructions. Following is an example of the most complicated instructions: "Every time the blue light comes on, tell youself 'push,' and then push the button. Every time the yellow light comes on, just watch it. Don't say anything, and don't push the button, but be sure to watch the light" (Jarvis, 1964). Beiswenger (1968a) found that children's performance in response to similar instructions was very poor. The youngest subjects in the replications cited may not have understood what they were supposed to do.

Instructions for a single signal task are less complicated than for a discrimination task. In the present experiment the verbal and motor responses were introduced and tested one at a time (in counter-balanced order) before the combined verbal-motor task was introduced. Complete counterbalancing of all tests including the combined test was forsaken in the interest of task comprehension.

Inter-stimulus Interval

The experimental tasks of the replication studies were difficult because of the very short inter-stimulus intervals used. The interval in Luria's experiments ranged from two to 4.5 seconds (personal communication). In the replications cited, the inter-stimulus intervals were .25 to one second (Jarvis, 1964), an average of one second (Joynt and Cambourne, 1968), one to two seconds (Miller *et al*., 1970), and one to three seconds (Beiswenger, 1968b).

In the present experiment the inter-stimulus interval was fixed at four seconds and the duration of light signals was 1.5 seconds. A constant ISI made the task easier than a variable ISI. Even so, the task proved to be difficult enough.

The Present Study

In light of the outcome of previous replications and the information contributed by related studies, the present study incorporates a replication of Luria's research on verbal regulation of the ball-squeezing response in a single signal task and an examination of the effects of training on the ball-squeezing task and on verbal regulation. The present study differs from previous replications in several respects: the use of a single signal task rather than a discrimination task, the comparison of verbal and ball-squeezing performance, younger subjects, and a longer, fixed inter-stimulus interval. The automatic timing of signals in the present study as well as in other replications differed from Luria's procedure.

Subjects took three single signal tests, requiring verbal responses alone, motor responses alone, and verbal and motor responses together. Subjects then received training with verbal responses, training with motor responses or a comparable amount of free play with the same equipment. Training provided practice in understanding and following instructions, in making either verbal or motor responses, and in the inhibition of responses before the signals. Training tasks employed direct and conditional instructions which covered single trials and series of trials, and used both verbal and light signals. After training all subjects took the same three single signal tests again.

It was predicted that subjects who received verbal training would perform better than other subjects on the verbal posttest and that their superior verbal performance would also result in better performance in comparison to other subjects on the combined verbal-motor posttest. It was predicted that subjects who received motor training would perform better than other subjects on the motor posttest but that due to lack of verbal training their verbal and combined verbal-motor performance would be poorer than that of the verbally trained group.

METHOD

Subjects and Replications

There were 36 subjects (13 boys) ages two years five months to three years six months. All of the children in the desired age range at three day care centers were tested, each day care center constituting a complete replication of the experiment. There were 12 subjects in each replication. Additional subjects were tested at the first day care center, but six were dropped in order to equalize numbers among replications. (Two were the only subjects who made no correct verbal responses during practice or testing, two had at least seven correct trials on the motor pretest and two refused to take one or all of the posttests.) Only 12 subjects were available at each of the other two day care centers. One subject in the control group of Replication 3 refused further tests after the Stanford-Binet. Scores for this subject were estimated for all tests from cell means. Two other subjects from the motor training group (one each from Replications 2 and 3) refused to take one and two tests respectively and were scored zero for correct trials. Their error scores were estimated from cell means.

Training Groups

During training Group V was trained to make verbal responses, and Group M was trained to make motor responses. Group C took the criterion tests but received no training. Instead, subjects in Group C were brought to the training room as frequently as the trained subjects and were encouraged to play with the toys used for training while the experimenter observed and responded to their initiatives.

Criterion Tests

Three tests were given to each subject before training was begun and after it was completed. Each test required the subjects to respond to conditional instructions. A motor response (squeezing a rubber ball) was required for Test M, a verbal response (saying "push") for Test V, and both a verbal and a motor response to each light signal for Test VM. The instructions for the tests were as follows: for Test V, "When the light comes on, say 'push'"; for Test M, "When the light comes on, squeeze the ball"; and for Test VM, "When the light comes on, say 'push' and squeeze the ball." Tests V and M always preceded Test VM. The order of Tests V and M was counterbalanced within each training group. The second and third criterion tests were usually given in the same session, at least one day after the first test.

Procedure

Subjects were tested individually. The Stanford-Binet Intelligence Test was administered first. Subjects were then assigned to training groups which were matched according to chronological age, mental age and sex.

The criterion pretests were administed next. The verbal test was introduced as follows. The experimenter asked, "See this box? There's a light in there (demonstrate). Say 'push'. When the light comes on, say 'push'." The motor test was introduced as follows, after demonstration of the light: "This is a ball. You can squeeze it like this. You squeeze it when the light comes on, squeeze the ball." At least three practice signals were given, instructions being repeated as needed. During practice correct responses were reinforced ("good") and errors were corrected. After at least two correct practice trials, the instructions were repeated once, followed by two reinforced trials and then without interruption by the ten test trials. During the tests no verbal reinforcement was given, and the only corrections was, "watch the light." In the remaining criterion tests the new response was introduced as described above and familiar elements of the experiment were reviewed as follows: "Do you remenber what's in here (light box)? When the light comes on, what do you say (do)?"

The word "push" was selected because subjects in a pilot study said "push" more readily than "yes" or "go" and because many subjects demonstrated spontaneously the meaning of "push" by pushing the table or the light box when they said "push."

Training

After the three criterion pretests were completed, four training sessions (free play for Group C) were given. Training consisted of practice in following instructions of increasing difficulty (see Table 1). Following are the kinds of instructions practiced during each training session:

1. Direct instructions, and conditional instructions with an enforced delay in opportunity to respond;
2. A conditional instruction before each verbal signal ("now");
3. A conditional instruction before a series of verbal signals;
4. Conditonal instructions before each light signal and before a series of light signals.

The criterion for each instruction was at least five correct responses, including the last three consecutive responses. An explicit inhibition was included in the instructions at the beginning of Session 2. Then subjects practiced to criterion again on the same task without the explicit inhibition. In subsequent sessions the inhibition

TABLE 1.--Training Instructions.

Session	Training: Verbal	Training: Motor
1 a	What's this (object presented)? Say (name of object).*	Give me the (one of two objects).*
b	Say ______ (no objects used).*	Put the block in the box (block presented).*
c	When I show you a toy (object not present), tell me what it is (object presented).*	When I show you a toy (object not present), show me what you can do with it (object presented).*
2	See this toy (object presented)? When I say "now," tell me what this is. But don't say anything yet... now!*	See this toy (object presented)? When I say "now", put it in the box. But not yet...now!*
3	See this toy (object presented)? This time I will just say "now." Then you tell me what this is... now!**	See this toy (object presented)? This time I will just say "now." Then you show me what you can do with it...now!**
4 a	Today the light will tell you when to talk. See this toy (object presented)? When the light comes on, tell me what it is.* **	Today the light will tell you when to do something. See this toy (object presented)? When the light comes on, put it in the box.* **
b	When the light comes on, say "push."**	(12 blocks presented). When the light comes on, put a block in the box.**

*Instructions given on every trial.
**Instructions given once before a series of trials.

was used only as a correction on the trial following a trial with an early response. If a subject did not reach criterion in a given session, the session was repeated on another day. Seven subjects repeated a total of nine sessions. During training every correct response was reinforced ("good") and every error was corrected.

At the end of training the three criterion tests were given again. Training and testing for a subject were completed no more than in four weeks.

Equipment

Objects used in training were similar to those from Stanford-Binet test items at ages two to four. Some of the objects which suggest specific action were used for those motor training sessions in which the experimenter asked, "Show me what you can do with this." The same objects were used for comparable verbal training sessions. The remaining objects were used for training sessions requiring general actions such as putting the object in a box or giving it to the experimenter, as well as for the comparable verbal training sessions. There were two sets of similar, though not identical, action objects, three sets of non-action objects and one set of wooden blocks (See Table 1, Appendix B). Each set was used only once except when training session were repeated or required more trials than the number of objects in the set.

Words used in the first session of verbal training were selected from the first twenty items on the Peabody Picture Vocabulary Test (see Table 2, Appendix B).

A light signal box for the criterion tests was a six-inch translucent plexiglas cube containing a 25-watt bulb. The light was operated either manually by a silent mercury switch or automatically by a Gerbrand timer with a 16 mm film loop. During the criterion tests the light was operated automatically with a fixed inter-stimulus interval of four seconds and a duration of 1 1/2 seconds.

A soft rubber ball from a toy bicylce horn was attached to a C clamp which was mounted at the edge of the table between the subject and the light signal box. The ball was connected by plastic tubing to an air pressure switch which was set at .18 psi (light pressure). The occurrence and duration of light signals and motor responses were recorded on an Esterline-angus event recorder. A parallel record of verbal responses was made on a tape recorder which also recorded the light signals and motor responses.

During training and testing the experimenter sat across the table from the subject with the light signal box placed between them. Training task responses were recorded by the experimenter.

Scores and Statistics

Each subject took three criterion pretests and three criterion posttests consiting of ten trials each. Scores are reported as means per test. Each test was scored for correct responses, extra responses (X's) and omissions (O's). The number of extra responses is larger than the number of trials with extra responses, since some trials contained more than one extra response. Therefore, analyses of variance were performed both for trials with extra responses and for the number of extra responses as well as for correct responses and omissions.

Test VM, which includes both verbal and motor responses, can be scored in two ways: (1) counting verbal responses and motor responses as separate sets, or (2) counting only the responses in the intersection of these two sets; i.e., the trials on which both the verbal and motor responses were correct, extra or omitted. Scores were counted in both ways, resulting in two possible analyses for each of the following measures: correct trials, trials with extra responses, number of extra responses, and trials with omissions. The experimental factors are summarized in Table 2. The analyses of variance follow procedures for multivariate analyses with repeated measures described by Winter (1962).

TABLE 2.--Statistical Design.

Factor	Level		
	Five-Factor Analysis		
Replication	1	2	3
Training Group	Verbal (V)	Motor (M)	Control (C)
Response Form	Verbal (v)	Motor (m)	
Criterion Test Repetition	Pre-	Post-	
Mode	Single (s)	Combined (c)	
	Four-Factor Analysis		
Replication	1	2	3
Training Group	Verbal	Motor	Control
Response Form	Verbal	Motor	VM
Criterion Test Repetition	Pre-	Post-	

When responses on Test VM were scored as separate sets of verbal and motor responses, the statistical analysis contained five factors, the last three being repeated measures. When Test VM responses were scored as the intersection of the verbal and motor response sets, the statistical analysis contained four factors, the last two being repeated measures.

The four-factor analysis is the most appropriate test of the prediction of verbal-motor response interaction. In the present experiment, however, it became apparent that counting only pairs of responses on the combined tests failed to account for many correct responses which were paired with errors in the other response form. Therefore, the five-factor analyses were performed to permit closer examination of all responses which occurred on the combined tests. It should be remembered throughout, however, that the five-factor analyses fail to account fully for the interaction of verbal and motor responses. Even though verbal and motor responses in the combined mode occurred on the same test, suggesting some interaction, scoring did not take into account whether verbal and motor responses occurred together on the same trials.

The results presented are based primarily on the five-factor analyses. Added information from the four-factor analyses is included as necessary. An analyses of verbal-motor response pairs trom Test VM concludes the presentation of results.

Both the four and five-factor analyses of variance are mixed models. The replication factor (R) is random, and all other factors are fixed. In a mixed model, the usual error term is not always the appropriate denominator for an F test. When the numerator does not include the random variable, the denominator is an interaction of the random variable with the factor(s) contained in the numerator. For example, the denominator of the F ratio for the repeated measure T is R (replication) x T. The denominator of the F ratio for G x T is R x G x T. When the random variable appears in the numerator of an F ratio, the denominator is the usual error term; e.g., the demoninator for either R x T or R x G x T is T x subjects within groups.

RESULTS AND DISCUSSION

The assumption of homogeneity of variance was not rejected for either the four-factor or the five-factor analyses of variance for correct trials. The Fmax ratio for the four-factor analysis was 24.13, with df = 3 and k = 27. The critical value at p = .05 with df = 3 and k = 12 is 124.0 (Pearson, 1958). The Fmax ratio for the five-factor analysis was 99.67, with df = 3 and k = 24.

The assumption of homogeneity of variance could not be tested for trials with extra responses or number of extra responses because of the presence of several variances equal to 0. No test was performed on the analysis of omissions because it was judged to be unimportant in light of the outcome of the tests on correct trials.

One error term from the five-factor analysis of variance for correct trials (F x subjects within groups) was also tested for homogeneity of covariance, following a procedure developed by Box (Winer, 1962). Again, the assumption of homogeneity of covariance was not rejected.

Training Groups

The training groups were matched as closely as possible according to chronological age, mental age (as measured by the Stanford-Binet Intelligence Test) and sex (see Tables 3 and 4). According to analyses of variance for chronological age and for mental age, there were no significant differences for replication, training groups or the replication x training group interaction (see Tables 1 and 2, Appendix A).

Mental ages of the subjects were consistently higher than their chronological ages even though the children apparently came from average homes. An attempt was made to find out the occupations of parents, but most parents did not furnish the requested information on the parental consent form. It appeared that subjects came from a variety of socio-economic levels and not just from advantaged homes. Children in all three day care centers came from single working parent families, poor families in which both parents worked, and middle class families seeking preschool training for their children.

There are two possible reasons why MA's were consistently higher than CA's. The Stanford-Binet Test was administered by only one experimenter, who did not have extensive experience in testing preschool children. Standard procedures for administering the test were carefully followed. Nevertheless, higher than average MA's were obtained in all three experimental replications. Second, day care center attendance may have an effect on mental age.

TABLE 3.--Mean Age in Months.

Replication	Training Group		
	Verbal	Motor	Control
	Chronological Age		
1	35.25	35.75	38.00
2	37.50	37.00	37.50
3	37.50	37.50	37.00
	Mental Age		
1	43.75	45.75	43.50
2	43.00	43.50	45.75
3	42.50	45.75	45.25

TABLE 4.--Distribution of Subjects by Sex.

Replication	Training Group		
	Verbal	Motor	Control
	Males		
1	1	1	2
2	1	2	1
3	2	1	2
	Females		
1	3	3	2
2	3	2	3
3	2	3	2*

*One subject refused further tests after the Stanford-Binet test. Scores for this subject were estimated for all tests from all means.

In the present study, the replications were comparable in MA. But the present sample may not be comparable to other samples of three year olds who have not had day care experience.

Criterion Test Order

The order of Test V and M was counterbalanced within each training group and Test VM was always given last. A training group x order unweighted means analysis (Winer, 1962) did not identify any effects due to order. Likewise, no interactions of order with other experimental factors were observed. Therefore, the order factor was not included in subsequent analyses.

Performance on Pretests

Similar performance among training groups was expected on the pretests. Nevertheless, the training groups did differ in pretest performance ($\overline{X}_V = 2.65$, $\overline{X}_M = 2.79$, $\overline{X}_C = 3.69$, see Table 5), which complicates the interpretation of any interactions which include the training group factor. Training group differences are discussed below in conjunction with the training group x test repetition x form interaction.

Performance During Training

More trials were required to reach criterion in verbal than in motor training ($\overline{X}_V = 4.93$, $\overline{X}_M = 2.68$),

TABLE 5.--Mean Correct Verbal and Motor Responses on the Pretest in the Single and Combined Modes for Each Training Group.

Training Group	Response Form	
	Verbal	Motor
	Single Mode	
Verbal	2.67	2.92
Motor	2.42	3.58
Control	5.00	4.58
	Combined Mode	
Verbal	2.33	2.67
Motor	2.50	2.67
Control	2.75	2.42

but the difference was not significant according to an analysis of variance (see Table 1, Appendix C). As expected, the instructions varied in difficulty ($F = 18.73$, $p < .01$). Two instructions, from training sessions two and three, required more practice in verbal than in motor training (see Table 6). Subjects tended to name objects before the signal was given, and verbal responses by subjects were more difficult for the experimenter to inhibit than motor responses. The training group x instruction interaction fell short of statistical significance ($F = 2.75$, $p < .10$). However, the training data suggest that verbal and motor training were not fully comparable even though the instructions were the same for both training groups. A comparison of performance during training and testing follows the discussion of criterion test performance.

TABLE 6.--Mean Number of Trials Above the Minimum Needed to Reach Criterion in Training.

	Instruction						
Group	1a	1b	1c	2	3	4a	4b
V	.67	0	1.75	13.83	9.08	4.74	4.42
M	.42	0	1.00	3.75	5.75	5.75	2.08

Predictions for Posttest Performance

The prediction was that performance on Posttest VM, the combined test, would improve following verbal training since the trained verbal response would be available to direct the motor response in the combined task. In contrast, performance following motor training should improve on Posttest M only and not on Posttest VM since the verbal response will not have been trained and therefore would not be available to direct the motor response in the combined task. A small amount of improvement for all groups was expected on all of the posttests as a result of having taken the tests previously (criterion test repetition). But improvement resulting from test repetition is to be distinguished from the differential effects due to kind of training which are outlined above.

The complete analyses of variance for trials correct, trials with extra responses, number of extra responses, and trials with omissions, along with Newman-Keuls analyses, are shown in Appendices D, E and F.

The Effects of Training and Criterion Test Repetition on Response Forms

The predicted effects should have produced a significant training group x test repetition x response form interaction for correct trials in a four-factor analysis, since the performance of Training Group V should have improved on Posttests V and VM while Training Group M should have improved on Posttest M only. But the interaction did not approach significance ($F = 1.76$, see Table 1, Appendix E). There was, however, a significant main effect for response form ($F = 12.09$, $p < .05$) because of the much lower scores on Test VM (see Table 7). It should be remembered that for the analysis under discussion, correct trials on Test VM are only those trials on which both the verbal and the motor response were correct. It is obvious that performance on the combined task was not superior to performance on the motor task alone. On the contrary, scores on Test M were more than twice as high as on Test VM.

TABLE 7.-- Four-Factor Analysis: Changes From Pretest to Posttest in Mean Number of Correct Trials for Each Training Group on Each Criterion Test.

Training Group	Criterion Test Response Form		
	Verbal	Motor	Verbal-Motor
Pretest			
Verbal	2.67	2.92	1.17
Motor	2.42	3.58	1.17
Control	5.00	4.58	1.08
Posttest			
Verbal	4.92	4.17	1.75
Motor	5.25	3.08	2.58
Control	4.50	3.92	1.92

In the five-factor analysis, for which Test VM was scored as two separate sets of responses - verbal and motor, the predicted effects should have produced a significant interaction of training group, criterion test repetition, response form, and mode of response. But in the preset experiment this interaction did not approach significance on any of the scores: correct trials, extra responses or omissions. However, the training group x criterion test repetition x response form interaction for correct trials approached significance ($F = 6.92$, $p < .10$). The trend was produced partly by the superior performance of Group C in both verbal and motor response forms on the pretests together with their smaller amount of improvement from pre- to posttest by comparison with either trained group (see Figure 1). The prediction was based, however, on the expectation of similar performance among groups on the pretests and relatively greater improvement by the trained groups on the posttests. But the fact that Group C did not maintain their advantage through the posttests suggests that there was a difference in the effects of free play and training. Since the highest mean number of correct trials on the pretest was five trials out of ten (Group C on Pretest V), it is unlikely that the lesser improvement of Group C resulted from a ceiling effect.

In contrast to the prediction, the trained groups performed similarly in both response forms on the posttests. Training in a response form did not lead to greater improvement in the corresponding criterion posttest.

The same training group x test repetition x response form interaction was significant for a number of extra responses ($F = 9.99$, $p < .05$; see Table 3, Appendix E).

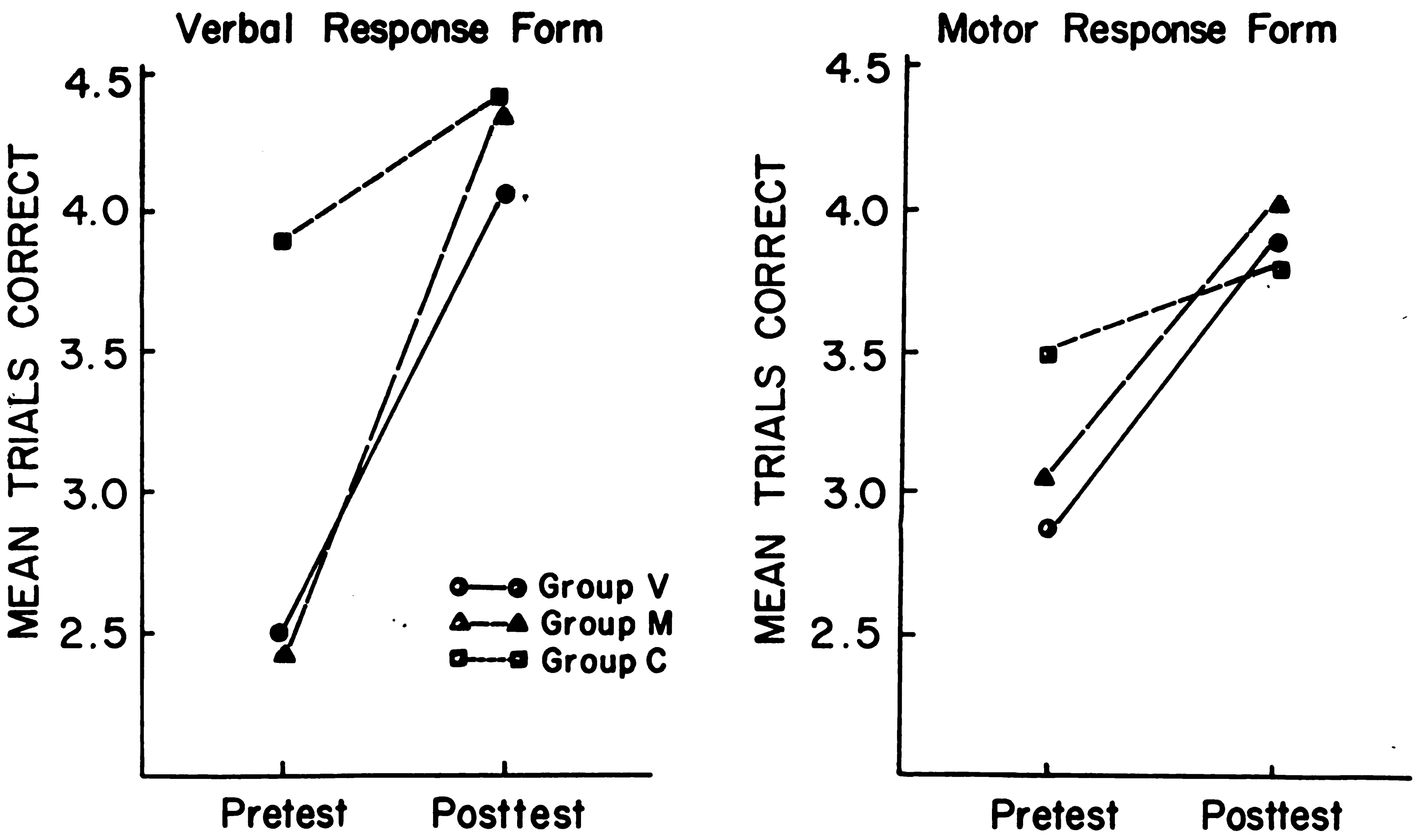

Figure 1.--Changes in correct trials for each response form as a function of training and criterion test repetition.

The number of extra verbal responses increased from pre- to posttest for all training groups, while the number of extra motor responses decreased, with the exception of Group M (see Figure 2). According to a Newman-Keuls analysis (Table 1, Appendix F), Group M had significantly fewer extra motor responses on the pretest than Group C. But none of the other training group differences in extra motor or verbal responses was significant. In spite of the increase from pre- to posttest in extra motor responses, correct motor responses by Group M also increased on both Tests M and VM. It is likely that the increase in extra motor responses was produced by only a few subjects in Group M. The influence of individual differences on the number of extra responses in particular is discussed in connection with response forms.

The Effects of Training and Test Repetition on the Single and Combined Modes

Some differences among training groups were observed in the interaction of training with test repetition and mode of response for correct trials ($F = 3.38$, $p > .10$; see Table 1, Appendix E), as well as in the interaction of training with test repetition and response form described previously. As mentioned above, Group C performed better on the pretests in the verbal response form than the other training groups. An examination of the interaction of

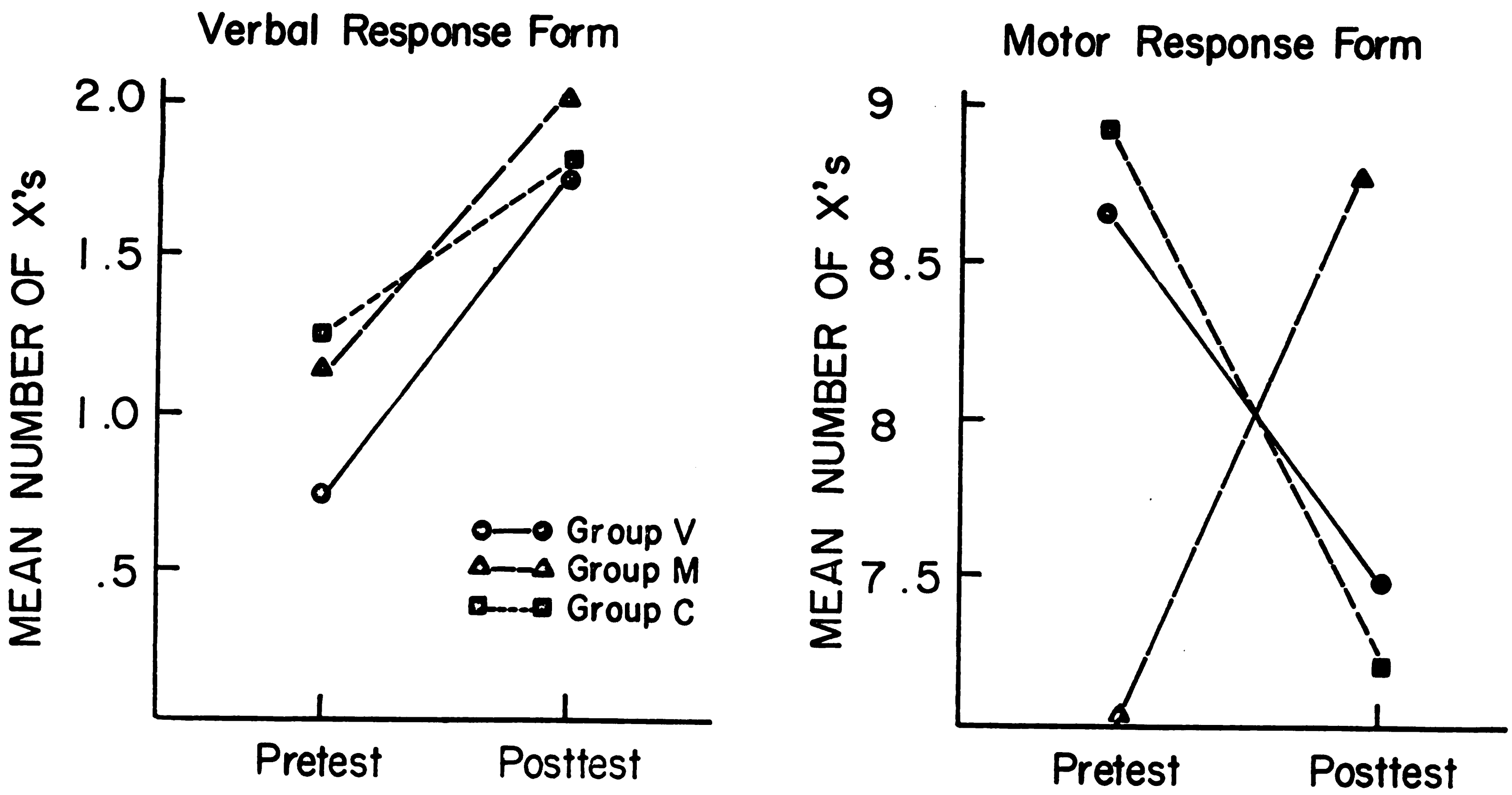

Figure 2.--Changes from pretest to posttest in the number of extra responses in each response form for each training group.

training group, test repetition and single versus combined modes of response shows that Group C's superior pretest performance was in the single mode (see Table 8). On the posttests, however, their scores in the single mode declined, while increasing in the combined mode. Contrary to all predictions, Group V on the posttest, following verbal training, had the fewest correct verbal responses of any group in the combined mode.

TABLE 8.--Changes From Pretest to Posttest in Mean Number of Correct Trials in the Single and Combined Modes for Each Training Group.

	Test Repetition	
Training Group	Pretest	Posttest
	Single Mode	
Verbal	2.79	4.54
Motor	3.00	4.17
Control	4.79	4.17
	Combined Mode	
Verbal	2.50	3.42
Motor	2.58	4.25
Control	2.58	4.04

It is interesting to consider how training might have affected the posttest performance of the initially superior Group C. Subjects in Group C generally seemed to be less interested in free play than other subjects were in their training sessions. Their play frequently consisted of naming toys as they took them out of the box. Only a few engaged in imaginative play, and these were among the younger, not the older, subjects. It may be that the more active direction involved in training was more interesting and thus contributed to more active cooperation on the posttests.

More training for Groups V and M might have enabled them to surpass Group C on the posttests. Training consisted of only four sessions lasting no more than five to ten minutes each. Both the training sessions and free play sessions provided general training in the experimental situation. All subjects accompanied the experimenter to the test room several times, played with interesting toys and had the undivided attention of an adult. This general training and the repetition of criterion tests contributed to some posttest improvement, especially by Groups V and M, but verbal and motor training did not produce the predicted differential effects.

The Effect of Criterion Test Repetition on Response Form and Mode

Correct Trials

In contrast with the prediction of the present experiment that the addition of the subjects' own speech would facilitate motor performance after verbal training, Luria predicts that facilitation will occur apart from either training or test repetition if children's "speech is well-trained." The outcome of the present experiment contradicts both predictions. Correct motor responses in the combined mode increased significantly from pretest to posttest, but there was no improvement in motor performance in the single mode. The observed changes were not a function of differential training. In statistical terms, the test repetition x response form x mode interaction for correct trials was significant ($F = 62.93$, $p < .05$; see Table 1, Appendix E).

Considered from the perspective of test repetition, the interaction resulted from the lack of improvement from pretest to posttest in motor responses in the single mode in contrast to increases in correct motor responses in the combined mode and in verbal responses in both modes (see Figure 3). According to a Newman-Keuls analysis (see Table 2, Appendix F), the increases from pretest to posttest in correct verbal-single, verbal-combined and motor-combined responses were significant.

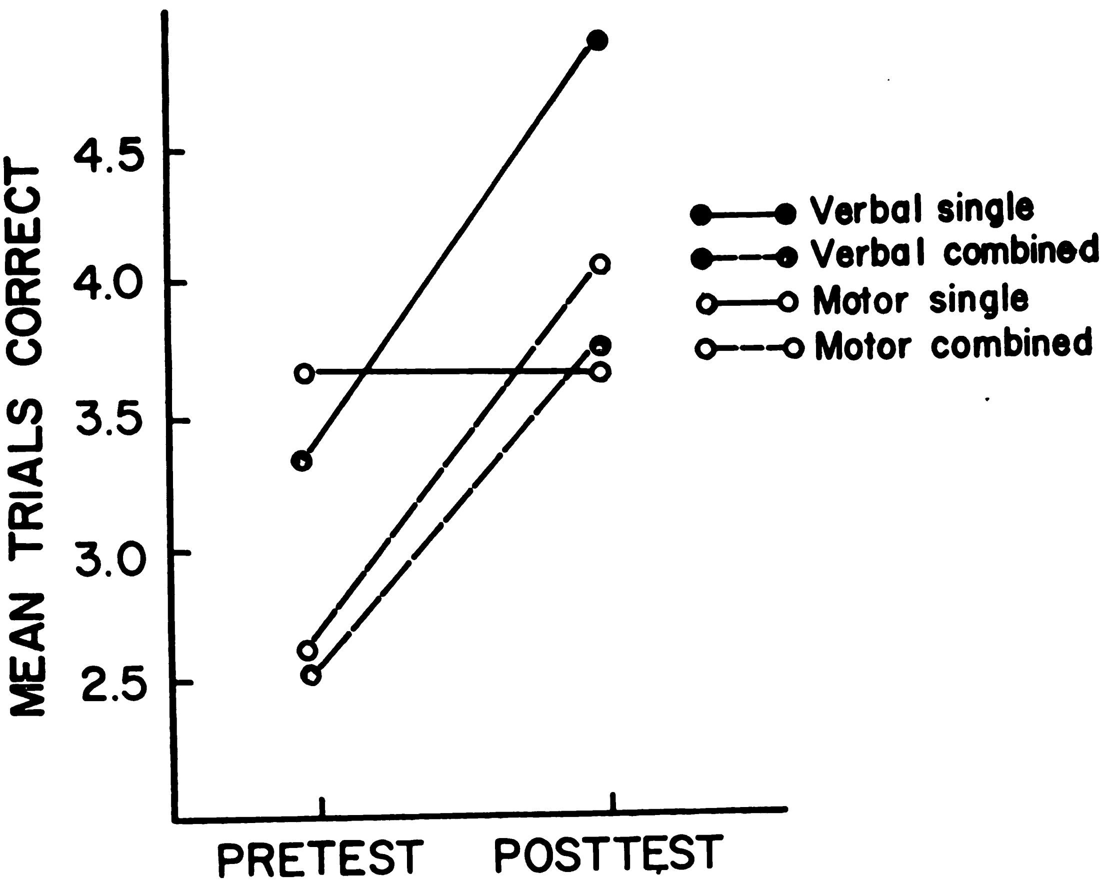

Figure 3.--Changes from pretest to posttest in correct verbal and motor responses in the single and combined modes.

The interaction also reflects differential effects of the single and combined modes of response. According to Luria's hypothesis there should have been more correct motor responses in the combined mode on both pretests and posttests. The prediction of the present experiment was that motor performance in the combined mode would be better than in the single mode only on the posttests. The finding concerning motor performance is that there was significantly more correct motor responses in the single mode than in the combined mode on the pretests, according to the Newman-Keuls analysis. But although there were more correct motor responses in the combined mode than in the single mode on the posttests, the difference was not significant. Thus on the pretest the addition of verbal responses led to a significant decrement in motor performance, while on the posttest the predicted improvement in motor responses as a result of the addition of verbal responses failed to occur.

The combined mode of response was generally more difficult than the single mode. There were significantly fewer correct responses over all in the combined mode ($\overline{X}_S = 3.92$, $\overline{X}_C = 3.23$, $F = 88.39$, $p < .05$; see Table 1, Appendix E). It should be remembered that the analysis disregards whether correct verbal and motor responses occurred together. Thus the number of correct responses is higher than under the alternate scoring method in which only responses in correct pairs are counted as correct. Verbal and motor performance on the pretests were both significantly better in the single mode than in the combined mode. On the posttests as well verbal performance was significantly better in the single mode. Motor performance on the posttest was better (though not significantly better) in the combined mode.

The verbal and motor response forms also contributed differently to the interaction. The mean number of correct verbal responses on Posttest V in the single mode was significantly higher than any other score, according to the Newman-Keuls analysis, which gives some support to Luria's contention that the verbal task can be performed more readily than the motor task by children of this age. However, there were fewer (though not significantly fewer) correct verbal than motor responses on both the combined pretests and posttests, calling into question the hypothesis that the verbal response guides the motor response in a direct way. Changes in motor performance with test repetition and variation in mode of response have already been discussed.

The significant interaction of test repetition, response form, and mode for correct trials resembles Luria's findings in three respects. First, on the posttests the verbal response form in the single mode was superior to the motor response form. Second, there was no improvement across test repetitions in performance of the ball-squeezing response in silence. Third, on the posttest, performance of the ball-squeezing response under combined instructions was somewhat (though not significantly) better than performance of the ball-squeezing response alone.

Repeated testing was apparently not a variable in Luria's experiments. Therefore, it is difficult to apply Luria's predictions with certainty to findings which involve repeated testing. However, it does appear from Luria's descriptions of his own research that verbal regulation should have been observed in the combined pretest of the present study, if all other experimental conditions had been the same. The fact that the posttest results of the present study were more similar to Luria's findings than the pretest results suggests that there were differences between Luria's research and the present study. There may be differences in the general kinds of training given to Luria's subject population and the subject population of the present study, apart from specific training for the experiment. There may also have been differences in introducing and practicing the tasks before criterion testing.

Apart from the factor of repeated testing, neither the pretest nor the posttest results, when examined separately, support Luria's hypothesis as understood by the present author. In neither case was the combined response significantly superior to the ball-squeezing task performed in silence. In fact, on the pretest the reverse was true. With repeated testing performance of the verbal and combined responses improved, while squeezing the ball in silence did not. This outcome is consistent with Luria's hypothesis but fails to provide an unequivocal demonstration of verbal regulation. It appears that some of the significant factors which contributed to Luria's results have not been clearly identified. The general effects of training and repeated testing observed in the present study are merely a beginning.

Omissions

There was also a significant interaction of test repetition, response form and mode for omissions ($F = 55.10$, $p < .05$, see Figure 4). According to a Newman-Keuls analysis (See Table 3, Appendix F), verbal omissions decreased significantly from pretest to posttest in both the single and combined modes. But motor omissions, of which there were fewer on the pretests, did not decrease significantly in either mode.

Comparing omissions in the single and combined modes, on the posttest there were significantly more omissions in both response forms in the combined mode than in the single mode. On the pretest there were also

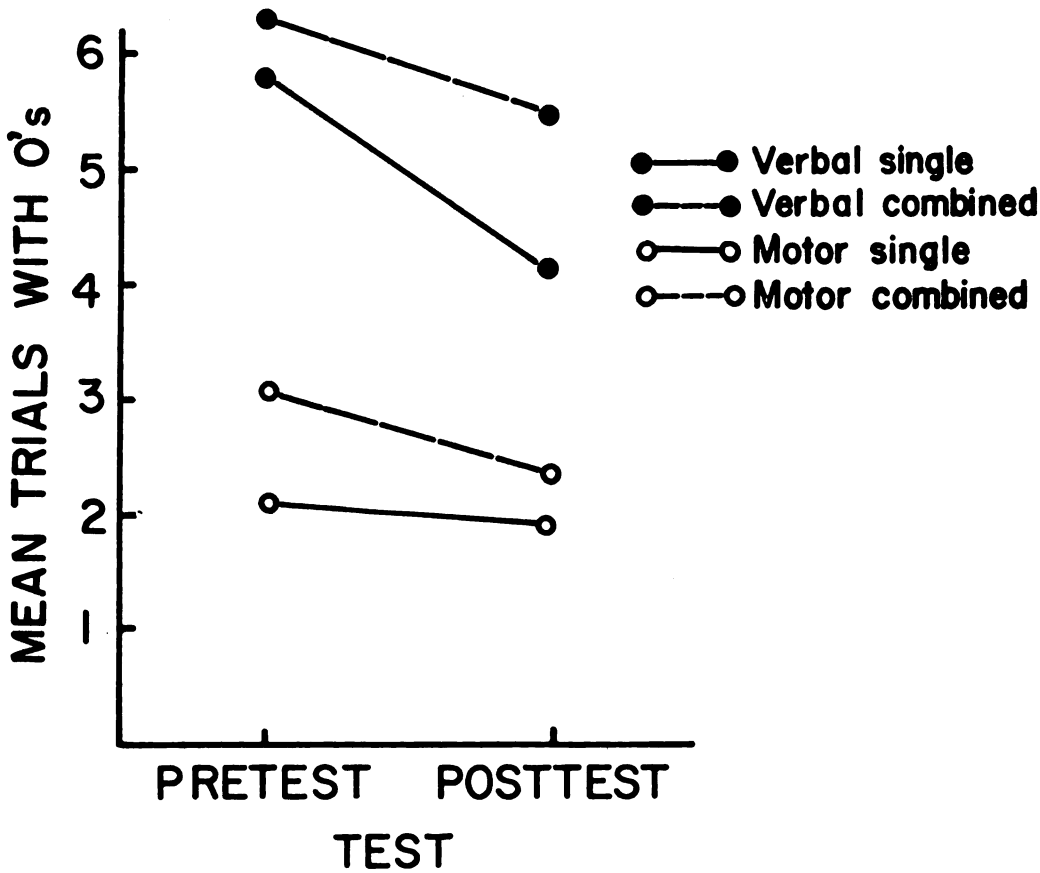

Figure 4.--Changes from pretest to posttest in omissions of verbal and motor responses in both the single and combined modes.

significantly more motor omissions in the combined mode than in the single mode. But the difference between modes in verbal omissions on the pretest was not significant. There were many verbal omissions on the pretests in both modes ($\overline{X}_s = 5.81$, $\overline{X}_c = 6.22$). The combined task generally inhibited responding. In the analysis of omissions (see Table 4, Appendix E) the main effect for mode was significant ($F = 65.27$, $p < .05$). What happened to the combined tests to motor responses when verbal responses were omitted will be discussed in connection with the analysis of verbal-motor pairs.

Verbal and Motor Response Forms Compared

Correct Trials

Essential for Luria's prediction is the assumption that carrying out a conditional instruction to each of a series of signals can be performed more readily with a verbal response than with the motor response of squeezing a ball. Apparently this assumption was valid for the population from which Luria's subjects were selected. In the present experiment the over all difference between the verbal and motor forms in correct responses was small and not significant ($\overline{X}_v = 3.63$, $\overline{X}_m = 3.51$, $F < 1$). Only on the posttest in the single mode were there more correct verbal than motor responses. On the pretests there were more correct motor than verbal responses in both modes.

There was, however, a significant interaction of response form with replication ($F = 5.91$, $p < .01$, see Figure 5). In the second replication subjects made significantly more correct verbal than motor responses, according to a Newman-Keuls analysis (see Table 4, Appendix F). Further, subjects in Replication 2 made significantly more correct verbal responses than subjects in the other replications, but their motor performance was not significantly different.

If superior verbal performance contributes to improvement in motor performance in the combined task, Replication 2 should have also had more correct verbal-motor pairs on Test VM than the other replications. But while their scores on Tests V and VM were higher (see Figure 6), the difference according to a four-factor analysis of correct trials was not significant ($F = 1.98$, $p > .10$; see Table 1, Appendix D). By the same reasoning Replication 2 should have had more correct motor responses in the combined mode. But according to a five-factor analysis the interaction of replication, response form and mode did not approach significance (see Table 1, Appendix E).

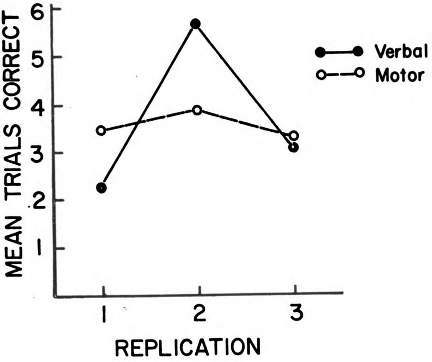

Figure 5.--Correct verbal and motor responses compared for each replication, using the five-factor scoring method.

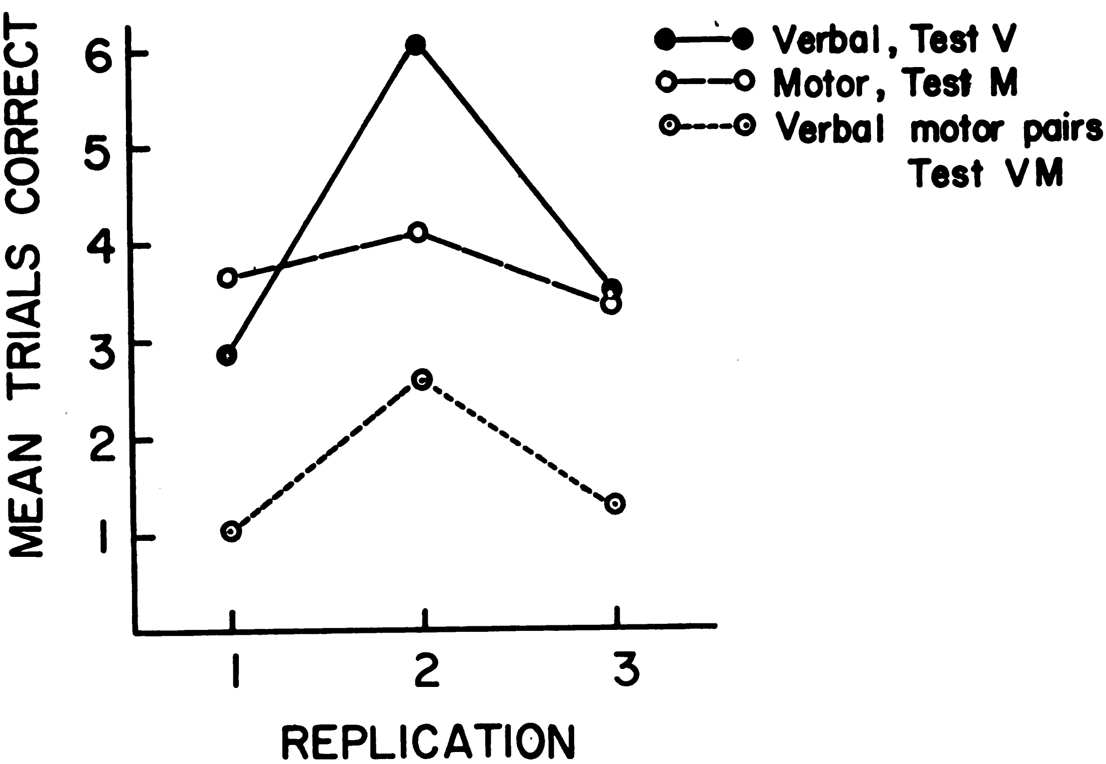

Figure 6.--Correct verbal, motor and combined verbal-motor responses compared for each replication, using the four-factor scoring method.

Extra Responses

The most common motor error was an extra response (X). There were significantly more trials with X's in the motor form than in the verbal form ($\overline{X}_v = 1.01$, $\overline{X}_m = 4.0$, $F = 18.92$, $p < .05$; see Table 2, Appendix E). Further, there was also a significant interaction of response form with replication for trials with X's ($F = 3.75$, $p < .05$). According to a Newman-Keuls analysis, (Table 5, Appendix F), Replications 2 and 3 had significantly more trials with motor X's than Replication 1, and Replication 2 had significantly more verbal X's than Replication 3 but not significantly more than Replication 1 (see Figure 7). It should be noted that Replication 2, which had the most trials with extra responses in both response forms, also had the most correct trials in both response forms. It appears that extra responses do not always indicate poor performance or a lack of task comprehension.

The difference between response forms in mean <u>number</u> of extra responses was large ($\overline{X}_v = 1.44$, $\overline{X}_m = 7.99$) but not significant ($F = 16.38$, $p < .10$; see Table 3, Appendix E). Individual differences were greater in the <u>number</u> of extra responses than in <u>trials</u> with extra responses. In the present experiment six subjects made from 54 to 132 extra responses each and accounted for more than

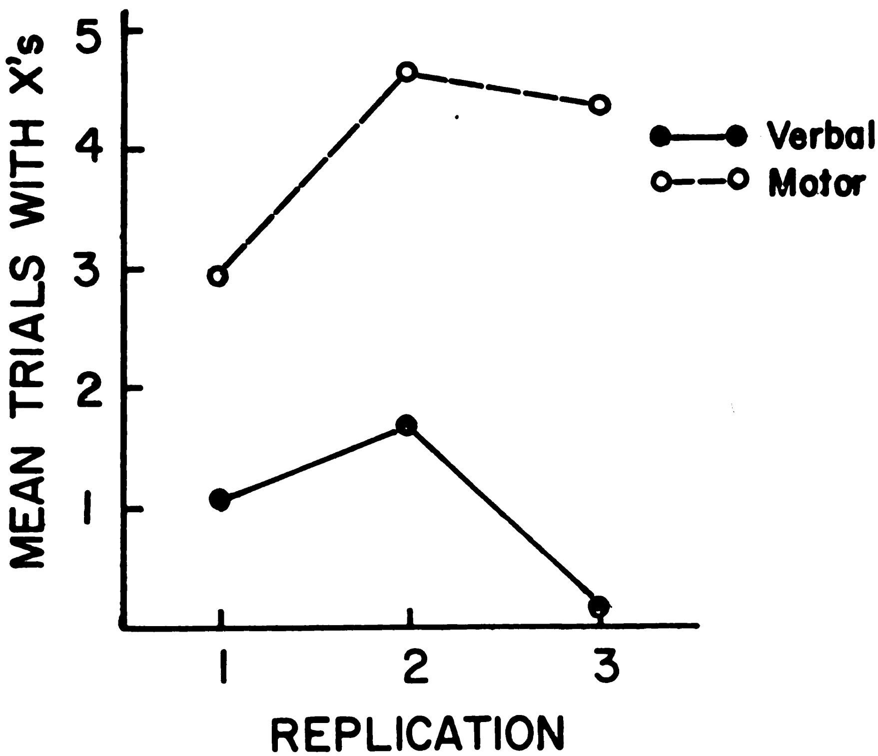

Figure 7.--Trials with extra verbal and motor responses, for each replication.

one-third of the total number of X's. The mean number of X's for the remaining subjects was 29.

<u>Omissions</u>

There were more (though not significantly more) trials with omissions in the verbal form ($\bar{X}_v = 5.25$, $\bar{X}_m = 2.43$, $F = 8.69$, $p < .10$; see Table 4, Appendix E). In the present experiment, subjects omitted verbal responses on more than half of the trials. This result contrasts with Luria's finding that the verbal response was performed readily and could therefore be used to direct the motor response. Luria (1961) mentioned the contribution of extensive speech training to the performance of the combined task. One explanation for the divergent results may be that the day care center programs and special training involved in the present experiment provided a comparatively small amount of verbal training.

There was a significant difference among replications in the number of omitted responses ($F = 8.34$, $p < .01$, see Table 4, Appendix E). According to a Newman-Keuls analysis, (Table 6, Appendix F), Replication 2 omitted significantly fewer responses than either of the other replications. The replication x response form interaction was also significant ($F = 5.74$, $p < .01$; see Figure 8). Replication 2 omitted significantly fewer verbal responses than the other replications, according to

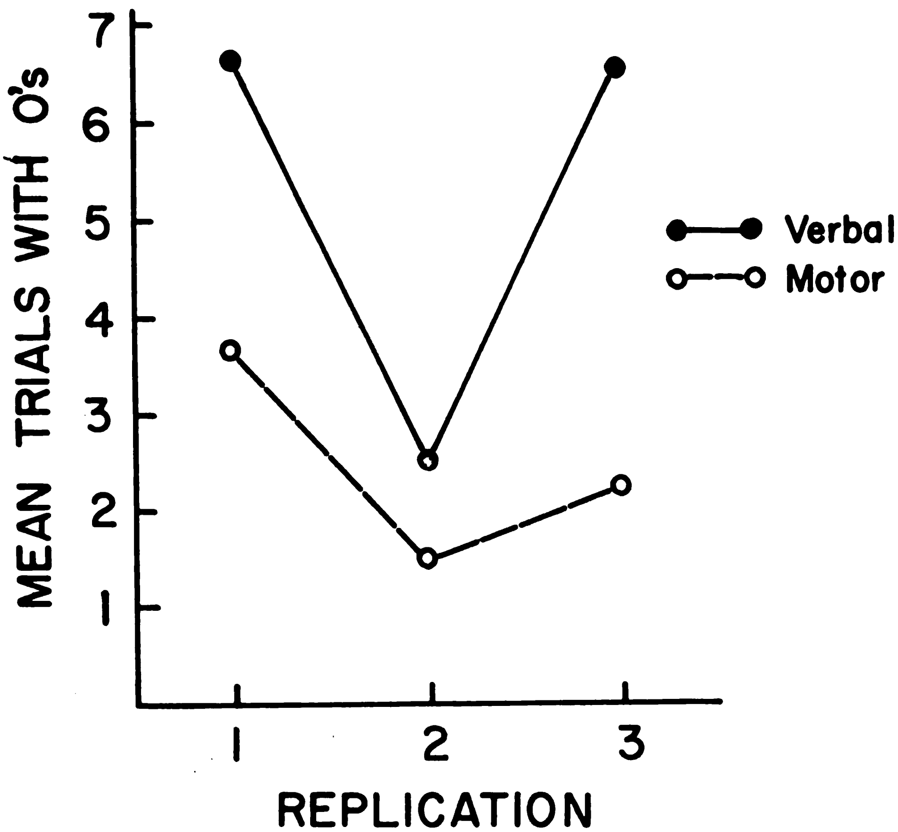

Figure 8.--Verbal and motor omissions for each replication.

a Newman-Keuls analysis (see Table 7, Appendix F). Replications 1 and 3 omitted significantly more verbal than motor responses, but for Replication 2 the difference between verbal and motor omissions was not significant.

In summary, the expected superiority of the verbal form was not found in the present study. Instead, the verbal response was omitted on more than half of all trials. The motor response was omitted less often, but there were many trials with extra motor responses, as Luria and others have found.

Replication 2 subjects differed from the general pattern, espceially in the verbal form. As mentioned previously they made significantly more correct verbal responses and omitted significantly fewer verbal responses. Surprisingly, they also made more, not fewer, extra verbal responses. It appears that they were more responsive in general, especially in the verbal form. But their superior verbal performance did not lead to significantly better performance in the combined task.

Replications

Differences among replications were observed particularly in interaction with response forms. As described above, subjects in Replication 2 generally made more responses. They had significantly more correct trials than Replication 1 and more (though not significantly more) correct trials than Replication 3 according to a Newman-Keuls analysis (see Table 8, Appendix F). They also had significantly fewer omissions and more (though not significantly) correct trials, extra responses and trials with extra responses. However, there were no significant differences among replications in chronological or mental age. The three day care centers - located in Midland, Bay City and Saginaw, Michigan - were under the same ownership and conducted similar programs. The reason for the differences is not apparent in the data gathered. But differences in mood among staff and children and in responsiveness of children to adults were noticeable. An attempt was made to discover parents' occupations, but parents frequently omitted the requested information on the parental consent form. The day care centers refused to divulge information about parents from their files without the parents' consent.

Performance on the Combined Tests

Thus far, scores from the combined pretest and posttests have been treated as two separate sets of responses, performed under the same instructions but not necessarily on the same trials. The intersection of these two sets contains pairs of verbal and motor responses which occurred on the same trials of the combined tests. When both sets represent correct responses, the intersection contains pairs of correct verbal and correct motor responses. When both sets represent trials with extra responses, the intersection contains trials with both extra verbal and extra motor responses, and similarly with omissions.

The pairs of responses just described comprised the combined test scores in the four-factor analyses of correct responses, trials with extra responses, and omitted responses. For these analyses the combined test scores were one level of the response form factor (F), the other two levels being the verbal test scores and the motor test scores.

In the four-factor analysis of correct responses which was discussed previously, the main effect for response form was significant because of the low scores from the combined tests ($F = 12.09$, $p < .05$, see Table 1, Appendix D). The number of correct pairs on the combined test was much lower than the number of correct responses on either the verbal test or the motor test ($\overline{X}_v = 4.13$, $\overline{X}_m = 3.71$, $\overline{X}_{vm} = 1.61$).

In the four-factor analyses of trials with extra responses and of omissions, the main effects for response form were also significant (See Tables 2 and 3, Appendix D). There were more trials with extra responses on the motor test ($\overline{X}_m = 4.22$) than on the verbal test ($\overline{X}_v = 1.07$) or the combined test ($\overline{X}_{vm}$ = .62). There were more omissions on the verbal test ($\overline{X}_{v}$ = 4.72) than on the motor test ($\overline{X}_{m}$ = 2.06) or the combined test ($\overline{X}_{vm}$ = 2.28). It appears from the four-factor analyses of errors that there were few errors of either kind on the combined tests. But the low error scores are an artifact of the scoring method. Only those pairs containing the same error in both response forms were counted for these analyses.

On the combined tests there were also pairs of verbal and motor responses that were not alike. Correct responses in one response form occurred with errors in the other response form, and extra responses in one response form occurred with omissions in the other response form. There are nine possible combinations of verbal and motor responses in all. Three contain like responses and the other six contain responses that are not alike. In Table 9, the intersection of any row (motor responses) and any column (verbal responses) identifies a verbal-motor response pair and gives the mean frequency with which that particular pair occurred on both the pretest and the posttest.

In Table 10, the response pairs are listed in rank order according to the frequency of their occurrence on the combined pretest and posttest. On the combined pretest, the most frequent response pair was a verbal omission with

TABLE 9.--Mean Frequency of all Verbal-Motor Response Pairs on the Combined Tests.

	Verbal Responses		
Motor Responses	Correct	Extra	Omitted
Combined Pretest			
Correct	1.14	.28	1.44
Extra	1.08	.58	2.22
Omitted	.22	.06	2.56
Combined Posttest			
Correct	2.08	.14	1.78
Extra	1.08	.61	1.39
Omitted	.56	.17	2.03

TABLE 10.--Rank Order of Response Pairs According to the Frequency of Their Occurrence on the Combined Pretest and Posttest.

	Combined Pretest Responses		Combined Posttest Responses	
Rank Order	Verbal	Motor	Verbal	Motor
Most Frequent	Omitted	Omitted	Correct	Correct
.	Omitted	Extra	Omitted	Omitted
.	Omitted	Correct	Omitted	Correct
.	Correct	Correct	Omitted	Extra
.	Correct	Extra	Correct	Extra
.	Extra	Extra	Extra	Extra
.	Extra	Correct	Correct	Omitted
.	Correct	Omitted	Extra	Omitted
Least Frequent	Extra	Omitted	Extra	Correct

a motor omission. But on the posttest the most frequent pair was a correct verbal response with a correct motor response. As expected, extra motor responses occurred most often when the verbal response was omitted, but the frequency of this response pair decreased from pretest to posttest. Surprisingly for the response interaction hypothesis, pairs of verbal omissions with correct motor responses occurred fairly often on both tests, as did pairs of correct verbal responses with extra motor responses. These five response combinations, which were the most frequent ones, account for an average of 8.14 trials on the combined pretest and 8.35 trials on the combined posttest.

The frequency of correct verbal-motor pairs suggests the occurrence of verbal-motor interaction. The frequent omission of both responses may indicate the difficulty of the combined task for very young children.

Training and Test Performance Compared

The differential effects of training on criterion test performance were assessed by the interaction of the training group and test repetition factors with other factors in the analyses of variance. The only effect observed which could be attributed to training was a general tendency toward greater improvement from pretests to posttests by both of the trained groups in comparison with the control group.

Another way to measure the relationshp of training and test performance is by the correlation of training and criterion test scores. The correlation was computed for the trained groups only since there was no training scores for the control group. Since training scores consist of trials to criterion on the training tasks, lower training scores reflect better performance in training, while better performance on the criterion tests yields higher scores. A positive relationship between training and criterion test performance is shown by a negative correlation.

The correlation of training with the three criterion pretests was small ($r = -.15$), but the correlation of training with the three criterion posttests was significant ($r = -.42$, $t = 2.17$, $p < .05$). The correlation of training scores with the posttest for which subjects had been trained was about the same ($r = -.43$). Again, there is no evidence of differential effects from the two types of training, verbal and motor.

The correlation of criterion pretest scores with posttest scores for the trained groups was higher ($r = .79$) than the correlation of training scores with criterion posttest scores for the same subjects. The difference between the two correlations suggests that individual subjects were more consistent in repeating the same criterion tests than they were in performing two similar but not identical tasks (training and the criterion tests).

A separate correlation was computed for the criterion pretest and posttest scores of the control group. The correlation for the control group was lower ($r = .50$) than for the trained groups ($r = .79$). The control group improved less from pretests to posttest than the trained groups did, according to the analysis of variance for correct trials discussed previously. The lower correlation for the control group shows that that group was less consistent in repeating the criterion tasks. Since the activity between the pretests and posttests was different for the control group than for the trained groups, the implication is that training had a positive effect on consistency in creiterion test performance.

Training differed from the criterion tests in the materials used, even though the instructions were similar, and in the case of Training Session 4, identical. There were also differences in the kinds of verbal errors that occurred. During criterion testing, especially the pretests, there were numerous verbal omissions. But during training there were few verbal omissions and many early verbal responses. Verbal training was geared to overcome the previously observed reticence of young children to speak in accordance with instructions. But in training children were stimulated to speak more by the toys than by the instructions. For this reason learning to speak in response to instructions may have been minimal during training. The observed decrease in verbal omissions from criterion pretest to posttest among all groups appears to have resulted from general warm up effects rather than from verbal training.

Other methods of training might contribute more to the understanding of processes involved in the ball-squeezing and verbal tasks.

Comments on the Ball-Squeezing and Verbal Tasks

During motor training children were sometimes instructed to put a block or toy into a box for every signal. These tasks seemed to be much easier than either the ball-squeezing or verbal tasks. Consequently after the completion of testing for Replications 2 and 3, children were given another test in which they were asked to put a block into a box when the light came on. The first objective was to compare performance on the block task with the ball-squeezing task. Another objective was to see whether young children could perform the block task without verbal reinforcement on each trial. During training all correct responses had been reinforced. The third objective was to check informally the effectiveness of corrections given during performance of the task, since the absence of corrections during the ball-squeezing tests together with the automatic timing of signals seemed to result at times in the complete breakdown of task performance.

The block test was given after the last criterion posttest and in the same session. No verbal response was required. The experimenter piled 31 blocks on the table within the children's reach and placed a box nearby. The instruction was given only once: "When the light comes on, put a block in the box." Light signals were operated manually. The experimenter waited until the response was completed before giving the next light signal. Occasionally the light was delayed to see if children were waiting for the signal.

Every error was corrected. A block put in the box before the signal was removed from the box by the experimenter, and the subject was reminded to wait for the light. When two blocks were put into the box together, one was removed with the correction, "Just one block." Omissions, of which there were few, were prompted by, "Watch the light." No positive reinforcement was given.

No variables were experimentally manipulated. Nevertheless the outcome was interesting and opens further avenues for research in young children's learning by instructions. Each subject's score is the longest string of consecutive correct responses. This method of reporting results was chosen instead of the total of correct responses since testing was casual and some children were allowed to stop playing before all 31 blocks were put into the box. During the earlier criterion tests, only one subject made ten correct ball-squeezing responses on one test, and two subjects made nine correct ball-squeezing responses on one test (but not necessarily consecutively). But in the block task the average longest string of correct responses was 13.26 for Replication 2 and 11.27 for Replication 3. The longest strings ranged from three to 31, with a grand mean of 12.3. Children obviously performed better in the block task than in either the ball-squeezing or verbal tasks.

While playing the experimenter's block game, it was common for children to devise their own games. Most children either built some kind of structure in the box as they added each block or arranged blocks according to color and form. Testing was occasionally terminated because of the collapse of an unstable structure.

The block task appeared to be more interesting and to provide more proprioceptive feedback on performance. Children understood the instructions and had little difficulty in following a light signal. Extra responses and omissions were observed in the block test when children appeared to be paying greater attention to their own game than to the experimenter's game. But such errors were much less frequent in the block test than in the ball-squeezing or verbal tests.

Luria's hypothesis is of course not rejected because of children's success in the block test without the addition of verbal responses. However, it does appear that the kind of verbal-motor interaction which Luria found and which was also present to a small degree in the present experiment is limited to tasks like the ball-squeezing response. The special characteristics of the ball-squeezing response should be identified by experimental manipulation. Some of those characteristics appear to include the paucity of proprioceptive feedback, lack of lasting effects, lack of interest for young subjects, and the arbitrary structure of the task. The verbal task seems to share many of the same characteristics, at least for the subjects in the present experiment. Luria and others focused on the problem of inhibition in the ball-squeezing task. But the problem of inhibition does not exist in the verbal task. Rather, the problem in the verbal task was to overcome inhibition. More than half of all verbal responses were omitted on the criterion tests. But even though the typical errors were different for the verbal and ball-squeezing tasks, performance was equally poor in both, in contrast to performance in the block task.

Conclusion

Verbal responses affect performance on various tasks, including the ball-squeezing task according to the present study. But the functions of verbal responses differ according to the requirements of the particular task.

In addition to the inhibition of motor perseveration, the ball-squeezing task requires compliance, understanding of the instructions, performance with limited sources of feedback and no knowledge of results, and tolerance for boredom. Resistance to the task was not mentioned by Luria or by the authors of the replications cited previously. But the present author observed that many children apparently did not like either the ball-squeezing or the verbal tasks. There were frequent protests such as, "I don't want to do this any more," or "I want some toys." Occasionally subjects refused to take a criterion test. No protests occurred during training, however, and there were only one or two protests during the block task.

If lack of interest is an important problem in the ball-squeezing task, the addition of overt verbal responses may help by requiring increased attention and effort during task performance and by providing an additional source of feedback (the sound of the subject's own voice). According to this interpretation, overt verbal responses in the ball-squeezing task probably function similarly to overt verbal responses by impulsive children. Children whose cognitive style is impulsive probably have difficulty in concentrating their attention on the Matching Familiar Figures test, and therefore they choose a matching picture quickly and make frequent errors. Luria's subjects may have been more compliant in performing an uninteresting task because children in Soviet day care centers may be more accustomed to obeying instructions than their American counterparts.

According to Luria, the chief problem in the ball-squeezing task is inhibition of the motor perseveration which is caused by stimulation of the palm by the ball. Since several problems are present in the ball-squeezing task, it is not possible to determine which if any of the problems is solved by the addition of overt verbal responses. For these reasons, the ball-squeezing task is not an adequate paradigm experiment for the study of verbal regulation.

Luria's hypothesis is based on only one response, and his explanation concerning the inhibition of nervous impulses applies only to that task. The verbal mediation hypothesis does not provide an adequate explanation of verbal regulation either because it does not account for correct motor responses made without the aid of overt verbal responses. Further, the verbal mediation hypothesis implies that overt verbal responses are necessary and sufficient to produce correct motor responses, but there is no evidence in replications of Luria's research to support such a claim.

Since there is evidence for verbal-motor interaction in other tasks as well as limited evidence from the present study, a broader theory is needed. Such a theory should be based on the existing data which suggest that verbal responses have a variety of functions and that the function of verbal responses in a given task (if any) depends on the requirements of that task.

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APPENDICES

APPENDIX TABLE A-1.--Analysis of variance: chronological age.

Source	df	MS	F
Replication (R)	2	8.028	
Training Group (G)	2	.45	
R x G	4	1.28	
Subj. w. Group	27	16.31	

APPENDIX TABLE A-2.--Analysis of variance: mental age.

Source	df	MS	F
Replication (R)	2	.53	
Training Group (G)	2	18.53	
R x G	4	6.69	
Subj. w. Group	27	55.51	

APPENDIX TABLE B-1.--Objects used in training.

Action Objects	Non-Action Objects	
Engine	Bed	Book
Scissors	Dog	Spoon
Pitcher	Doll	Pencil
Umbrella	Leaf	Stove
Crayon and Paper	Key	Soap
Airplane	Horse	Chicken
Car	Tree	Block
Ball	Box	Truck
Cup	Hat	Penny
Iron	Flag	Rabbit
Table Knife	Chair	Shoe
Fork	Ship	Button
Telephone	Coat	Wagon

APPENDIX TABLE B-2.--Training words.

Clown
Wash
Run
Catch
Mitten
Can
Pin
Jump
Fall
Knock

APPENDIX TABLE C-1.--Analysis of variance: Training Scores.

Source	df	MS	F
Between subjects			
Replications (R)	2	12.07	
Training Groups (G)	1	212.63	
R x G	2	155.64	
Subj. w. Groups	18	96.50	
Within Subjects			
Instructions (I)	6	285.36	18.73**
R x I	12	15.24	
G x I	6	84.42	2.75
R x G x I	12	30.69	
I x Sub. w. Groups	108	43.11	

** $p < .01$

APPENDIX TABLE D-1.--Analysis of variance: trials correct.

Source	df	MS	F
Between Subjects			
Replications (R)	2	68.23	3.46*
Training Groups (G)	2	6.81	
R x G	4	11.80	
Subj. w. Groups	27	19.74	
Within Subjects			
Criterion Test			
Repetition (T)	1	37.50	2.41
R x T	2	15.54	4.32*
G x T	2	12.10	2.37
R x G x T	4	5.10	
T x Subj. w. Groups	27	3.60	
Response Form (F)	2	130.70	12.09*
R x F	4	10.81	1.98
G x F	4	3.52	
R x G x F	8	4.91	
F x Subj. w. Groups	54	5.46	
T x F	2	10.29	2.47
R x T x F	4	4.17	
G x T x F	4	7.39	1.76
R x G x T x F	8	4.19	
T x F x Subj. w. Groups	54	3.65	

*$p < .05$

APPENDIX TABLE D-2.--Four-factor analysis of variance: trials with extra responses.

Source	df	MS	F
Between subjects			
Replications (R)	2	25.04	3.96*
Training Groups (G)	2	1.85	
R x G	4	4.81	
Subj. w. Groups	27	6.32	
Within Subjects			
Criterion Test			
Repetition (T)	1	.91	
R x T	2	.23	
G x T	2	.12	
R x G x T	4	1.69	
T x Subj. w. Groups	27	3.70	
Response Form (F)	2	276.93	19.99**
R x F	4	13.85	4.22**
G x F	4	2.84	
R x G x F	8	4.47	
F x Subj. w. Groups	54	3.28	
T x F	2	1.87	
R x T x F	4	6.27	2.01
G x T x F	4	1.26	2.34
R x G x T x F	8	.54	
T x F x Subj. w. Groups	54	3.12	

*$p < .05$

**$p < .01$

APPENDIX D-3.--Four-factor analysis of variance: trials with omissions.

Source	df	MS	F
Between Subjects			
Replications (R)	2	160.84	7.96**
Training Groups (G)	2	18.09	
R x G	4	23.87	
Subj. w. Group	27	20.22	
Within Subjects			
Criterion Test			
Repetition (T)	1	39.19	3.92
R x T	2	10.01	
G x T	2	9.06	4.13
R x G x T	4	2.19	
T x Subj. w. Group	27	10.81	
Response Form (F)	2	157.63	8.83*
R x F	4	17.85	2.41
G x F	4	2.35	2.08
R x G x F	8	1.13	
F x Subj. w. Group	54	7.42	
T x F	2	25.69	7.99*
R x T x F	4	3.21	
G x T x F	4	5.02	
R x G x T x F	8	4.70	
T x F x Subj. w. Group	54	3.76	

*$p < .05$

**$p < .01$

APPENDIX TABLE E-1.--Five-factor analysis of variance: trials correct.

Source	df	MS	F
Between Subjects			
Replications (R)	2	97.91	3.42*
Training Groups (G)	2	8.84	
R x G	4	13.75	
Subj. w. Groups	27	28.62	
Within Subjects			
Response Form (F)	1	1.00	
R x F	2	57.19	5.91**
G x F	2	2.96	
R x G x F	4	4.52	
F x Subj. w. Groups	27	9.68	
Criterion Test			
Repetition (T)	1	81.28	5.60
R x T	2	14.51	2.95
G x T	2	7.07	
R x G x T	4	4.93	
T x Subj. w. Groups	27	4.92	
Mode (M)	1	34.03	88.39*
R x M	2	.39	
G x M	2	6.26	
R x G x M	4	3.27	
M x Subj. w. Groups	27	5.41	
T x F	1	7.03	1.97
R x T x F	2	3.57	
G x T x F	2	1.01	6.92
R x G x T x F	4	.15	
T x F x Subj. w. Groups	27	3.60	
T x M	1	5.84	
R x T x M	2	8.71	
G x T x M	2	12.42	3.38
R x G x T x M	4	3.67	
T x M x Subj. w. Groups	27	5.50	

APPENDIX TABLE E-1.--Continued.

Source	df	MS	F
F x M	1	6.42	5.49
R x F x M	2	1.17	
G x F x M	2	2.50	
R x G x F x M	4	5.82	2.17
F x M x Subj. w. Groups	27	2.68	
T x F x M	1	13.78	62.93*
R x T x F x M	2	.22	
G x T x F x M	2	9.09	
R x G x T x F x M	4	9.44	3.97*
T x F x M x Subj. w. Groups	27	2.38	

*p < .05

**p < .01

APPENDIX TABLE E-2.--Five-factor analysis of variance: trials with extra responses.

Source	df	MS	F
Between Subjects			
Replication (R)	2	34.85	2.86
Training Group (G)	2	4.68	
R x G	4	12.42	
Subj. w. Groups	27	12.20	
Within Subjects			
Response Form (F)	1	642.01	18.92*
R x F	2	33.93	3.75*
G x F	2	2.51	
R x G x F	4	11.31	
F x Subj. w. Groups	27	9.04	
Criterion Test			
Repetition (T)	1	3.56	19.65*
R x T	2	.18	
G x T	2	.43	
R x G x T	4	2.37	
T x Subj. w. Groups	27	4.32	
Mode (M)	1	5.56	5.97
R x M	2	.93	
G x M	2	5.85	3.46
R x G x M	4	1.69	
M x Subj. w. Groups	27	2.55	
T x F	1	12.50	2.33
R x T x F	2	5.38	1.95
G x T x F	2	.79	
R x G x T x F	4	.82	
T x F x Subj. w. Groups	27	2.76	
T x M	1	10.13	
R x T x M	2	8.79	1.85
G x T x M	2	2.17	3.72
R x G x T x M	4	.58	
T x M x Subj. w. Groups	27	4.74	

APPENDIX TABLE E-2.--Continued.

Source	df	MS	F
F x M	1	2.00	
R x F x M	2	1.54	
G x F x M	2	.38	
R x G x F x M	4	1.17	
F x M x Subj. w. Groups	27	2.64	
T x F x M	1	.68	
R x T x F x M	2	1.26	
G x T x F x M	2	.72	
R x G x T x F x M	4	.96	
T x F x M x Subj. w. Groups	27	3.44	

*p < .05

APPENDIX TABLE E-3.--Five-factor analysis of variance: number of extra responses.

Source	df	MS	F
Between Subjects			
Replications (R)	2	160.59	1.70
Training Groups (G)	2	.59	
R x G	4	94.51	
Subj. w. Groups	27	94.50	
Within Subjects			
Response Form (F)	1	3094.22	16.38
R x F	2	188.88	2.42
G x F	2	1.65	
R x G x F	4	62.71	
F x Subj. w. Groups	27	78.16	
Criterion Test Repetition (T)	1	2.72	
R x T	2	44.59	
G x T	2	22.48	
R x G x T	4	25.19	
T x Subj. w. Groups	27	28.27	
Mode (M)	1	10.13	
R x M	2	44.26	
G x M	2	43.97	4.10
R x G x M	4	10.73	
M x Subj. w. Groups	27	35.04	
T x F	1	26.89	
R x T x F	2	26.21	
G x T x F	2	18.25	9.996*
R x G x T x F	4	1.83	
T x F x Subj. w. Groups	27	13.46	
T x M	1	110.01	4.25
R x T x M	2	25.90	
G x T x M	2	12.13	
R x G x T x M	4	14.80	
T x M x Subj. w. Groups	27	23.94	

APPENDIX TABLE E-3.--Continued.

Source	df	MS	F
F x M	1	8.68	
R x F x M	2	15.48	
G x F x M	2	7.09	
R x G x F x M	4	6.30	
F x M x Subj. w. Groups	27	18.56	
T x F x M	1	45.13	4.96
R x T x F x M	2	9.09	
G x T x F x M	2	5.34	
R x G x T x F x M	4	15.06	
T x F x M x Subj. w. Groups	27	22.47	

*p < .05

APPENDIX TABLE E-4.--Five-factor analysis of variance: trials with omissions.

Source	df	MS	F
Between Subjects			
Replications (R)	2	260.48	8.34**
Training Groups (G)	2	23.93	
R x G	4	32.11	
Subj. w. Groups	27	31.22	
Within Subjects			
Response Form (F)	1	572.35	8.69
R x F	2	65.90	5.74**
G x F	2	2.76	
R x G x F	4	3.77	
F x Subj. w. Groups	27	11.47	
Criterion Test			
Repetition (T)	1	42.01	
R x T	2	20.96	
G x T	2	5.60	
R x G x T	4	2.97	
T x Subj. w. Groups	27	9.80	
Mode (M)	1	58.68	65.27*
R x M	2	.90	
G x M	2	3.01	
R x G x M	4	2.84	
M x Subj. w. Groups	27	5.01	
T x F	1	42.01	4.06
R x T x F	2	10.34	3.88*
G x T x F	2	1.26	
R x G x T x F	4	.85	
T x F x Subj. w. Groups	27	2.66	
T x M	1	4.01	2.91
R x T x M	2	1.38	
G x T x M	2	7.93	
R x G x T x M	4	6.66	
T x M x Subj. w. Groups	27	5.29	

APPENDIX TABLE E-4.--Continued.

Sources	df	MS	F
F x M	1	1.68	
R x F x M	2	4.86	
G x F x M	2	2.76	
R x G x F x M	4	3.39	
F x M x Subj. w. Groups	27	3.94	
T x F x M	1	11.68	55.10*
R x T x F x M	2	.21	
G x T x F x M	2	6.68	
R x G x T x F x M	4	5.73	
T x F x M x Subj. w. Groups	27	4.73	

*p < .05
**p < .01

APPENDIX TABLE F-1. Newman-Keuls Analysis of Number of Extra Responses: Training Group x Test Repetition x Response Form.

Test Scores	Vv_1	Mv_1	Cv_1	Vv_2	Cv_2	Mv_2	Mm_1	Cm_2	Vm_2	Vm_1	Mm_2	Cm_1
Ordered Means	.708	1.13	1.29	1.75	1.79	2.00	7.04	7.21	7.46	8.63	8.71	8.92

	Vv_1	Mv_1	Cv_1	Vv_2	Cv_2	Mv_2	Mm_1	Cm_2	Vm_2	Vm_1	Mm_2	Cm_1
Vv_1		-	-	-	-	-	**	**	**	**	**	**
Mv_1			-	-	-	-	**	**	**	**	**	**
Cv_1				-	-	-	**	**	**	**	**	**
Vv_2					-	-	**	**	**	**	**	**
Cv_2						-	**	**	**	**	**	**
Mv_2							**	**	**	**	**	**
Mm_1								-	-	-	-	*
Cm_2									-	-	-	-
Vm_2										-	-	-
Vm_1											-	-
Mm_2												-

$S_{\overline{B}} = .276$, $f = 4$

*$p < .05$
**$p < .01$

APPENDIX TABLE F-2.--Newman-Keuls analysis of correct trials: test repetition x response form x mode.

Test Scores	$v\text{-}c_1$	$m\text{-}c_1$	$v\text{-}s_1$	$m\text{-}s_1$	$m\text{-}s_2$	$v\text{-}c_2$	$m\text{-}c_2$	$v\text{-}s_2$
Ordered Means	2.53	2.58	3.36	3.69	3.72	3.75	4.06	4.89

	$v\text{-}c_1$	$m\text{-}c_1$	$v\text{-}s_1$	$m\text{-}s_1$	$m\text{-}s_2$	$v\text{-}c_2$	$m\text{-}c_2$	$v\text{-}s_2$
$v\text{-}c_1$			*	*	*	*	*	**
$m\text{-}c_1$			*	*	*	*	*	**
$v\text{-}s_1$				-	-	-	-	*
$m\text{-}s_1$					-	-	-	*
$m\text{-}s_2$						-	-	*
$v\text{-}c_2$							-	*
$m\text{-}c_2$								*

$S_{\overline{B}} = .078$, f = 2

*p < .05

**p < .01

APPENDIX TABLE F-3.--Newman-Keuls Analysis of Omissions: Test Repetition x Response Form x Mode.

Test Scores	$m\text{-}s_1$	$m\text{-}s_2$	$m\text{-}c_2$	$m\text{-}c_1$	$v\text{-}s_2$	$v\text{-}c_2$	$v\text{-}s_1$	$v\text{-}c_1$
Ordered Means	1.97	2.13	2.72	2.89	3.64	5.33	5.81	6.22
	$m\text{-}s_1$	$m\text{-}s_2$	$m\text{-}c_2$	$m\text{-}c_1$	$v\text{-}s_2$	$v\text{-}c_2$	$v\text{-}s_1$	$v\text{-}c_1$
$m\text{-}s_1$		–	*	*	*	**	**	**
$m\text{-}s_2$			*	*	*	**	**	**
$m\text{-}c_2$				–	*	**	**	**
$m\text{-}c_1$					*	**	**	**
$v\text{-}s_2$						*	**	**
$v\text{-}c_2$							*	*
$v\text{-}s_1$								–

$S_{\bar{B}} = .077$, f = 2

*p < .05

**p < .01

APPENDIX TABLE F-4.--Newman-Keuls analysis of correct trials: replication x response form.

Test Scores	R_1v	R_3v	R_3m	R_1m	R_2m	R_2v
Ordered Means	2.21	3.06	3.31	3.42	3.81	5.63
	R_1v	R_3v	R_3m	R_1m	R_2m	R_2v
R_1v		-	-	-	-	**
R_3v			-	-	-	**
R_3m				-	-	**
R_1m					-	**
R_2m						**

$S_{\overline{B}} = .448$, f = 27

**p < .01

APPENDIX TABLE F-5.--Newman-Keuls analysis of trials with extra responses: replication x response form.

Test Scores	R_3v	R_1v	R_2v	R_1m	R_3m	R_2m
Ordered Means	.19	1.13	1.73	2.96	4.40	4.65
	R_3v	R_1v	R_2v	R_1m	R_3m	R_2m
R_3v		-	*	**	**	**
R_1v			-	*	**	**
R_2v				-	**	**
R_1m					*	*
R_3m						-

$S_{\overline{B}} = .434$, $f = 27$

*p < .05

**p < .01

APPENDIX TABLE F-6.--Newman-Keuls analysis of omissions for replications.

Replication	R_2	R_3	R_1
Ordered Means	1.99	4.39	5.14
	R_2	R_3	R_1
R_2		**	**
R_3			-

$S_{\overline{B}}$ = .57, f = 96

**p < .01

APPENDIX TABLE F-7.--Newman-Keuls analysis of omissions: replication x response form.

Test Scores	R_2m	R_3m	R_2v	R_1m	R_3v	R_1v
Ordered Means	1.46	2.21	2.52	3.63	6.56	6.67

	R_2m	R_3m	R_2v	R_1m	R_3v	R_1v
R_2m		-	-	*	**	**
R_3m			-	-	**	**
R_2v				-	**	**
R_1m					**	**
R_3v						-

$S_{\overline{B}} = .489$, $f = 27$

*$p < .05$

**$p < .01$

APPENDIX TABLE F-8.--Newman-Keuls analysis of correct trials for replications.

Replication	R_1	R_3	R_2
Ordered Means	2.81	3.19	4.72
	R_1	R_3	R_2
R_1		-	*
R_3			-

$S_{\overline{B}} = .546$, $f = 96$

*$p < .05$