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Instructional Methods and Psychomotor Performance

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Psychology

by

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ABSTRACT

INSTRUCTIONAL METHODS AND PSYCHOMOTOR PERFORMANCE
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The present study dealt with the savings in training time and/or cost achieved through transfer of learning. The transfer task for the experiment was coning. Coning refers to part of the process in forming a vessel using the potter's wheel. In the complex psychomotor task of coning, the clay is manipulated with the hands into the shape of a tall cone, and then lowered into a cake-shaped mound.

This experiment compared four training methods or media using performance on the coning task as the criterion of transfer effectiveness. The first group was trained by the use of verbal material (a tape recording of the procedures and principles involved in coning), the second group by visual material (a film demonstrating coning by an instructor), the third group by performing motor movements along with a demonstrating instructor on film, and the fourth group by a qualified instructor which allowed S actual practice with clay while under constant instructor guidance.

Each of the media groups was divided, one receiving two repetitions of the media treatment and the other receiving six repetitions. This resulted in eight
After the training phase, each S was tested twice, on trial 1 and trial 2, using two performance measures, conformity of a tall cone with a model and centricity of the cake-shaped mound. Thus, the experimental design was a $4 \times 2 \times 2$ mixed factorial design with repeated measures on the third factor.

Three hypotheses were tested. First, there would be significant differences due to media training. Second, main effects for trials would show that performance on trial 2 would be better than on trial 1 due to practice. Third, main effects for repetitions would show that conditions of six training repetitions would perform better than conditions of only two training repetitions.

The results were analyzed using analysis of variance, Duncan's Multiple-Range Test and the Pearson-Product-Moment correlation technique. Results dealing with the first hypothesis showed significant main effects for media on the centering task. The instructor and visual media scored best. The first hypothesis was supported. Results dealing with the effect of trials showed that trial 1 performed better than trial 2. These data were explained in terms of fatigue and learning interference. Regarding main effects for repetitions, no significant differences were observed. There were two significant interaction effects for the coning task: media $\times$ trials and media $\times$ repetitions. The particular medium was a factor common to both interaction effects. It was concluded that the visual medium might be more cost effective than any of the other media for the coning task and the centering task.
Introduction

The present study dealt with the savings in training time and/or cost achieved through transfer of learning. The transfer of learning is assessed by the degree to which learning a task is facilitated by the previous learning of another task. This definition also applies to that particular area of transfer called learning to learn. Performance by an experimental group, previously trained on another, usually similar, task is compared with the performance of a control group having no special training.

In the present study, the task was coning. This term refers to part of the process in forming a vessel on the potter's wheel. The clay is raised into the shape of a cone, and then lowered into a cake-shaped mound.

This experiment compared four training methods using performance on the coning task as the criterion of transfer effectiveness. The first was trained by the use of verbal material, the second by visual material, the third through motor movements, and the fourth by a qualified instructor using his customary teaching method. Each of these four groups was divided, one receiving two repetitions of the media treatment and the other receiving six repetitions. This resulted in eight experimental groups. After training, each subject was tested twice.

The data were analyzed for main effects of media, repetitions, and test trial. Possible second-order and third-order interactions were also analyzed. It was expected that six repetitions would prove more effective than two repetitions, and that the second
trial would prove significantly better than the first trial. It was also expected that the instructor group would show the best performance, with the visual group showing better performance than either the verbal group or motor group. Because of the complex nature of the task, higher-order interactions were anticipated.

Traditional verbal transfer tasks. A review of the literature dealing with transfer reveals that most of the studies have used, and continue to use, lists of verbal material as the original learning and transfer task. Of the 125 transfer experiments reported by J.W. Kling and L.A. Riggs (1971), only five involved non-verbal tasks. Of these five, none involved a motor response. There are several possible reasons for this. Historically, Ebbinghaus laid the foundation for transfer of learning research by his studies of serial memorization using nonsense tri-grams, thereby setting a precedent. Traditionally, academically oriented psychologists may have associated a greater status to mental tasks as distinguished from psychomotor tasks. Lastly, experimenter may have felt that verbal material would afford more precise stimulus and response scaling. Whatever the reason, psychomotor tasks were neglected in early studies, and even today, constitute a small proportion of transfer of learning research.

Research done using verbal tasks cannot be assumed to apply when psychomotor tasks are used. Even today, 25 years after it was first published, textbooks cite Osgood's (1949) model of the transfer and retroaction surface as definitive. This model estimates the amount of transfer as a function of both response and stimulus similarity. Although the combining of these two factors into one model was a distinguished achievement, one must recall that it was based on the memorization of
verbal lists. There is evidence to suggest that Osgood's model is not adequate even for verbal material. For example, Dallett (1965) and Houston (1965) have devised different transfer surfaces to describe the stimulus conditions affecting re-paired associates, a phenomenon not predicted by Osgood's surface. In addition, many other factors such as baseline proficiency of the subjects, schedules of practice, extent of feedback, warm-up, level of motivation, task organization and task complexity have yet to be incorporated into a single model.

Another difficulty with extending Osgood's model to other kinds of tasks lies in determining an unambiguous experimental definition of similarity. This is especially difficult where the task is psychomotor, and where alternative training methods are to be compared. For example, in comparing methods for training a baseball player, it would be difficult to develop a criterion to order the following training tasks along a continuum of similarity: teaching the trainee physiology, learning the physics of spheres in flight, observing good baseball players on video tape, or physically practicing baseball sub-skills like batting. The difficulty of defining similarity is characteristic of cross-modal transfer. It is difficult to determine whether material perceived through the hearing sense modality is more or less similar to training material perceived through the sense modality of vision. Therefore, it is difficult to establish which mode of training is more similar to the performance task. Certainly, the fact that a given training method or sense modality proves superior for a particular performance task can't be taken to imply, ipso facto, that it was more similar. Similarity must be validated independently of any facilitating effects on transfer.
The present study involved a psychomotor task. Since this study assessed the effectiveness of using either verbal, visual, motor, or instructor training media, it can be considered an experiment in cross-modal transfer.

Bi-lateral and cross-modal tasks. Cross-modal transfer of learning refers to a task which is learned using one sense modality, but performed with another. Studies involving bi-lateral transfer of learning were brought to bear on behaviorism's extreme peripheralist position advocated by Watson (1930). According to this point of view, all psychological processes were conceived of in terms of muscular or glandular responses and their associated stimuli. A number of studies in bi-lateral transfer (Weig, 1932; Munn, 1932; Briggs, 1953; Pigg, 1954) demonstrated that tasks learned with one limb aid in the subsequent performance of that task with another limb. Similar studies have been conducted using visual functions. In an experiment by Lashley (1922), the left eyes of white rats were blindfolded, whereupon they were trained to avoid the brighter of two lights. As soon as the rats were able to perform successfully, the blindfold was transferred to the right eye. The rats continued to perform successfully, exhibiting a high degree of positive transfer. These results were interpreted as supporting the centralist position of transfer of learning, in opposition to Watson.

Other, more recent, studies using animal subjects in cross-modal transfer tasks (Ettlinger, 1969) have validated the efficacy of cross-modal transfer. Milner (1970) demonstrated positive transfer from the tactile sense modality to the visual modality under conditions of constant illumination. Blakeslee (1966) used cebus monkeys to show that cross-modal transfer
of discrimination learning between vision and touch occurs in both directions.

With cross-modal transfer validated through numerous experiments, a question arose as to whether greater transfer of training on a psychomotor task is to be gained through active motor involvement in the task, or through the acquisition of its principles alone. The crux of these divergent points of view is embodied in two theories of transfer: Thorndike's theory of identical elements and Judd's theory of generalization.

According to Thorndike (1903), one could expect positive transfer to the extent that one ability required components acquired in some other skill. Transfer is said to occur only if part of the final task consists of things specifically learned in the first task. This approach culminated in Osgood's model which is based on the similarity of stimuli and the similarity of responses.

According to Judd (1927), transfer takes place to the extent that one can generalize his experiences. His theory is illustrated by an experiment with boys shooting at a target submerged in water. One group was instructed concerning the laws of light refraction under water. This group demonstrated greater proficiency in hitting the target when it was submerged first in twelve inches of water, and later in four inches of water. Judd's conclusion was that the training of the experimental group transferred by the generalization of a principle to a variety of situations.

It is characteristic of human beings, and to some extent animals, to select cues from their environment in order to augment learning. Selecting these task-
related stimuli may be covert and automatic as in being able to identify a friend's voice against a background of a din of voices at a gathering, or overt, as attention is fixed on an object or process of interest. Pausing to observe the situation in order to select the most task-relevant cues was coined "vicarious trial and error" (VTE) by Muenzinger (1938). VTE can be viewed as an adaptive mechanism which enhances proprioceptive and visual feedback in association with the relevant discriminative stimuli. Just as Thorndike's and Judd's theories bear on psychomotor learning, VTE is particularly important when the psychomotor task is complex.

Experimental confirmation of VTE began as early as 1912 when Lashley observed that the rats in his experiment paused, moving their heads back and forth as they were confronted with the alternatives of two discriminative stimuli in a discrimination box. The same head waving watchfulness was noted by Lashley (1938) when using a jumping-stand. He found that such behavior was most pronounced just prior to a run of correct responses. Increasing VTE up to the point of solving the discrimination problem with its decline following attainment of asymptotic performance in animals was noted by Muenzinger (1938). White and Plum (1965) noted the same tendency in children as they oriented their eyes while performing a visual discrimination task.

In the present study, the Visual experimental condition afforded subjects the opportunity to observe the most effective hand movements involved in performing the transfer tasks. Observing the clay change its shape in response to hand position and pressure supplied S with valuable VTE feedback allowing him to assess
the most critical task-relevant cues. Thorndike's theory is related to the Motor experimental condition which involved S having to perform hand movements in the training phase that were identical to those performed in the testing phase. Since these training movements were performed in the absence of clay, there was no opportunity for VTE. Judd's theory is related to the Verbal experimental condition which involved S listening to a verbal description of the process and principles of the transfer tasks. For the Verbal experimental condition, there was also no opportunity for VTE during the training phase.

The optimal training modality. In recent years, transfer studies have dealt with the extent of transfer from verbal material to tasks involving different sense modalities (Pimsleur and Bonkowski, 1961; Garvill and Molander, 1971). The findings of these studies confirmed positive transfer. Of specific pertinence to the present study is the transfer from verbal material to psychomotor skills. Baker and Wylie (1950) varied the amounts of verbal training on the subsequent learning of a motor task with significant transfer observed after 24 trials. Battig (1956) found that the amount of positive transfer from verbal pretraining to motor performance decreases as motor task complexity increases. This finding suggests that verbal pretraining should be discontinued at the point of its greatest contribution to transfer.

Regarding the visual mode, Lobb (1970) used a discrimination task entailing irregular heptagons. One group was trained to identify the heptagons visually, and the other, tactually. The visually trained group was tested tactually and the tactually trained group tested visually. The results showed that visual training increased identification by touch, but that
the converse was not so. Perret and Estermann (1970) used a pursuit rotor task to study cross-modal transfer from visual-motor to tactile-motor and vice versa. Significant positive transfer for male subjects was reported in the visual-motor to tactile-motor situation, but the converse showed no significant results. In these studies, the visual faculty was most effective.

Concerning the relative value of the visual mode as represented by video-tape and an actual instructor, Baron (1969) compared two groups on a task that involved justifying a line of type. He found that the group trained by use of the video-tape performed with equal effectiveness to the instructor-trained group. Carre (1973) compared three training methods, video-tape, an actual instructor, and a combination of both, using a discus turn and throw as the transfer task. Despite post-test improvement by all conditions, the findings do not support the use of any particular condition as a critical variable in the initial stages of learning this novel complex motor skill.

It is possible that a given type of task requires a specific mode of training for maximum transfer. A given training mode might be totally ineffective were another type of task used. The complexity of the problem is pointed up by Ritchie and Muckler (1954) when they proposed a two-stage conceptual scheme in order to account for the different curves of retroaction exhibited by motor and discrimination variables. It is possible that the mode of training is so dependent on the type of task that few binding generalizations concerning optimal transfer can be made. If this is so, research on a particular type of task might yield the particular training mode for optimal transfer. This approach to transfer implies
the creation of both training mode and task taxonomies, an immensely difficult project.

Cost effective transfer. When research on transfer is applied to training situations, optimal techniques are sought in order to reduce training costs. Lawrence (1954) developed criteria, expressed in mathematical models for evaluating the cost effectiveness of training and transfer programs. Specifically, he was interested in pretraining. Pretraining can be defined as a training procedure of high transfer value which enables a subject to achieve an increased rate of learning on a second task. Lawrence postulates that transfer of training procedures are useful only when preliminary training plus job training cost less than job training alone costs. Often, the object of pretraining is to bring the subject up to a criterion level of proficiency before passing to further advanced training on a second task. He presents equations that take into consideration the various factors involved in such a comparison.

An important aspect in the use of pretraining transfer is the optimal time to pass from the original pretraining to the transfer task. Roscoe (1971) has shown that pretraining using an aviation ground trainer is cost effective only up to a certain point. He notes that the first hour of instruction in a ground trainer can save more than one hour of pre-solo flight training, but that the fifteenth hour in a ground trainer does not. Since the degree of transfer progressively decreases using the trainer, it must be determined when to leave the ground trainer and continue training in the air. He has developed a method called Incremental Transfer Effectiveness. It allows the estimation of the optimal point at which pretraining ceases to be more cost effective than training on the second task would be.
Roscoe has shown that the effectiveness of successive increments of training on one task, as measured by the relative incremental savings in learning a second task, is a negatively decelerated function of the time devoted to pretraining. Furthermore, he has posited that this relationship, inferred from his study of an aircraft pilot training situation, applies "to any successively related educational experience (p. 564)."

One of the objectives of the present study was to add experimental evidence in consideration of Roscoe's assertion concerning the generalizability of his findings. To some degree Roscoe's assertion conflicts with the findings and conceptual scheme of Ritchie and Muckler which requires a more complex analysis of the task-relevant variables for each specific task. The present study analyzed the pretraining effectiveness of three sense modalities, verbal, visual, and motor. The respective costs of each were noted. These were compared with the fourth experimental group trained by a qualified instructor, a cost factor being associated with this method as well.

Experimental hypotheses. The primary hypothesis dealt with the relative transfer values of the four training media. Based on the literature, the following hypothesis was expected to be confirmed: the anticipated order of transfer effectiveness for each of the training media respectively was (from most effective to least effective) instructor training, visual training, verbal training, and motor training. In order to gain a more comprehensive understanding of the psychomotor processes involved in the coning task, it was decided to test for the effects of transfer on two trials. The objective was to determine what effects, if any, the pretraining (in the sense used by Lawrence) had on the rate of improvement.
Assuming that the higher the baseline extent of transfer on trial 1, the less the subsequent improvement on trial 2, the following hypothesis was expected to be confirmed: all experimental groups would show some improvement in transfer performance from trial 1 to trial 2, with the order of greatest rate of improvement (from greatest to least) being motor training, verbal training, visual training, and instructor training.

The third hypothesis dealt with the expected positive effects of increased training on transfer. The following hypothesis was expected to be confirmed: all experimental groups would show greater positive transfer as a result of longer training periods, but that the extent of transfer was complex and not equal for all modes of training.
Method

Experimental Design

The present study employed eight experimental groups. (See Table 1). The experimental design was a $4 \times 2 \times 2$ mixed factorial design, with repeated measures on the third factor. There were four media used in the training phase; verbal, visual, motor, and instructor. Through a pilot study, it was determined that most transfer on the four training media occurred between three and six repetitions of the training medium. That is, the greatest change in positive transfer generally occurred within this range. Therefore, two levels of repetition were used; two repetitions of each medium, and six repetitions of each medium. There were two trials per subject, representing the third factor. Limitations of equipment (on loan from the CSUN Art Department) and space disallowed testing $S$ over several trials in order to gain fuller data on performance trends for the different training media.

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<th>Experimental Media</th>
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conditions.

The present study did not include a control group. The reason is clear when the classic transfer paradigm is examined for suitability with complex psychomotor tasks. The classic design involves an experimental group which receives experimental treatment and a control group which receives either no treatment or treatment irrelevant to the transfer task. Any observed differences in performance are attributed to experimental treatment. However, this design is inappropriate where the control group lacks any familiarity whatsoever with the performance task. In such a case, the control group subjects will either be unable to perform the task or their performance will be so poor as to spuriously inflate the extent of transfer of the experimental group. Most measures of transfer place the control group performance measure in the denominator of a ratio. If that denominator is zero or close to zero, the impression of exaggerated transfer by the experimental group is created. This impression is created regardless of how good or poor the performance of the experimental group.

Experimental Subjects

The subjects for this study were 72 university students at California State University, Northridge. They were students enrolled in the Psychology Department who had had no previous experience using a potter's wheel. The mean age of the experimental subjects was 20.4 years old. Male and female students were randomly self-assigned to one of the eight experimental groups. Each experimental condition was comprised of nine subjects. Subjects were tested over a two-week period, from the hours of 0800 to 1700, Monday through Friday. The testing order for subjects according to groups
was: verbal medium, visual medium, motor medium, instructor medium at two repetitions for every group, and the same order at six repetitions for every group.

Experimental Tasks

**Verbal experimental group.** The pretraining experimental task for the verbal groups was listening to a tape recording which described the process of coning. The tape delineated the hand positions, hand movements, pressure to be exerted, and principles related to successful coning. The duration of the exposure to the recording was 35 seconds per repetition. One of the verbal groups received two repetitions, while the other received six.

**Visual experimental group.** The pretraining experimental task for the visual groups was observing a film which showed a potter performing the coning process with clay. The film was unaccompanied by sound or any other form of explanation to S. It clearly showed the response of the clay to the movements of the potter's hands. The duration of the film was 35 seconds per repetition. One of the visual groups received two repetitions, while the other received six.

**Motor experimental group.** The pretraining experimental task for the motor groups was performing the hand movements required for successful coning. These movements were demonstrated in a film. The film was unaccompanied by sound or any other form of explanation to S. The demonstration showed the hand movements only, with the clay omitted entirely. As the potter in the film demonstrated the proper movements, S copied those movements, imitating them as accurately as possible. The film was unaccompanied by sound or any other form of explanation to S. The duration of the film was 35 seconds per repetition. One of the
motor groups received two repetitions, while the other received six.

Instructor experimental group. The pretraining experimental task for the instructor group required that the instructor's method parallel, as closely as possible, that of the other pretraining media. Without such equivalence, a valid comparison of the instructor group with other groups would have been problematic. E was the instructor. E had had several years of full time teaching experience in pottery. Since E was the demonstrating potter in the visual group and motor group films, and the writer of the verbal group material, his teaching method was identical to those of the other pretraining media. The possible advantage of the instructor medium was its combined use of verbal, visual, motor media, actual hand on hand experience, and corrective feedback in the pretraining phase of the experiment. This was the only group to have physical contact with the clay. While the basic factors such as correct hand positions remained identical with those of the other pretraining media, the constant person-to-person communication between S and the instructor permitted a flexible instructional interaction.

The instructor medium treatment might resemble the following simplified example. The instructor would verbally communicate a principle found on the tape and available to those in the verbal group. E.g., put water on clay before each stage to keep it slippery. At the same time, the instructor was placing S's hands on the clay, beginning the coning task. The instructor would leave S's hands and check to see whether S was performing correctly. If so, S was complimented. If not, he was verbally corrected while the instructor was demonstrating the correct hand position. Then the
instructor would place S's hands on the clay a second time. S would ask if he was doing it correctly, etc. The duration of the pretraining session was equal to two repetitions of the other pretraining media, 70 seconds. One of the instructor groups received the equivalent in time of two repetitions, while the other received the equivalent of six.

Standard transfer task. The standard transfer performance task required S to perform the coning process with the clay on the potter's wheel. The following hand positions are involved in coning: (a) with the clay on the wheelhead in the shape of a low cone (five inches in diameter and four inches high), squeeze inward at the base of the cone using both palms, (b) when you feel the clay has a small groove at the base, slowly begin raising both hands with both palms continuing to press inward, (c) as your hands come upward, the clay begins to rise in the shape of an elongated cone (three inches in diameter and eight inches tall), (d) come all the way to the top, bringing your hands away from the top slowly, (e) to bring the clay downward under control, place right (R) elbow into center of stomach, bend R wrist back so that the R palm touches the side of the cone at its top; at the same time, cover half of the top of cone with left (L) palm, the fingers of the L hand curling over the far edge of the clay slanting to the R, (f) press directly downward with L palm and press forward slightly with R palm (the clay will come down until it finally resembles a cake-shaped mound), (g) hold both the R and L hands steady as in the previous step, making sure the mound does not sway and that the top of the mound is perfectly flat. Thus, the clay was raised into the shape of a cone,
and then lowered into a perfectly centered cake-shaped mound. The standard transfer task was done twice, in two immediately consecutive trials, in order to obtain data on any improvement due to practice.

In the performance of the transfer task, several factors were held constant from subject to subject and from trial to trial. Two Shimpo brand potter's wheels of the same model were borrowed from the CSUN Art Department for use in the experiment. Both wheels were driven by a standard one-third horse-power electric motor and had a wheelhead measuring 10 inches in diameter. Both were equipped with a water-catch to prevent water and clay from spinning off onto S. Both wheels had a constant speed, variable r.p.m. capability controlled by either a foot pedal or handle lever. The clay used in the experiment was ordered from a supply company in one batch, insuring that its consistency was uniform. The amount of clay used for each trial weighed three kilograms. E centered the clay on each wheelhead and formed the standard beginning cone shape, a cone with a five inch diameter at its base and four inches tall. The wheelhead speed for both wheels was set at 150 r.p.m. The distance of each stool from the wheel was six inches. Identical water containers insured adequate availability of water. The wheels were situated back to back, in mirror image fashion, so that S would be facing a blank wall during both trials.

Transfer task performance measures. There were two measurements which served as performance criteria: the difference between the ideal cone shape and S's actual cone, and the degree of centricity of the cake-shaped mound. The coning measurements for both testing trials were obtained in the following way.
An ideal model cone three inches wide at its base and eight inches tall was created out of clay and bisque fired. This cone served as a physical model to be duplicated as accurately as possible by S during the testing phase of the experiment. Prior to the experiment, this model was photographed while centered on the wheelhead. The camera, a 35 mm model with a standard 1.7 lens, was situated in the exact position that subsequent photographs of S's cones were taken from. This identity of position was assured by floor anchors for the tripod and a positioning target pattern on the wall behind the wheel. After S had formed his cone, E photographed it. To obtain the performance score, the negative of the model cone was projected onto a wall and its outline drawn. S's cone was then projected onto the wall with its base coinciding with that of the drawn model. A planimeter was used to measure the perimeter of the overlapping cones. In all cases, any deviation from the ideal cone shape results in a lower common perimeter measurement for S's cone. The less the common perimeter, the poorer was the performance. All photographs were numbered for ease in later identification. The same technique was used for both trials.

The centering measurements for both testing trials were obtained in the following way. An ideal cake-shaped model mound was created out of clay and bisque fired. This mound served as a physical model for S. Graph paper calibrated in centimeters was mounted on the wall behind the wheel. The graph paper was positioned so that, from the camera's line of sight, the mound was silhouetted against it. Should the clay mound be off-center, it appears to move back and forth as observed against a two-dimensional
perspective. To measure this two-dimensional displacement, the wheelhead was stopped; the mound was photographed with the camera in its anchored position; the wheelhead was revolved 180 degrees and a second photograph taken. In obtaining the centering performance score, the location on the graph paper where the vertical side of the mound reached was recorded in centimeters. The same measurement was recorded using the second centering photograph. With the mound turned 180 degrees, the location of the side of the mound, as measured on the graph paper, will have changed if the mound is not perfectly centered. The difference between the two measurements gives the extent of centricity. The more accurate the centering, the smaller was this difference score. Four photographs were used for both trials of the centering measurement. The same procedure was employed in both trials.

**Experimental Procedure**

When S entered the room, he could not see the potter's wheels or the clay as that portion of the room was hidden from view by a drawn curtain. S was requested to remove cumbersome clothing, to roll up long sleeves, to take off hand jewelry and to be seated on a chair provided. S was briefly interviewed. S was queried as to whether he had any previous experience using a potter's wheel. If the answer was negative, E proceeded to fill in the information on the data form for every S. The factors noted included sex, weight, height, hand-span (measured from tip of thumb to tip of little finger with hand spread), sport activities, and any other special activities relating to manual coordination and strength. Although not directly related to experimental hypotheses, these data were found useful in analyzing the results.
Before beginning the pretraining phase of the experiment, S was told that the purpose of the study was to determine which of several ways of teaching pottery might be most effective. S's cooperation was enlisted. E said,

"The purpose of this experiment is to determine which of several training methods is most effective in teaching pottery. You will undergo a brief training period involving an important part of the process of making a vessel on the potter's wheel. After this training, you will have two opportunities to perform what you have learned using clay and a potter's wheel. Try your best and good luck."

Depending on the particular experimental group, S underwent pretraining as follows.

**Verbal pretraining.** E said,

"You are about to hear a tape recording explaining how to perform hand movements relating to part of the process for making a vessel on the potter's wheel. Careful attention to the tape will aid you in actually performing this process later on in the experiment. While listening to the tape, close your eyes and concentrate on picturing the process. Fold your hands in your lap until the tape ends."

Both the closed eyes and the folded hands were to insure that no motor activities occurred with the hands which might constitute a biasing factor. The tape recording was then played either twice or six times depending on the particular appropriate condition. The repetitions of the tape were immediately successive with no time interval between each repetition.

It should be noted that although S was asked to picture the process in his mind with closed eyes, this is not to be confused with rehearsal as recognized in the fields of short term memory and paired associate learning. In the latter fields, the material to be learned has already been presented to S and he has time to review it. Both of these conditions are lacking in this experiment. Furthermore, while it is
true that in the verbal medium condition S is asked to picture the process, with this instruction omitted in the other media conditions, this is simply due to the nature of the different media. For the verbal medium, picturing is an integral part of attending.

**Visual pretraining.** E said,

"You are about to see a silent film showing how to perform hand movements relating to part of the process for making a vessel on the potter's wheel. Careful attention to the film will aid you in actually performing this process later on in the experiment. While watching the film, note how the clay responds to the pressure of the hands. Fold your hands in your lap until the film ends."

The 8 mm film was then shown either twice or six times depending on the particular experimental condition. The repetitions of the film were immediately successive with no time interval between each repetition.

**Motor pretraining.** E said,

"You are about to see a silent film showing how to perform hand movements relating to part of the process for making a vessel on the potter's wheel. While viewing the film, put both feet flat on the floor in front of you, and actually perform the hand movements as demonstrated in the film. Perform the movements along with the demonstrator in the film as accurately as you can. Imitating the movements shown to you in the film will aid you in actually performing this process with clay later on in the experiment."

The 8 mm film was then shown either twice or six times depending on the particular experimental condition. The repetitions of the film were immediately successive with no time interval between each repetition.

**Instructor pretraining.** E said,

"You are about to be instructed in how to perform part of the process for making a vessel on the potter's wheel. Pay careful attention and do exactly as instructed. This training period will aid you in actually performing this process later on in the experiment."

E served as the instructor. S was asked to take a seat at one of the wheels. The hand positions and movements
that the instructor taught were identical to those shown on the film and heard on the tape. The principal characteristics of the instructor medium were that S had actual practice with the clay; S received verbal, visual, and motor information; and S received correction, feedback, and guidance from the instructor who was constantly monitoring S's performance. The time spent for this medium was the same as for the other media, although instructor treatment units were defined by their total time and not confined to 35 seconds as in other media pretraining treatment conditions. S was given instructor pretraining for either 70 seconds or 210 seconds depending on the particular experimental condition.

Transfer task. Upon completion of the pretraining phase of the experiment, the curtain partition was drawn revealing two potter's wheels. Each wheel was turned on and the clay positioned correctly for the transfer task. In front of S, sat a three-dimensional clay model of the ideal cone. S was asked to be seated at one of the wheels. E said,

"Before you is an amount of clay. Try your best, using the training you have received, to duplicate exactly the shape of the model cone in front of you. Note its height and proportions. You have one minute, which is more than enough time. Should you finish before that time, please take your hands away from the clay and wait for further instructions. If you have not finished when the one-minute bell sounds, slowly take your hands away from the clay and wait for further instructions."

After one minute had elapsed, E photographed the cone formed by S.

The cone model was replaced by the mound model in preparation for coming down with the clay until it resembled a cake-shaped mound. E said,

"Try your best, using the training you have received, to lower the cone into the shape of the mound model."
in front of you. It is important that the mound be perfectly centered. That is, it should resemble a perfectly even circle as it revolves, and should not sway back and forth. You have a minute, which is more than enough time. Should you finish before that time, please take your hands from the clay and wait for further instructions. If you have not finished when the one-minute bell sounds, slowly take your hands away from the clay and wait for further instructions."

After one minute had elapsed, E photographed the mound formed by S. E then revolved the wheelhead 180 degrees and photographed the mound a second time. The time required for photographing was 30 seconds. S was then asked to take a seat at the second wheel to perform the transfer task for the second trial. E repeated the instructions as in the first trial. While S was coning, the camera was repositioned in order to photograph the performance of S on the second wheel. Altogether, two trials of the transfer task yielded four performance scores per S. The total time for the experiment was about 20 minutes per S. E thanked S for his participation and E prepared the wheels for the next S.
Results

Reliability of Scores

The reliability of the scores was assessed using the Pearson product-moment correlation. The reliability of the performance measures was dependent on two factors. The first factor in obtaining reliable measurements was to verify the reliability of the photographs. It was important to determine whether the camera was consistently in the correct position. To establish the reliability of the photographs, duplicate photographs were taken for five randomly selected performances. The scores for the first set of photos were correlated with those of the second set for each of the five performances. The correlation of the photographs for coning was $r = .99$ at a level of significance of $p < .001$. The correlation of the photographs for centering was $r = .99$ at a level of significance of $p < .001$.

The second factor in obtaining reliable measures was to verify the reliability of the scoring. From 10 randomly selected photographs, repeated scores were obtained. The correlation of the scores for coning was $r = .99$ at a level of significance of $p < .001$. The correlation of the scores for centering was $r = .99$ at a level of significance of $p < .001$.

Coning Performance

The results of the coning task are summarized in Table 2. This table provides the performance means for all experimental conditions associated with the coning task. The numbers represent the perimeter of S's cone that was in common with the ideal cone model. A higher number represents a better performance.
### TABLE 2
Mean Coning Performance

<table>
<thead>
<tr>
<th>Experimental Media</th>
<th>2 Repetitions</th>
<th>6 Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>Verbal</td>
<td>19.69</td>
<td>23.01</td>
</tr>
<tr>
<td>Visual</td>
<td>25.47</td>
<td>24.66</td>
</tr>
<tr>
<td>Motor</td>
<td>24.72</td>
<td>24.00</td>
</tr>
<tr>
<td>Instructor</td>
<td>24.18</td>
<td>24.48</td>
</tr>
</tbody>
</table>

### TABLE 3
Mean Centering Performance

<table>
<thead>
<tr>
<th>Experimental Media</th>
<th>2 Repetitions</th>
<th>6 Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>Verbal</td>
<td>0.17</td>
<td>0.97</td>
</tr>
<tr>
<td>Visual</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Motor</td>
<td>1.11</td>
<td>1.19</td>
</tr>
<tr>
<td>Instructor</td>
<td>0.25</td>
<td>0.33</td>
</tr>
</tbody>
</table>
The analysis of the results for the coning task are summarized in Table 4. No significant main effects were observed. Significant results were obtained for the Media X Repetitions interaction and for the Media X Trials interaction. Figure 1 and Table 5 show the Media X Repetions interaction. Table 5 provides a display of the significant differences computed using the Duncan's Multiple-Range Test. For R1 (two repetitions), the verbal medium proved significantly worse than every other medium. However, the verbal medium at R2 (six repetitions) was significantly better than the verbal medium at R1. The verbal group at R2 not only performed as well as any of the other groups, but proved significantly better than the motor group at R2. Figure 1 illustrates the dramatic change in the verbal medium from R1 to R2.

The analysis of the results for the Media X Trials interaction are shown in Figure 2 and Table 5. Table 5 provides a display of the significant differences computed using the Duncan's Multiple-Range Test. For T1 (trial 1), the verbal medium proved significantly worse than the visual medium.

Centering Performance

The results for the centering task are summarized in Table 3. This table provides the performance means for all experimental conditions associated with the centering task. The numbers indicate the degree of centricity in centimeters. The lower the number, the better was the performance.

The results of the centering task were analyzed using analysis of variance and are summarized in Table 6. Significant main effect differences were observed for media and trials. T1 proved significantly better than T2. Figure 3 displays an analysis of the
### TABLE 4
Analysis of Variance: Coning

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetitions (R)</td>
<td>1</td>
<td>21.47</td>
<td>1.22</td>
</tr>
<tr>
<td>Media (M)</td>
<td>3</td>
<td>26.13</td>
<td>1.48</td>
</tr>
<tr>
<td>Trials (T)</td>
<td>1</td>
<td>1.17</td>
<td>0.17</td>
</tr>
<tr>
<td>M X R</td>
<td>3</td>
<td>60.64</td>
<td>3.45*</td>
</tr>
<tr>
<td>R X T</td>
<td>1</td>
<td>4.20</td>
<td>0.60</td>
</tr>
<tr>
<td>M X T</td>
<td>3</td>
<td>20.90</td>
<td>2.98*</td>
</tr>
<tr>
<td>S (RM)</td>
<td>64</td>
<td>17.59</td>
<td></td>
</tr>
<tr>
<td>R X M X T</td>
<td>3</td>
<td>3.13</td>
<td>0.45</td>
</tr>
<tr>
<td>ST (RM)</td>
<td>64</td>
<td>7.02</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05

**p < .01
Fig. 1. Coning scores (in inches) as a function of media and repetitions.
TABLE 5
Duncan's Multiple-Range Tests (Coning)
Media X Repetitions

<table>
<thead>
<tr>
<th>R1-V</th>
<th>R2-M</th>
<th>R1-In</th>
<th>R1-M</th>
<th>R2-In</th>
<th>R1-Vs</th>
<th>R2-Vs</th>
<th>R2-V</th>
</tr>
</thead>
</table>

Media X Trials

<table>
<thead>
<tr>
<th>T1-V</th>
<th>T2-M</th>
<th>T1-M</th>
<th>T1-In</th>
<th>T2-Vs</th>
<th>T2-V</th>
<th>T2-In</th>
<th>T1-Vs</th>
</tr>
</thead>
</table>

Note.--Experimental groups are arranged in ascending order of computed means. Non-underlined groups in the same row are significantly different from the non-underlined group furthest to the left. For Table 5, the following code is used: two repetitions (R1), six repetitions (R2), verbal medium (V), visual medium (Vs), motor medium (M), instructor medium (In), trial 1 (T1), and trial 2 (T2). The level of confidence is p<.05.
Coning performance (Expanded scale)

Fig. 2. Coning scores (in inches) as a function of media and trials.
<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetitions (R)</td>
<td>1</td>
<td>0.39</td>
<td>0.57</td>
</tr>
<tr>
<td>Media (M)</td>
<td>3</td>
<td>2.46</td>
<td>3.62*</td>
</tr>
<tr>
<td>Trials (T)</td>
<td>1</td>
<td>1.78</td>
<td>4.80*</td>
</tr>
<tr>
<td>M X R</td>
<td>3</td>
<td>1.39</td>
<td>2.04</td>
</tr>
<tr>
<td>R X T</td>
<td>1</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>M X T</td>
<td>3</td>
<td>0.87</td>
<td>2.34</td>
</tr>
<tr>
<td>S (RM)</td>
<td>64</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>R X M X T</td>
<td>3</td>
<td>0.21</td>
<td>0.58</td>
</tr>
<tr>
<td>ST (RM)</td>
<td>64</td>
<td>0.37</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
Fig. 3. Main effects centering performance for media. The tied media bar graphs are not significant.
data using the Duncan's Multiple-Range Test to determine the significant differences among media. Both the instructor medium and the visual medium were significantly better than the motor medium. The instructor medium also approached being significantly better than the verbal medium. It should be noted that Figure 4 shows the media X trials interaction which was significant only at \( p < .10 \). This level of confidence was not sufficient to draw reliable conclusions. However, the dramatic decrement in performance by the verbal medium and, to lesser extent, by the motor group, contrasts sharply with the performance of the visual and instructor media. This may indicate a fundamental difference in motor skills retention capability as a function of medium.

Correlations

The correlations of the four performance measures and the four physiological indices are presented in Figure 5. These data were analyzed for significant correlations using a t-test with the Pearson Product-Moment Correlation procedure. The level of significance employed was \( p < .05 \). In interpreting the matrix, it should be noted that for the centering measures, the smaller the number, the better was the performance. By contrast, for the coning performance scores, the larger the number, the better was the performance.

The centering task for trial 1 significantly correlated with the centering task for trial 2 \( (r = 0.34) \). Similarly, the coning task for trial 1 correlated with that of trial 2 \( (r = 0.45) \). The category of sex was coded 1 equals male and 2 equals female. Sex significantly correlated with coning for trial 1 \( (r = -0.26) \) showing that males performed better. Other physiological variables (sex, weight, height, and
Centering performance error in centimeters.

Fig. 4. Centricity scores as a function of media and trials.
<table>
<thead>
<tr>
<th></th>
<th>Center</th>
<th>Center</th>
<th>Cone</th>
<th>Cone</th>
<th>Sex</th>
<th>Wt.</th>
<th>Ht.</th>
<th>Hand span</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00</td>
<td>0.34</td>
<td>0.16</td>
<td>0.03</td>
<td>-0.08</td>
<td>0.03</td>
<td>0.03</td>
<td>0.09</td>
</tr>
<tr>
<td>2</td>
<td>0.34</td>
<td>1.00</td>
<td>0.15</td>
<td>0.21</td>
<td>0.08</td>
<td>0.29</td>
<td>-0.31</td>
<td>-0.09</td>
</tr>
<tr>
<td>3</td>
<td>0.16</td>
<td>0.15</td>
<td>1.00</td>
<td>0.45</td>
<td>-0.26</td>
<td>0.22</td>
<td>0.17</td>
<td>0.06</td>
</tr>
<tr>
<td>4</td>
<td>0.03</td>
<td>0.21</td>
<td>0.45</td>
<td>1.00</td>
<td>-0.21</td>
<td>0.17</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>-0.08</td>
<td>0.08</td>
<td>-0.26</td>
<td>-0.21</td>
<td>1.00</td>
<td>-0.76</td>
<td>-0.73</td>
<td>-0.58</td>
</tr>
<tr>
<td>6</td>
<td>0.03</td>
<td>-0.29</td>
<td>0.22</td>
<td>0.17</td>
<td>-0.76</td>
<td>1.00</td>
<td>-0.79</td>
<td>0.62</td>
</tr>
<tr>
<td>7</td>
<td>0.28</td>
<td>-0.31</td>
<td>0.17</td>
<td>0.05</td>
<td>-0.73</td>
<td>0.79</td>
<td>1.00</td>
<td>0.67</td>
</tr>
<tr>
<td>8</td>
<td>0.09</td>
<td>-0.09</td>
<td>0.06</td>
<td>0.04</td>
<td>-0.58</td>
<td>0.62</td>
<td>0.67</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Fig. 5. Correlation matrix of the four experimental measures and four physiological indices. The numbers in the vertical refer to the same verbal labels as along the horizontal.

* p < .05
hand-span) generally correlated among themselves.
Discussion

Media Treatments

The primary hypothesis concerning the possible effects of different media treatments on coning performance was partially upheld. This substantiation came from the significant main effects observed for the centering task. It was further hypothesized that the order of media effectiveness would be instructor medium, visual medium, verbal medium, and motor medium, in descending order of effectiveness. Although not all media treatments for the centering task were significantly different from one another, their order of transfer effectiveness was precisely the same as predicted. The instructor medium showed the best performance, followed by the visual medium, the verbal medium and the motor medium.

While the order of effectiveness points to the instructor medium for the best transfer, this medium was not significantly better than the visual medium. These findings confirmed the results of Baron (1969) and Carre (1973), both of whom found that a live instructor and a video-tape are equally effective in their transfer effectiveness. The finding that the visual medium was significantly better than the motor medium was consistent with the studies by Lobb (1970), and Perret and Estermann (1970). They both found that the visual sense modality was superior to the tactile-motor. According to Battig (1956), the more complex the task, the less effective is the verbal pretraining in facilitating transfer. The generally poor transfer value shown by the verbal medium in the centering task condition reinforces the findings of Battig's study.
For the centering task, the motor medium was significantly less effective than both the visual and instructor media. Part of the explanation might rest with task complexity. Performing a long series of hand positions and movements without any understanding as to their intended and expected effects on the clay could provide S with too little task-related information. In terms of vicarious trial and error, fewer cues are available to S during the motor medium training. S neither saw nor felt the clay during training. Both the instructor and the visual media provided S with an opportunity to take advantage of cues related to training with those media. In the case of the visual medium, S can see the clay responding to the hands. In the case of the instructor medium, S actually practices with clay. The centering task required a great deal of hand-eye coordination, training that the motor medium does not provide.

In terms of the general theories relating to transfer, vicarious trial and error might account for typically better performance by the visual medium. Observing the clay react to hand position and pressure could have provided S with VTE feedback, permitting him to associate the most task-relevant cues. If one equates Judd's theory of generalization with the verbal medium which involved principles as well as details on how to perform the coning and centering tasks, then Judd's theory is not corroborated when dealing with the centering task. However, when the analysis of the coning task data is noted, the media X repetitions interaction showed a significant difference between the verbal medium of two repetitions and that of the verbal medium of six repetitions. This finding may point to the need for a longer period of assimilation when using
verbal media on a psychomotor task. Depending on the definition of "identical elements," Thorndike's theory is either seen in a good light or a bad one. If the instructor medium is assumed to represent the greatest fidelity of identical elements between training medium and transfer task, then Thorndike's theory seems to be valid. If, on the other hand, the motor medium is assumed to represent the best embodiment of the theory of identical elements, then Thorndike's concepts appear to be less satisfactory than the other theories.

Transfer Trials

The second hypothesis dealt with the expected improvement by all experimental groups when going from trial 1 to trial 2. These anticipated practice effects were expected to be in the order: motor medium, verbal medium, visual medium, and instructor medium. This order was based on the assumption that those media with the highest initial performance scores for trial 1 would probably show the least subsequent improvement. The only medium to exhibit the pattern of poor initial performance on trial 1 followed by good subsequent performance on trial 2 was the verbal medium as seen in the media X trials interaction for the coning task. In fact, for the centering task, there was a significant main effects decrement in performance from trial 1 to trial 2.

There are two possible causes for the superior main effects performance of trial 1 over trial 2. One cause is the physical fatigue which results from the exertion involved in controlling the clay. Carron and Allen (1971) report on the detrimental effects fatigue has on both performance and learning a gross motor task. A second possible cause lies in the order of the testing trials. That order was coning (trial 1), centering (trial 1), coning (trial 2), and centering
(trial 2). Since the performance decrement occurred between the two centering trials, it is possible that the coning task (trial 2) acted as an interference between them. Patrick (1971) examined the effect of an interpolated motor response on short-term memory and found that interference took place. Had the two coning trials and the two centering trials been performed in the order: coning (trial 1), coning (trial 2), centering (trial 1), centering (trial 2), the findings concerning the main effects for trials may have been different.

Training Repetitions

The third hypothesis dealt with the expected improvement of task performance when the training intervals were increased from two repetitions to six repetitions (or their equivalent in time for the instructor medium). The media X repetitions interaction proved significant for the coning task. The verbal medium receiving two repetitions showed significant improvement when receiving six repetitions. Although the main effects scores for repetitions, both for the coning task and the centering task, showed improvement from two repetitions to six repetitions, these improvements were below the level of significance.

Media Selection

Concerning the desirability of one training medium over another, since the visual and the instructor media were statistically equivalent in their respective effects on performance, it would be more cost effective to devote resources to the visual medium as it can be employed to train many people at one time as easily as one. Furthermore, the instructor medium involves higher hourly salary costs and is suitable for training only one person at a time.
References


