California State University, Northridge

CROSS-MODAL TRANSFER OF FINE MOTOR SKILL ABILITY

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

by

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The thesis of Frederick Kurt Schack is approved:

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ABSTRACT

CROSS-MODAL TRANSFER OF FINE MOTOR SKILL ABILITY

by

Frederick Kurt Schack

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The purpose of this study was to investigate the phenomenon of cross-modal transfer from hands to feet on a two-arm tracing apparatus.

Forty-six male undergraduate students who were enrolled in physical education or recreation classes at California State University, Northridge, volunteered as subjects for this research. Forty-five of these subjects completed all three of the testing periods. The subjects were equated on the basis of a pre-test and assigned to one of three groups, H, F, or C, by the matched triplets method. Group H practiced with their hands, Group F with their feet, and Group C on an unrelated task. All three groups were tested using their feet. The study lasted six weeks, with two training sessions per week. Pre- and
post-testing was completed during the first and last weeks.

The analysis of variance test was used to analyze the data. Results indicated that Group F performed significantly better than Group H (P< .05) and Group C (P< .01). There was no significant difference between Group H and Group C throughout the investigation. The results supported the null-hypothesis that there is no significant difference between subjects practicing with their hands and subjects who practice unrelated tasks on the ability to perform the skill with their feet.
CHAPTER I

INTRODUCTION

Physical education enlists many different methods of teaching. It is concerned with the extensive number and variety of factors which describe the whole student. The student's performance in an activity is based on three factors: (1) the teacher's ability to teach, (2) the student's ability to learn and perform, and (3) the student's prior experience(s) with the activity or similar activities. The teacher may use one or a number of the different principles of learning to teach the skill. One method is to have the student attempt to relate the skill in question to a similar, already mastered activity or task. This method employs the principle of transfer of training, that is, using another activity to cause improved performance in a new or similar skill.

In sports such as handball and basketball, the more highly skilled performer is usually an individual who is as accomplished with one hand as he is with the other. To attain this level of proficiency, the athlete may have used a type of transfer of training called bilateral
transfer. While the athlete practices the skill with his dominant hand, he notes those factors that cause him to be successful with that hand and then attempts to repeat the same act in the same way with the non-dominant hand.

In this study, however, a third type of transfer, called cross-modal transfer, was investigated. In this type of transfer, the training is with the hands, and the criterion test is with the feet.

The Problem

Statement of the Purpose

It was the purpose of this study to investigate the phenomenon of cross-modal transfer from hands to feet.

Hypothesis

This investigation was designed to test the hypothesis that there is no significant difference between subjects practicing with their hands and subjects who practice unrelated tasks on the ability to perform the skill with their feet.

Importance of the Study

In physical education, elementary physical skills are learned so that one may attain a high level of proficiency in more difficult skills. For example, one
usually practices a number of elementary tumbling skills before attempting a more difficult maneuver. Transfer of training is used not only to improve an athlete's skill level, but also to teach concepts to beginners.

Scope and Limitations

The research involved forty-six male undergraduate volunteers who were enrolled in physical education or recreation classes at California State University, Northridge. Their ages ranged between eighteen and thirty-three years. The study was six weeks in duration; and it was concerned only with the effect of cross-modal transfer on the criterion task. All subjects were instructed not to practice the skill in any way outside of the laboratory and to refrain from discussing their training sessions with anybody other than the experimenter.

Assumptions

For the purpose of this study, the following assumptions were made:

1. The students volunteering for this study have an average age equal to that of the student population at California State University, Northridge.
2. The training task was not practiced outside of the laboratory conditions.

3. It was not discussed by any of the students except in the presence of the investigator.

4. Six weeks were considered sufficient to properly investigate the hypothesis of this research.

Definition of Terms

The unique terms in the investigation were defined as follows:

1. **Bilateral Transfer**: the skill acquired by one limb as a result of practice with an opposite limb.

2. **Cross-education**: bilateral transfer as well as transfer from one limb to the remaining three limbs of the body.

3. **Cross-modal Transfer**: the transfer of skill attained by the arms and hands or legs and feet as a result of practice with the opposite set of limbs.

4. **Fine Motor Task**: a task in which the center of gravity of the body remains relatively stationary while the center of gravity of any one or all of the limbs changes at will.

5. **Gross Motor Task**: a task in which the center of gravity of the body makes definite changes in its
6. Irregular tracking maze: a maze designed so that there is no specific formation or path that is identical to any other part of the total maze—a movement may be repeated, but not in the same way it was previously made.

7. Learning: an observable change in behavior as a result of practice.

8. Performance: the ability to attain a score on a task at any given time.

9. Task: an activity that can be used to measure performance or learning.

10. Transfer: the effect that practice on one task has on the performance of a second task.

11. Two-arm tracing apparatus: a device consisting of two maneuverable metal arms supporting a stylus which may be used to track a maze (see Figure 2).

Summary

Chapter I has included an introduction and description of the problem under investigation in this research. Also included were a number of terms which have been defined for use in this study so that the author and reader may have the same understanding.
Organization of the Remaining Chapters

This investigation is divided and organized into five chapters, the remaining four of which are as follows: Chapter II contains a review of literature which is related to the present research while Chapter III presents the research procedures and methods used to test the hypothesis. In Chapter IV a presentation, interpretation, and discussion of the results of the data may be found. Chapter V completes the study with a conclusion, summary, and recommendations for future investigations.
CHAPTER II

REVIEW OF LITERATURE

Consideration in this review has been given to several areas that appeared to be of importance to cross-modal transfer research. First, a basic understanding of the nature of transfer is paramount. Once this has been explained the areas of specific concern to this research are presented: task difficulty, cross-education, and the measurement of transfer.

Nature of Transfer

Transfer is the effect that training, or performance, on one task exerts on the performance of another (3). The basic approach involved in studying this phenomenon is the comparison of the performance between two groups of subjects on a given task, one group of which has trained on a different task. The influence that the training for one task has on the performance of a second task can be positive, negative, or ineffective (2).

The initial research on the subject was discussed by Woodworth and Schlosberg (7) as well as several other
authors (8,51). They indicated that the earliest research was done in 1858 by E. H. Weber, who noted that some children who were trained to write with the right hand could exhibit very good mirror-writing with the left hand with no additional training.

Much of the early work in transfer of training centered around the formal discipline theory: skill will transfer to a second task provided the first task required difficult mental exercise (3). The theory was tested by studying the effect of learning Latin on the ability to improve mastery of English grammar. Most of the research involving this academic controversy proved the theory to be quite inadequate (18,48,49,52).

As a result of these early studies, Thorndike (5) proposed his "identical elements" theory of transfer. This theory predicts that transfer between any two tasks will be dependent on the amount of similarity between the tasks.

Thorndike's "identical elements" theory did not satisfy all learning theorists, for it contrasted sharply with the "general principles" position of transfer. The "general principles" theory stated that there are certain general principles or ideas which may transfer from one task to another. For example, one may say that learning
the application of Newton's Laws on Motion in one sport may assist the performer in solving problems involving these laws in another sport.

The two theories should not be seen as contrasting, that is, mutually exclusive of one another, but as an alternate explanation of a given situation.

The stimulus-response theory offered yet another way of explaining transfer, but really represents an exposition of Thorndike's "identical elements" ideas. Much of the research in this area produced prior to 1949 has been summarized by Osgood (46) in his hypothetical transfer surface. His diagram, as modified by Woodworth and Schlosberg (7) in Figure 1, showed that when two tasks contain nearly the same stimuli and nearly the same responses, positive transfer is to be expected. However, there have been exceptions to Osgood's diagram (24,52,53); Deese and Hardman provide a good example: they demonstrated the occurrence of more negative transfer when the responses to a given stimulus were similar than when they were dissimilar.

The real value of Osgood's transfer surface seemed to be best summarized by Deese (3:224): "...the exact shape of the diagram has no meaning; only the general relationships are meaningful."
FIGURE 1

Osgood's Hypothetical Transfer Surface
With respect to motor learning in general and transfer of training specifically, Henry and Rogers (33) developed the neuromotor memory drum theory, which suggested that both innate and learned motor patterns are stored and become accessible in controlling later voluntary acts. These patterns may then be used in a skill never before practiced, should the skill contain tasks which have already been stored.

Transfer does not always involve learned skills but may result from the innate responses of a skilled performer, such as the effect one's balance has on his ability to wrestle. A study of this particular phenomenon was reported by Mumby (43): in his investigation of balance and wrestling ability, his findings indicated that an individual's ability to wrestle successfully is directly related to his ability to maintain steady pressure against changing dynamic conditions. Mumby's work showed that a skill which may be innate can be transferred without actually training for transfer.

Finally, it has been suggested that transfer may occur between tasks judged similar in perceptual components. Vincent (50) found transfer between two tasks similar in perceptual components (balance, laterality and stimulus color or shape) but different in motor components.
(total body vs. arms and hands only). He suggested that the transfer phenomena could be explained through similarity between the perceptual aspects of the two tasks. In the perceptual process [(1) set, (2) stimulation, (3) reception, (4) perception, (5) decision, (6) action, and (7) evaluation], steps 1-4 were considered similar by Vincent in his two tasks. Identical task elements were eliminated by using grossly differing motor skills.

The nature of transfer has been discussed in terms of its effect on performance and the theoretical reasons for its occurrence. Four possible explanations have been considered: identical elements (5), general principles (3), similarity in stimulus or response (46), a neuro-motor memory theory (33), and perceptual components (50).

**Task Difficulty**

Rotary pursuit models have been used in a variety of experiments (9,38,39,45) to determine the most efficient training speed for facilitating transfer in a test situation.

Lordahl and Archer (39), Namikas and Archer (45), Ammons, et al. (9), and Lincoln and Smith (38) studied the effect of the speed of rotation on transfer task performance. The training speed of rotation for each study
varied from forty to eighty revolutions per minute. The transfer test in three of the studies (9,39,45) used sixty rpm while the investigation by Lincoln and Smith combined forty, fifty, sixty, and seventy rpm into sixteen transfer combinations. The results of these studies showed that performance was inversely related to training speeds and that practice at the same speed on both training and transfer tasks was the most effective.

**Easy to Difficult.** Kaestner and Grant (36) found that early tracking on a simple task seemed to improve later training and testing on a more complex task; initial training on the difficult task followed by later training on the simpler task was not as effective in transfer. The tracking tasks used in this study encompassed two spatial dimensions in which the subjects followed a sine-wave pattern (simple) and aperiodic patterns (complex).

In a similar study, Barch and Lewis (11), after having trained 230 airmen on the Iowa Pursuit model, reported greater positive transfer from a simple to a difficult task than from a difficult to a more difficult task or between tasks of equal difficulty.

**Difficult to Easy.** Positive transfer, according to Jones and Bilodeau (35), is best accomplished if the initial task was complex and the transfer task was simple.
They used a clover leaf design (complex) and a circular tracking figure (simple). The research involved controlling a moveable pointer in two dimensions by turning handles with both hands.

Bartlett (1) suggested that there may be positive transfer of more difficult tasks to simpler ones. He stated that if two tasks are presented, one more difficult than the other, and that if one may assist the other, then it may be best to learn the more difficult one first. Barch (10), Gagne, et al. (27), and Lewis (37) have also reported a greater amount of transfer from a complex to a simple task.

Regarding the response variable, Day (23) indicated that it was easier to transfer training from a difficult task to a simple task than to transfer from a relatively easy task to a more difficult one. This conclusion was reached as a result of a review and summary of studies concerning task difficulty. In his review Day encountered the problem of variation in experimental results from study to study as a result of inconsistencies in defining task difficulty.

**Difficult-to-Difficult.** Difficult-to-difficult learning tasks require subjects to train on a complex task followed by performance on a task which is as difficult
as or more difficult than the initial training task. The experiments in this area have a limiting factor on them: the subjects used were retarded.

Clarke and Cookson (38) indicated that imbecile children can approach imbecile adult levels in certain perceptual-motor areas. They used card sorting and typewriter key sorting to test this hypothesis. Their results showed that the younger subjects were able to retain their learning set and improve the perceptual and conceptual discrimination components over a period of time. It was demonstrated that, after six months of not practicing, they were able to learn a difficult sorting task more easily than the easier one previously learned. This and other investigations (14,15,17) suggested that the transfer concept may have already developed in childhood or early adolescence.

After reviewing the literature prior to November, 1962 which concerned transfer between difficult and easy tasks and conducting verifying experiments, Holding (34) concluded that (a) with simple tasks the easy training was better, and (b) the complex skills favored difficult-to-easy practice. He also reported that difficulty was not a useful criterion in predicting transfer of skill. Several other studies (29,31,41) supported Holding's
conclusions. Specifically, they indicated that the complexity of the training task is unrelated to the performance of the transfer activity. The findings on which this conclusion was based showed that varying the size of the visual stimulus (causing a corresponding change in precision of movement) seemingly did not influence either the rate of learning or the extent of skill that is transferred. Travers (6) made similar conclusions, emphasizing that under certain conditions, transfer occurs more readily if the initial task is difficult and, under other circumstances, when the initial task is easier.

Research in the area of task difficulty has attempted to show the different ways one may train for an activity in terms of its difficulty. In some cases (11,36) it was better to train for transfer on an easy task before a more difficult one. Other investigators (1,10,23,27,35,37) have produced evidence supporting the position that it is better to practice a task more difficult than the one which will eventually be performed. Furthermore, some researchers (14,15,16,17), although they used retarded subjects, suggested that learning must be complex for transfer to occur, but others (6,29,31,34,41) reported findings that complexity of the training task is not important to transfer task performance.
Cross-Education

Cross-education is sometimes used to describe transfer; however, in this paper it will be used to describe studies that concentrate on the effect of training on one limb of the body and consequent transfer to one or more of the remaining three limbs (8, 12, 13, 19, 20, 21, 40, 44, 51).

A pursuit rotor was employed by Briggs and Brogden (13:472) to "...determine the functional relation between precision and angle of linear pursuit movements of the left hand and arm, and the nature of bilateral transfer." On Day-One, the pursuit rotor was tilted to eight different angles for a training task using the right hand and arm; on Day-Two the device was tilted in an identical manner for subsequent performance using the left hand and arm. The evidence showed that there was a positive relationship between the training of one limb and transfer to the opposite limb.

While conducting some of the earlier experiments in transfer of training of a motor skill, Bray (12) found that previous practice in mirror-accuracy training with one hand greatly increased the initial accuracy of transfer to the foot on the same side. He noted that this
training saved approximately six trials with the transfer foot. He also varied the number of hand trials from ten to sixty and found no measureable effect of this variable on transfer to the foot. Bray's results further showed that transfer occurred from right foot to right hand, but less extensively than transfer from hand to foot.

One of the primary investigators in the area of cross-education was Thomas W. Cook. He performed a series of experiments (19,20,21) to study this phenomenon. In his first two studies (19,20), he used mirror-star tracing as the experimental task; he had his subjects attempt the maze with one limb, followed by attempts with the other three limbs. Transfer to all muscle groups was noted. In terms of the extent of transfer, it was greatest to the same limb on the opposite side; next, to the opposite limb on the same side; and least to the opposite limb on the opposite side. There were no significant differences between transfer from hand to foot and foot to hand. Cook made the following conclusion as a result of these studies: the amount of transfer was approximately proportional to the number of training trials. As the number of trials increased, there was proportionately less transfer. He referred to this as negative acceleration.
In a third experiment (21) Cook used an irregular tracking maze as the task but maintained most of the procedures from his prior experiments. For the most part, his results duplicated those of his other experiments (19,20); however, there were more extensive differences in the hand-foot practice series. He found that "... measured in absolute units the feet had more gain from transfer than the hands;" regarding the proportional differences in the amount learned during training, there were no significant differences between foot-to-hand and hand-to-foot (21:762).

An investigation by Munn (44) utilized a unique device to study bilateral transfer. In his study Munn used a wooden cup with a wooden handle on the bottom of it. Attached to the bottom of the handle was a cord with a wooden ball at the end. The object was to get the ball into the cup. One group of subjects was trained with the dominant hand and then tested on the non-dominant hand. The non-dominant hand group improved its initial trial score by 61.4 percent. A second group of subjects, who acted as controls, improved 28.5 percent. It was not indicated whether or not the mean difference of 32.59 percent between the groups was significant. There was a problem involved in his use or definition of control group,
because there was a total of only two groups of subjects. There should have been a third group that practiced with the non-dominant hand only. This would have made the results more clear.

In 1932, Wieg (51) studied transfer of training between the fingers and toes. The investigation compared the abilities of four groups of children and adults to use a "finger-toe" maze developed by Wieg. Results indicated that for all subjects, transfer was greatest from the less efficient limb to the more efficient limb, efficiency being based on initial trials to complete the maze. There was positive transfer in adults to all "idle" limbs, but in children transfer was both positive and negative. Overall results seemed to suggest that training was general rather than specific. These results conflicted with those of Bray (12) and led Wieg to criticize Bray's findings because he based his conclusions on too few records.

In his study of transfer, Allen (8) compared two methods of learning mirror-drawing to determine which might be more beneficial to later learning. He reported that the successive method (learning with one hand followed by testing with the other) was a more efficient method of learning than was the simultaneous method (both
hands functioning independently at the same time on identical mirror-drawing maze patterns).

A number of the cross-education studies (8,12,19, 20,21) have used mirror tracing, which produced responses containing perceptual components that may be more important than the combined elements of speed, strength, and accuracy. According to Milisen (40:641), when information is wanted or needed in cross-education, "the perceptual factors should be minimized and the motor skills should be stressed." The studies by Cook (19,20,21) indicated that bilateral transfer involves (a) the transfer of common elements, and (b) subconscious motor training of the apparently unused limb. Milisen, however, proposed a third possibility: in the non-dominant hemisphere of the cortex, there occurs a mirrored replica of a set of learned movement responses formed from the muscular patterns of the training limb. He arranged an experiment with a continuous cloverleaf-patterned maze, having one group of subjects practice in a clockwise direction and another in a counterclockwise direction, both using a right angled stylus. The right hand was the training hand, while the left hand was the transfer hand. Training the right hand in a counterclockwise direction produced the greatest amount of transfer to the left hand when the left hand
performed in a clockwise direction. According to Milisen, the common elements theory was inadequate to explain these results; dependence on the subminimal practice of the untrained limb, as well as the mirror representation in the non-dominant cerebral hemisphere, appeared the more adequate theory. This may also be in agreement with Henry's "memory drum theory" (33), in which specific patterns are learned and later recalled when a skill involving any one or all of those patterns is attempted.

Measurement of Transfer of Training

Over the years, attempts have been made to measure the effects of training in one activity on training in another. As a result of their many variations, these quantitative expressions do not allow one to compare in any standard or systematic way the extent of transfer under different experimental conditions. Many times a comparison may be made using the raw data which are reported. In some cases, however, comparison of degrees of transfer cannot be made directly because the learning associated with it has been measured in other ways such as: noting the number of trial attempts to reach a criterion, measuring the time required to perform a certain activity, or counting the frequency of errors (28).
After surveying an extensive variety of transfer studies and literature on the measurement of transfer, Gagne, et al. (28), reported that transfer of training may be a function of any one of six methods, with minor variations possible in each. These are stated as follows (28:97-8):

(1) A raw score, either amount of learning or amount of improvement; (2) percent of improvement over some particular stage of learning; (3) percent of contribution of the transferred task to the total learning of a final task; (4) percent of savings in learning a final task attributable to having learned an initial task; (5) percent of improvement to be expected in some given number of trials of direct learning; and (6) in addition, the presence or absence of transfer, but not its amount, has been indicated by the use of coefficients of correlation.

These authors further stated that if a measure of transfer is being used to its fullest extent for purposes of theoretical analysis, it should be obtained under conditions in which some measure is secured at the instant (a) when learning begins, (b) when it ends, and (c) at various intermediate stages of the learning process.

Summary

This review of literature concentrated on four areas related directly or indirectly to the present
Research: the nature of transfer, task difficulty, cross-

education, and the measurement of transfer.

Most of the research in transfer of training has
come from the experimental psychologists, beginning with
E. H. Weber in 1858 (7,12,51). Later investigations des-
cribed the identical elements theory (5), the general
principles approach (3), the stimulus-response concept
(46), and the perceptual component theory (50). Excep-
tions (24,32,53) were taken to the stimulus-response argu-
ment of Osgood (46).

Research (33) indicated the importance of the
possible programming effect of motor patterns and that
transfer may have innate characteristics as opposed to a
learned response (43).

Rotary pursuit models were used in a number of
experiments (9,38,39,45) to facilitate understanding the
effect of task difficulty on transfer. Regarding task
difficulty, opinion was divided concerning the training
best suited to stimulate transfer: easy-to-difficult (11,
36), difficult-to-easy (1,10,23,27,35,37), or difficult-
to-difficult (14,15,16,17). A number of authors (6,29,31,
34,41), however, have indicated that task complexity was
not a useful tool in predicting transfer of skill.
The final consideration of transfer of training research focused on cross-education studies. These investigations involved single limb transfer studies (8,13,40,44,51) and multiple limb transfer research (12, 19,20,21).

Concluding the review of literature was a brief discussion of the variety of ways that transfer of training may be measured (28).

**Implications for Present Study**

In relation to research in the theory of transfer of training, and specifically of cross-education, it should be understood that to apply this theory in the classroom situation is difficult; that the decision to teach for transfer should be based on a thorough understanding of the concepts of transfer, since negative as well as positive transfer could result.

All of the research on cross-education prior to this investigation has concentrated on single limb transfer. There has not been any research which considered simultaneous cross-modal transfer of skill on an identical task. Therefore, the present study has been conducted both to broaden the scope of cross-education research and to contribute to a better understanding of transfer of
training.
CHAPTER III

RESEARCH PROCEDURES

The purpose of this study was to investigate the effects of the cross-modal transfer of a fine motor task. Within this chapter is presented a brief summary of the preliminary procedures; the selection, assignment, and orientation of the subjects; the general design; testing procedures; instrumentation; training schedule and procedures; and the statistical design.

Preliminary Procedures

Six male volunteers from California State University, Northridge, were used in a pilot study on transfer of training involving the two-arm tracing apparatus (Figure 2). Five of the individuals tested were students enrolled in physical education classes, and one was a physical education instructor. All personnel were within the age range of the students who participated in the investigation.

Each subject participated using his hands for eight trials, then using his feet for the same number of
trials, two or three days later. The findings recorded in this pilot study gave the investigator an opportunity to construct a learning curve based on the results, to use the equipment under experimental conditions, and to practice a routine for conducting the investigation and collecting data.

On the basis of this preliminary study it was concluded that the two-arm tracing apparatus was a valid instrument for measuring learning of a fine motor skill requiring the use of both hands or both feet simultaneously. Reliability figures were not determined during these preliminary procedures, but were established later using data collected during the actual study.

Selection and Assignment of Subjects

Forty-six male students from California State University, Northridge, ages eighteen to thirty-three, volunteered to participate as subjects in this investigation. All but one of the subjects were enrolled in physical education or recreation activity classes. The requirements for acceptance as volunteers were: (1) no involvement in outside activity that might influence the degree of transfer, and (2) agreement to remain as subjects for six consecutive weeks.
All subjects received three familiarization periods, each followed by a pre-test using their feet on the two-arm tracing apparatus. They were then ranked according to their total score (time plus errors) on the pre-test and assigned to either Group H (hands), Group F (feet-control), or Group C (unrelated task-control) by the matched triplets method of grouping.

Orientation of Subjects

The subjects were familiarized with the nature of the study at the time they volunteered. During this phase they were told that they would be participating in a motor learning experiment that would take approximately five to ten minutes per day, twice a week for six consecutive weeks. The task itself was not explained at this time, except to say that it would be novel and that the subjects would be sitting on a bench.

General Design

The study lasted six weeks. Group F and Group H practiced twice a week for four weeks following the pre-testing sessions. They were tested at the end of the second week and at the conclusion of the training during the sixth week of the experiment. Group C practiced an
unrelated skill but was tested in the same manner as Groups F and H. All trials by each subject were individually conducted in the presence of the experimenter.

Group F was given three practice trials per session using their feet. Group H practiced in the same manner as Group F, except that they used their hands. Group C trained with the Smedley hand dynamometer, producing three maximum contractions per hand per session, excluding the testing periods. This placed each of the subjects in Group C under the same experimental conditions as Group F and Group H with respect to the presence of the investigator. The purpose of including Group C, therefore, was to control the variable of instructor influence.

Group C represents the prime control for determining the influences of transfer. If significant differences are observed between subjects who practice a transferable task and subjects who practice completely unrelated tasks, it may be assumed that transfer has occurred.

**Practice Paradigm.** The proactive paradigm was used as follows to test this investigation:

Experimental Group H

Pre-test Feet....Learn Hands....Test Feet
Experimental Group F (Feet-control)

Pre-test Feet....Learn Feet....Test Feet

Experimental Group C (Unrelated task-control)

Pre-test Feet....Unrelated Task....Test Feet

Selection of Skills

Criterion Test. This consisted of testing on the two-arm tracing apparatus (Figure 2).

Practice Task. This employed the same device as the criterion test and was used as the training device for Groups F and H (Figures 3 and 4 respectively).

Instrumentation

All subjects practiced and tested on the two-arm tracing device. They were seated comfortably in front of the maze on a bench, 1' 5 3/4" from the maze. The maze (Figure 5) was electronically scored for errors: each time the metal stylus made contact with the metal boundary of the tracking path, an error was recorded; this error was also signaled audibly to the subject by a clicking sound. The edges were serrated to eliminate the possibility of constant contact between the stylus and the maze. Time was measured to the nearest one-half second with a
FIGURE 3

Two-Arm Tracing Apparatus

(Using Feet - Group F)
FIGURE 4

Two-Arm Tracing Apparatus

(Using Hands - Group H)
hand-held stop watch.

Testing Procedure

Group-equating tests. The group-equating tests were conducted to establish a basis on which the three groups could be formed. The basis for equation was the lowest total score recorded on the two-arm tracing apparatus. The lowest total score was computed by converting the time, in seconds, and number of errors to Z-Scores and summing them. These tests were given following the familiarization period on Wednesday and Thursday of the first week. The subjects performed three non-scored familiarization trials and were then ranked according to the sum of all three testing trials.

Mid-training tests. One mid-training test of three trials was administered to each group during the fourth session to assess any trends in scores and to determine if differences among the three groups were present during the training program.

Post-tests. Post-tests for all three groups were conducted during the last week of the investigation; each individual had a final testing time and day (not necessarily the same time and day that he had during the training periods, however). An attempt was made to prevent
interference with the final examination week schedule which occurred at the same time. These tests were identical to those administered during the pre- and inter-training testing periods.

**Test-protocol.** The test on the two-arm tracing device consisted of three trials. Each subject entered the room at a specified time and day and was seated on the bench, as shown in Figure 3. He was positioned directly in front of the testing device, and his feet were strapped into the respective foot devices. When the subject was ready, the experimenter gave a signal to begin and started the stopwatch. The time-and-error score was given to the subject after each trial. This score was the only motivation provided to the subject during the testing and training periods.

**Training Schedule and Procedure**

Subjects were selected from classes which met for one hour a day, two days per week, either on Monday and Wednesday or Tuesday and Thursday. The class meeting times for those days varied between 8:00 A.M. and 1:00 P.M. The experimenter arranged for the subjects to meet for their sessions during their respective class meeting hours.
The study was conducted in a cubicle in the Human Performance Laboratory at California State University, Northridge. This area was relatively quiet and free from outside distractions and therefore presented a controlled environment for the training and testing sessions.

Group F subjects entered the room during their respective assigned times and immediately assumed a seated position on the bench; they then removed their shoes and placed their feet into the foot devices. The test administrator tied the laces of the tennis shoes. He then secured two straps which stabilized the toe and transverse arch areas. A third strap was located at the rear of the foot plate and crossed the leg at a $45^\circ$ angle. It was brought up from the inside at a $45^\circ$ angle, circled the ankle joint once, and fastened at a $45^\circ$ angle to the outside of the heel, thereby securing the ankle joint to the foot plate (Figure 4).

When each subject was ready, a signal was given to begin. The subject proceeded to guide the stylus through the maze as rapidly and as accurately as possible.

Subjects in Group H entered the training area in the same manner as Group F and followed the same procedure, except that their hands were secured instead of their feet. (The ankle strap was not used, since it would
have restricted movement to a great extent.) For Group H the maze was raised one foot from the floor so that the subjects could reach the maze comfortably (Figure 4).

The control group, Group C, entered the room, sat on the bench in the same manner as Groups F and H, but did not face the testing device. (During this time the maze was covered by two towels.) The Group C subjects were handed a Smedley hand dynamometer, with which they performed three maximum contractions with each hand. There was a thirty-second rest period between each contraction.

All subjects were reminded not to discuss their individual roles in this study with anyone until the conclusion of the research.

**Statistical Design**

The analysis of variance test was used to determine statistical significance in speed, accuracy, and total scores (speed plus accuracy) among the three groups. The test-retest method between Attempts Two and Three on the pre- and post-tests was used to obtain the reliability coefficient of correlation. When F-tests were significant at the five percent level of confidence, the Newman-Keuls multiple comparison test (4) was applied to determine the nature of the significance between mean differences in
speed, accuracy, and total score.

**Summary**

Forty-six students volunteered to be subjects in this investigation; forty-five of them completed the testing phase. Each subject was pre-tested with the feet on the two-arm tracing apparatus, ranked accordingly, and assigned to one of three groups by the matched triplets method.

The research lasted six weeks. All three groups practiced twice a week for the duration of the study, except for Weeks One and Six, during which the pre- and post-tests were administered. The mid-training test was given during the fourth training period.

Group H practiced with the hands, Group F with the feet, and Group C trained with a Smedley hand dynamometer. At the conclusion of the study, the mean scores from each group were compared statistically, using the analysis of variance test to determine significance.

Following the application of the research procedures, the results were recorded and analyzed and will be discussed in Chapter IV.
CHAPTER IV

PRESENTATION AND INTERPRETATION
OF THE FINDINGS

The purpose of this study was to investigate the effect of training on the cross-modal transfer of a fine motor task. More specifically, this project involved a novel motor task requiring the use of both hands (Group H) working simultaneously to cause a stylus to traverse a maze. After training on this task, subjects were then tested to determine their ability to perform this same task with their feet. Two other groups, acting as controls were also tested with their feet, but practiced using either their feet (Group F) or on an unrelated task (Group C).

The findings of this project are examined in this chapter with the following questions in mind: (1) were the scores on the two-arm tracing apparatus reliable measures of learning? and (2) were there any significant differences between the groups in their time, error, and total testing scores?
Reliability of the testing procedure and the irregular tracking maze was determined by test-retest reliability coefficients. Correlations were computed between Attempts Two and Three of the pre-test, mid-test, and post-test total scores (Table 1).

**TABLE 1**

<table>
<thead>
<tr>
<th>Test</th>
<th>Number of Subjects</th>
<th>r</th>
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</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>46</td>
<td>0.69</td>
</tr>
<tr>
<td>Mid-Test</td>
<td>46</td>
<td>0.79</td>
</tr>
<tr>
<td>Post-Test</td>
<td>45</td>
<td>0.78</td>
</tr>
</tbody>
</table>

The results showed the following reliability figures: pre-test, r=.69; mid-test, r=.79; and the post-test, r=.78. It was concluded that the test was moderately reliable.

**Analysis of Variance**

The analysis of variance technique was applied to determine whether there were significant differences among
the groups regarding the variables of time, errors, and total score. The Newman-Keuls multiple comparison test was used to assess the nature of the significance when a significant F occurred.

With respect to the pre-test data there were no significant differences between groups on time (Table 2, Figure 6), errors (Table 3, Figure 7), and total score (Table 4, Figure 8).

The analysis of variance on the mid-test results indicated a significant difference between groups for the variable of total scores only. The Newman-Keuls test indicated that Group F performed significantly better than Group C (P<.05) on the variable of total score (Table 4 and Figure 8).

Post-test data indicated a significant difference (P<.05) for time (Table 2, Figure 6), errors (Table 3, Figure 7), and (P<.01) for total score (Table 4, Figure 9). The Newman-Keuls test provided information showing that Group F performed significantly better than Group C (P<.05) on the variable of time, and that Group F performed significantly better than Group H (P<.05) and Group C (P<.05) on the variable of errors; with respect to total score, Group F performed significantly better than Group H (P<.05) and Group C (P<.01).
<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>F</th>
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<tr>
<td><strong>Pre-Test</strong></td>
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<tr>
<td>Group F</td>
<td>266</td>
<td>141.66</td>
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<tr>
<td>Group H</td>
<td>248</td>
<td>133.29</td>
<td>0.74</td>
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<tr>
<td>Group C</td>
<td>318</td>
<td>200.42</td>
<td></td>
</tr>
<tr>
<td><strong>Mid-Test</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>168</td>
<td>74.42</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>210</td>
<td>150.98</td>
<td>2.40</td>
</tr>
<tr>
<td>Group C</td>
<td>270</td>
<td>152.53</td>
<td></td>
</tr>
<tr>
<td><strong>Post-Test</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>124</td>
<td>60.65</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>178</td>
<td>112.68</td>
<td>4.23*</td>
</tr>
<tr>
<td>Group C</td>
<td>243</td>
<td>148.88</td>
<td></td>
</tr>
</tbody>
</table>

* Significant as $P < 0.05$
FIGURE 6

Analysis of Variance

Time

Number of Seconds

Pre-Test
F=0.74

Mid-Test
F=2.40

Post-Test
F=4.28* (.05)

Foot
Hand
Control
TABLE 3

SIGNIFICANCE OF DIFFERENCE BETWEEN MEAN ERROR TESTING SCORES ON THE PRE-TEST, MID-TEST, AND POST-TEST

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Test</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>189</td>
<td>39.71</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>203</td>
<td>42.78</td>
<td>0.80</td>
</tr>
<tr>
<td>Group C</td>
<td>182</td>
<td>54.85</td>
<td></td>
</tr>
<tr>
<td><strong>Mid-Test</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>162</td>
<td>25.73</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>182</td>
<td>29.55</td>
<td>2.49</td>
</tr>
<tr>
<td>Group C</td>
<td>181</td>
<td>28.83</td>
<td></td>
</tr>
<tr>
<td><strong>Post-Test</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>157</td>
<td>24.00</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>188</td>
<td>34.61</td>
<td>4.28*</td>
</tr>
<tr>
<td>Group C</td>
<td>184</td>
<td>35.99</td>
<td></td>
</tr>
</tbody>
</table>

* Significant as $P < 0.05$
FIGURE 7

Analysis of Variance

Errors

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th>Mid-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot</td>
<td>182</td>
<td>184</td>
<td>188</td>
</tr>
<tr>
<td>Hand</td>
<td>189</td>
<td>181</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>203</td>
<td>162</td>
<td>157</td>
</tr>
</tbody>
</table>

F-values:
- Pre-Test: F=0.30
- Mid-Test: F=2.49
- Post-Test: F=4.28* (.05)

Footnote: * indicates significance at the .05 level.
<table>
<thead>
<tr>
<th>Measure</th>
<th>(Sums of Z-Scores)</th>
<th>Standard Deviation</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>0.06</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>-0.03</td>
<td>0.44</td>
<td>0.16</td>
</tr>
<tr>
<td>Group C</td>
<td>-0.02</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Mid-Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>0.670</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>0.315</td>
<td>0.65</td>
<td>4.68*</td>
</tr>
<tr>
<td>Group C</td>
<td>0.137</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Post-Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group F</td>
<td>0.860</td>
<td>0.390</td>
<td></td>
</tr>
<tr>
<td>Group H</td>
<td>0.359</td>
<td>0.660</td>
<td>6.43**</td>
</tr>
<tr>
<td>Group C</td>
<td>0.187</td>
<td>0.540</td>
<td></td>
</tr>
</tbody>
</table>

* Significant as P< 0.05

** Significant as P< 0.01
FIGURE 8

Analysis of Variance
Total Score

Pre-Test
F=0.16

Mid-Test
F=4.68* (.05)

Post-Test
F=6.43** (.01)

Foot
Hand
Control

Z Scores
There were no significant differences between Group H and Group C throughout the study.

Discussion

Of the forty-six subjects that completed the initial testing phase, only one did not complete the post-test, and he was subsequently eliminated when post-test analyses were conducted. He was included in the pre- and mid-test results, however.

The findings of this research, which indicated that significant transfer did not occur, appear to be in accord with the results obtained by other researchers (12,13,19,20,21,40,44,51). The researchers cited here were concerned with bilateral transfer, which is closely related to this investigation. It must be mentioned, however, that these authors indicated positive transfer which may not have been statistically significant. The present study considered transfer to have occurred only if significant differences resulted between Group H and Group C on the transfer task. Since the results were insignificant, the discussion will focus on the reasons that transfer did not occur. It may be pointed out, however, that Group H, while not statistically different from Group C, produced mean scores that were in the direction of the
transfer effects. The five reasons given are by no means inclusive or necessarily listed in order of occurrence or importance.

Stimulus and response generalization can have either a positive or negative effect on transfer, depending on the "proper" generalization of the set-stimuli or the responses. Some of the subjects may not have been able to generalize the information from one task to the other in order to make a correct conclusion; consequently, transfer may have been hindered.

Interference may have resulted from increased tension in the subjects. If a task appears difficult, it can cause heightened tension, which can hinder performance (2,25,26). The subjects were not connected to any physiological measurement apparatus, but their outward appearances sometimes suggested increased tension, i.e., rigidly tilting the head concomitant with apparent tension in the legs and feet, stiffening the hands and arms, and holding the bench tightly.

A third possibility for the non-significant findings may be referred to as "pattern interference." When specific motor patterns are learned and recorded in response to a given movement, it is thought that they may be used again provided that the new task has as part of its
repertoire some of the same movements as the previously learned tasks (33). It is therefore hypothesized that the proprioceptive cues between the hands and feet may have been decidedly different, consequently preventing a smooth program transfer.

Cratty (22) may have given the best insight into patterned responses in his study of small pattern practice on large pattern learning. He said that subjects who practice small pattern mazes and then learn large pattern mazes learn each of these tasks independently as patterned wholes, taking into account only the irregular shape of the pathway and the requirement of speed on performance. The subjects seem to have neither concern for nor a recognition of the relationship of mazes as they perform the large pattern maze. Transfer, according to Cratty, will occur when patterns in two learning situations can be synthesized and incorporated into a dynamic relationship, e.g., common patterns and relationships will facilitate the performance of a task which is different from, but similar to, the learning task (2). This explanation lends itself to a Gestalt type of influence where understandings rather than the chaining of specific responses may be responsible for increased transfer task performance.

There is evidence, however, (3, 5, 33, 46), to suggest that
the ability to recognize transferable elements may improve transfer task performance.

A fifth reason for the non-occurrence may be that the subjects who trained with their hands did not have the physical "ability to transfer" the newly learned task. This "ability to transfer" element was identified by Mukherjee when he studied transfer of two-hand coordination skill as a function of initial ability level.

Although the above explanations appear reasonable for the lack of significance between Group H and Group C, transfer in this author's opinion, is basically eclectic. As other researchers (6,29,31,34,41) have pointed out, one must thoroughly inspect the skills involved in an activity before one attempts to determine the best means of learning that activity. Transfer, when it does or does not occur, can probably be explained by any one or all of the previously mentioned concepts.

Chapter V will present the conclusions based on the analysis and interpretation of the test data.
CHAPTER V

CONCLUSIONS, SUMMARY AND RECOMMENDATIONS

Conclusions

The null-hypothesis is accepted. Based on the findings and within the limitations of this research, the following conclusion appears warranted: Performance on a task using both feet simultaneously will not be affected significantly by practicing the same task with both hands simultaneously. More directly, practice on the task produces better results than practice for transfer, which does not significantly assist in performing the task.

Major Findings

1. There were no significant differences between groups on time, errors, and total score on the pre-test.

2. Mid-test results demonstrated the Group F performed significantly better than Group C (P< .05) on the variable of total score.

3. On the post-test, Group F performed significantly better than Group H (P< .05) and Group C (P< .01)
on the variable of total score.

4. There were no significant differences between Groups H and C throughout the study.

**Summary**

The purpose of this study was to determine the effects of cross-modal transfer of training from hands to feet. This was accomplished by having the subjects practice a task with their hands, after which they were tested on the same task with their feet.

Forty-six male undergraduate volunteers who were enrolled in California State University, Northridge, physical education and recreation activity classes were used as subjects for this investigation. Subjects were equated and grouped on the basis of their pre-test scores. Group H practiced with their hands, Group F practiced with their feet, and Group C practiced an unrelated task.

The study encompassed six weeks: the pre- and post-tests took one week each, and the training phase lasted four weeks. The mid-test was scored at the end of the second week of the training phase.

All groups were tested using the two-arm tracing apparatus. Pearson's Product Moment Correlation Coefficients were used to determine reliability of the
testing procedure. The test-retest method resulted in reliability coefficients of $r=0.69$ for the pre-test, $r=0.79$ for the mid-test, and $r=0.78$ for the post-test.

Analysis of variance tests indicated that there was no significant difference between Groups H and C throughout the study. This resulted in the acceptance of the null-hypothesis.

**Recommendations for Future Studies**

The following recommendations are offered for future research:

1. Since the learning curves of the H and C Groups appeared to be diverging, it is possible that a longer training period would produce significant differences. Therefore, a similar study should be made, increasing both the length of training time and the number of subjects.

2. The task in this research might be used in other studies as a novel task of hand-eye or foot-eye coordination.

3. One could experiment to determine if transfer occurs from feet-to-hands, since this investigation considered only hands-to-feet.

4. One might compare speed versus accuracy on the ability to transfer training between two tasks to
determine the best method for learning a task requiring both of these elements.
REFERENCES CITED


Periodicals


APPENDIX A

INSTRUCTIONS FOR USING THE TWO-ARM TRACING APPARATUS

"This is a learning study involving a person's ability to learn to trace the irregular tracking maze you see before you. The details of the investigation will be given to you at the conclusion of the study, if you desire.

"Listen carefully as I read the instructions for your initial position and for completing the maze.

"You will assume a seated position on the bench placed before the maze. Your feet (hands) will be strapped in the devices as indicated by the respective shoes. From the seated position you will control the stylus located at the apex of the two small metal arms. The stylus is controlled by the movement of the metal guides in the following manner: To move the stylus up towards the top of the maze, separate your feet (hands); to move it down, bring your feet (hands) together. Movement of the stylus to the right or left is accomplished by moving your feet (hands) to the right or the left.

"If the stylus appears to 'stick' in the grooves located within the maze, DO NOT force it out, but move the metal arms gently, according to the aforementioned
procedures. It is important that you do not force any movement!

"You will receive three trials per session. Your score for each trial will be based equally on the speed with which you complete the maze and the errors made during each trial. An error is made each time the stylus contacts the metal; it is recorded on a battery-powered counter. The final score will be the average of the three trial attempts.

"You will begin from the right, moving towards the left. Do not begin until told to do so. When you finish the maze, stop, relax, do not move until instructed to do so.

"After completing each session, do not talk to anybody about your part in this research as your discussion may affect the study.

"Once the stylus has been positioned, I will give the command, 'ready, go.' When you complete the maze, I will say, 'stop, relax.' Do you have any questions before beginning?"
APPENDIX B
DATA COLLECTION FORM

NAME ________________________ (Please Print)
ADDRESS ________________________
Number and Street  Apt.  City  Zip Code
AGE ______

TELEPHONE ________________________ SCHEDULE ________________________

<table>
<thead>
<tr>
<th>Time/ Days</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Total Time</th>
<th>Total Errors</th>
<th>Total T &amp; E</th>
<th>Mean Time</th>
<th>Mean Errors</th>
<th>Mean T &amp; E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
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<td></td>
<td></td>
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