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A Feedback Model: The Comparative Effectiveness of Different Types of Practice in the Acquisition of Two Perceptual Motor Skills

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A FEEDBACK MODEL: THE COMPARATIVE EFFECTIVENESS OF DIFFERENT TYPES OF PRACTICE IN THE ACQUISITION OF TWO PERCEPTUAL MOTOR SKILLS

by

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LIFE

Gerald John Mozdzierz was born in Chicago, Illinois on September 7, 1940.

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INTRODUCTION

A. The Purpose

Since the advent of the computer, psychologists have been constantly seeking ways to relate the functioning of man as a certain type of system to that of computer-machine systems. If one were to consider the metaphysical suppositions and the empirical realities underlying similarities and differences between man and machine, it soon becomes evident that there is more to man than there is to the most ultra-modern of all mechanico-electric computers. Man is a great deal more than an atomistic unity of highly precisioned, high-speed parts.

However, the man-machine analogy can be an excellent schematic-model for undertaking an investigation into some of the more mechanical aspects of man's functioning such as the learning of a perceptual motor skill.

Dember (1960) has described a perceptual system as one which has two properties simultaneously: 1) it is sensitive to certain types of energy or information, and 2) it is capable when properly stimulated of delivering messages that in turn modify the output of the system. He then defines a perceptual system as one that relates input to output. Input can be defined as energy entering a system from without and output as that which, or the amount of that which a system produces in a given length of time.

In the acquisition of a perceptual motor skill, however, it is not only

input which facilitates increases in performance, but also feedback. English and English (1958) define feedback in organisms as "the sensory report of the somatic result of a behavior: e.g. the kinesthetic report that indicates the speed and extent of a movement." (P. 204)

However, in the human organism, it seems as though certain motor learning can take place without the ordinary input and feedback which is normally characteristic of motor learning. Certain studies have been reported in which mental or imaginary practice has been shown to be effective in facilitating significant improvements in a variety of perceptual motor tasks. (The reader is directed to Chapter II in which the studies referred to here are reviewed.)

If the input - feedback - output schematic is to be adhered to in the light of these studies on imaginary practice, it appears then that a certain "internal input" and a unique kind of feedback are operative in these instances.

Powers, Clark and MacFarland (1960) have written a general feedback theory of human behavior from an initially theoretical physics point of view. It appears as though there is agreement between the two types of feedback presented above, and the Powers et al. conception of feedback. For these investigations, one type of feedback is wholly internal to a system, involving closed loops which do not cross the input or output boundaries of the system (much like what would be operative in imaginary practice), and the other is the type in which the feedback path exists through the output boundary, passes through the environment and re-enters at the input boundary, the rest of the loop being completed within the system. Both types of feedback can

exist simultaneously.

It appears, then, that in perceptual motor learning, input can come from a variety of sources, such as vision, audition, touch and imagination, and as a result of input, certain output or performance is noted which in turn creates feedback allowing the organism to correct its movement patterns. This, of course, is a gross simplification of the truly complex process of learning a motor skill in cybernetics terminology, yet it still conveys the basic manner in which input, feedback and output relate in a single system.

What is being attempted in this dissertation is an investigation of the comparative effectiveness of different types of practice involving different amounts and kinds of input and feedback information in the acquisition of two perceptual motor skills. More explicitly, this research seeks to compare the effectiveness of seldom or never used methods of practice with orthodox methods in the acquisition and over-all improvement in a pursuitmeter task and an upside-down alphabet printing task. By acquisition is meant the rate at which individuals practice in a particular task.

B. Types of Practice.

The different types of practice devised for comparison in this study will be described by the operations performed by subjects in using each type of practice. Each type of practice will also be described for the sources of input and feedback information apparently available to the subjects. All of the different types of practice will be applied to the alphabet printing task and the rotary pursuit task with specifications concerning number of trials practiced, length of trials, etc. to be given in a discussion of procedure.

1. Actual Orthodox Practice (AOP)

The orthodox manner of practice for the pursuitmeter task would consist of actively pursuing a revolving metal disc embedded in a circular masonite turntable top with a flexible handle wire stylus. The orthodox manner of practicing the alphabet printing task would consist of actually printing the capital letters upside down, from right to left in each line on a sheet of paper so that if the paper were inverted, the letters would appear right side up and in alphabetical order.

What sources of information are available to a subject as he uses Actual Orthodox Practice in learning the pursuitmeter task?

To begin with, the subject visually tracks the metal disc as it revolves at a constant speed of 60 rpm. When a ready signal is given and finally a start signal, the stylus is dropped upon the turntable and a continuous series of modifications between input in terms of where the disc is seen to be and output in terms of pursuing the disc with the stylus are effected. The modifications are realized by muscular movements as a result of visuo-motor feedback concerning error or discrepancy between where the stylus is and where it should be in order to make contact with the disc. When a naive subject makes a "hit" or in other words, effects contact between the disc and the stylus, a "click" can be heard from the timing mechanism being engaged. This is a further source of information being fed back to the subject for it tells him of success in terms of an auditory route. Then, too, he can see the disc and the stylus make contact. The movements are a continuous series of attempts to reduce error and increase the amount of time on target. This procedure is repeated for so many trials per day for so many days.

These, then, appear to be the sources of input and feedback for pursuit-meter learning by Actual Orthodox Practice.

Kinds of Input and Feedback:

Visual:

1. Seeing the disc revolving.
2. Seeing the stylus hitting the disc.

Auditory:

1. Hearing clicks as a "hit" is made (thus the subject knows how well he is doing).
2. Hearing scratches as the stylus pursues the disc.

Muscular:

1. Arm muscles moving and reporting feedback
2. Hand muscles moving and reporting feedback
3. Eye muscles moving and reporting feedback

As corrective movements are being effected

How do input and feedback operate in a subject who is using Actual Orthodox Practice to learn the alphabet printing task?

The subject is confronted with a blank piece of paper upon which he is to print the letters of the alphabet which he knows from rote memory as well as it is possible to know anything in upside down positions. The subject must use his memory of the letters as a basis for printing the letters upside down according to the instructions. Not considering the instructions, then, the initial input in this case thus arises from inside the organism. When the signal to start is given, the subject uses past knowledge of the letters in their normal positions to print them in the inverted order. As the subject

prints a letter, visual and motor feedback are available to him. If there is no discrepancy or error between the inverted engram (as devised by the subject), and the visuo-motor feedback concerning what has been printed, he can continue to the next letter.

Error can enter into the system in two ways: 1) a letter is incorrectly inverted as it becomes input into the system, in which case motor coordination or output which prints the letter will find no error; and 2) when a letter is correctly inverted as it becomes input but coercion of muscular pattern by virtue of habituation causes an incorrect character to be printed. The system may or may not detect the error depending on the self-initiated, task-determined speed of output, which if slow would make the system more likely to be sensitive to incongruities between input, output, and feedback.

Once the O has completed a trial, he is asked to count the total number of characters that he was able to accomplish in that trial. The information as to how well he is doing (in terms of the number of letters accomplished) also serves as feedback to the subject so that on the next trial, he seeks to better what he has done previously.

These, then, appear to be the sources of input and feedback for developing performance improvement in the alphabet printing task by Actual Orthodox Practice:

Visual:

1. Seeing the printed letter.

2. Seeing the pen make the letter.

Auditory:

1. Hearing the pen as it makes sounds.

Muscular:

1. Arm muscles moving and reporting feedback	As corrective
2. Hand muscles moving and reporting feedback	movements are
3. Eye muscles moving and reporting feedback	being effected.

Knowledge:

1. Knows how many characters he has printed.

The other types of practice to be considered will deviate from Actual Orthodox Practice in terms of the amounts and kinds of input and feedback available for achieving increases in performance efficiency.

2. Imaginary Practice (IP)

Holt (1964) has recently shown that the topic of imagery is making a slow but rather successful return to the psychological scene. In this experiment, subjects using Imaginary Practice to learn the two tasks under consideration will be requested to imagine the movements which would be necessary to accomplish the desired end. In the pursuitmeter task, then, subjects would have to imagine making the circular arm movements that are necessary to make contact with the revolving disc. Just as subjects using AOP must learn to make the circular arm movements, so too must the subject using IP effectively follow the disc with his eyes as it revolves and imagine his arm moving in a circular pattern in order to make contact with the disc. He must be able to achieve this without actually making any movements of the arm or hand.

The input involved here is entirely interior to the system as it functions. However, there are contingencies operating which force one to look more closely at the question of Imaginary Practice in terms of input and

feedback.

Freeman (1931) indicated that mental work, and imagination is generally recognized as a kind of mental work, was accompanied by variations in muscle tensions. He had obtained photographic registration of the thickening of several muscle groups during mental work. This indicated some valid and important evidence of the spread of neuromuscular activity during mental work.

Muscle action potentials have not only been found in generalized mental activity. Jacobsen (1929) found that in subjects trained in the subtle art of "progressive relaxation," when in a relaxed set and told to imagine doing any one of a number of actions, a definite action potential was recorded in the specific muscle group involved in the imaginary action.

The average value action potential found for imagining lifting a 10 pound weight although uncorrected for error was 41 microvolts. The average value action potential also uncorrected for error from the right biceps brachial region in such tasks as imagining climbing a rope, imagining pumping a bicycle tire, imagining chinning oneself and a number of other imaginary tasks was about 26 microvolts.

The discovery that action potentials exist in electrodes connected with specific muscles during the process of imagination or recollection of some muscular movement logically leads to the question of whether the fibers involved actually contract.

Jacobsen (1929) designed an experiment to answer the question which he had set. He arranged a lever so that under controlled conditions, flexion of the right arm could be magnified about 80 times and recorded photographically along with the action potential curve.

The results indicated that after a signal for the subject to imagine steadily bending his right arm or to imagine lifting a 10 pound weight in a like manner, the lever records a flexion of the arm. Generally, the flexion is of microscopic extent. When a second signal was given, the subject was instructed to relax any muscular tensions present and the lever would suddenly return to the position it had while the arm was at rest. When control trials were conducted in which subjects imagined bending the left arm or lifting the weight with that arm, no microscopic flexion of the right arm and no action potentials were noted or recorded from the right biceps region.

After weighing his evidence and that gleaned from other physiological literature, Jacobsen concludes that the detection of action-potentials in muscles during a process of imagining their movement always signified the presence of the shortening of muscular fibers.

The speculative question to be proposed here is this: If specific muscle fibers have been shown to shorten during imaginary movement of those muscles, can one logically expect that some afferent fibers associated with or near the muscle fibers being shortened constitute a type of implicit feed-back to the central nervous system concerning the movement imagined? Is this the means by which subjects learn dart throwing when they learn by imagining the task? Do these minute efferent action potentials give rise to gradual refinement of motor movements with the aid of implicit microscopic afferent potentials through some analytic central nervous system action?

In the alphabet printing task, the subjects would simply imagine printing the letters of the alphabet upside down without actually making any movements. The same points considered above for the pursuitmeter task are applicable

here and a rehashing of them would simply be redundant.

In order to meaningfully compare the results of the alphabet printing by AOP and IP, the number of trials practiced would be the same. The same point can be made for the pursuitmeter task although the two tasks will not have an equal number of trials per day or an equal number of days practice. This last point will be explained more fully in a description of the procedure followed in the testing of subjects in the two tasks.

3. Imaginary and Actual Orthodox Practice (I+AOP)

The subjects practicing the two tasks in this manner would spend one-half of their trials per day in Imaginary Practice as described previously and one-half of their trials per day in Actual Orthodox Practice. They would simply alternate types of practice on alternate trials. The total number of trials per day and the total number of days practice would be the same as the number of trials and number of days used in Actual Orthodox Practice. In using this type of practice, one can gauge the effectiveness of a combination of the input and feedback described in AOP and the speculative internal input and feedback described in IP.

4. Reduced Actual Orthodox Practice (RAOP)

The subjects using this practice orientation would have the same types of input and feedback available to them as the subjects in AOP but the amount of AOP would be reduced by one-half. The subjects in this group would actually practice as much as the subjects in the I+AOP group.

5. Continually Correct Practice (CCP)

A question which has presented itself to this experimenter while reading about the corrective, error-reducing function of feedback is this:

How much would increases in performance be facilitated by practicing the two tasks under consideration if all the movements being made were continually correct?

In learning the pursuitmeter task by Continually Correct practice in a rigid, non-flexible handle wire stylus would be solidly attached to the metal disc. Subjects would hold onto the handle and the turntable would begin to turn at 60 rpm. As a subject holds onto the stylus handle, he can make 100% contact with the disc by simply holding onto the stylus handle which is solidly attached to the disc as the disc revolves and the stylus pivots about the disc.

Subjects learning the alphabet printing task by this method would first print the capital letters of the alphabet right side up and from left to right on a page. They would then turn the page upside down so that they would be confronted with all the letters of the alphabet as they look upside down. The subjects would practice for the same number of trials per day for the same number of days as subjects of the AOP group by tracing directly on top of the upside down letters before them.

With this type of practice the feedback coming into the organism as a result of movements completed is not reporting error but rather a continual series of correct movements. Theoretically, the only visuo-motor feedback and knowledge of results which can be reported back into the system is error free.

Will this type of practice be more effective than the feedback in AOP which reports errors or discrepancies between the desired and the present state? This is essentially what is being investigated by this means of practice.

6. Imitation Practice (ImP)

This type of practice is patterned after AOP. In the pursuitmeter task, subjects using Imitation Practice would have a rigid handle wire stylus with which they would pursue the disc. However, they would only be allowed to pursue the disc an inch or so above the revolving turntable. In this way, they emulate or "imitate" AOP but they would be lacking certain input and feedback.

The sources of input and feedback would be:

Visual:

1. Seeing the disc revolving.
2. Seeing the stylus above the disc.

Muscular:

1. Arm muscles moving and reporting feedback
2. Hand muscles griping and reporting feedback
3. Eye muscles moving and reporting feedback

As rough corrective movements are being effected.

Knowledge of Results:

1. Rough information as to how well organism is doing which is determined by the approximate alignment of stylus and revolving disc.

Imitation Practice for the alphabet printing task consists in holding a ball point pen and making all the capital letters upside down from right to left with "phantom" impressions without actually making any marks on the paper. Subjects in this way "imitate" the movements of AOP but they lack

certain of the sources of input and feedback that AOP readily yields.

Sources of input and feedback for ImP would be:

Visual:

1. Seeing the pen moving in the shapes of the letters.
2. Seeing a "phantom" impression of the letter. (An impression of the letter which is made but which one can only get a fleeting glimpse of since it is not permanently recorded.)

Muscular:

1. Arm muscles moving and reporting feedback	As letters
2. Hand muscles moving and reporting feedback	are being
3. Eye muscles moving and reporting feedback	considered.

Knowledge of Results:

1. Subjects know how far they get, but cannot see the actual printed picture of the letters.

How well will this type of practice facilitate improvement in actually pursuing a revolving disc and actually printing the letters upside down in contrast to AOP?

7. Practice with No Knowledge of Results (PNKR)

The phrase "no knowledge of results" is in reality quite a relative consideration as Ammon's (1956) article on the subject reveals. Thus, the specific way in which knowledge of results is prohibited from returning to the subject as feedback must be specifically spelled out.

In the pursuitmeter task we can eliminate the clicking sound of the cumulative timer being activated when a "hit" is made. We can also eliminate telling the subject how many seconds out of the total number of seconds practice that he remained on target. This study proposed to eliminate both

sources of feedback concerning knowledge of performance. Except for knowledge of performance in the way described above, then, subjects practice in the same manner and for the same amount of time and with the same rest pauses as subjects in the AOP group.

The sources of feedback available for subjects using this type of practice are as follows:

Visual:

1. Seeing the disc revolving.
2. Seeing the stylus making contact with the disc.

Muscular:

1. Hand muscles moving and reporting feedback	As corrective
2. Arm muscles moving and reporting feedback	movements are
3. Eye muscles moving and reporting feedback	being attempted.

Knowledge of performance in the alphabet printing task was limited by not allowing the subjects of the PNKR group to count the number of letters accomplished after each trial. They could, however, obtain a rough estimate of how well they were doing by taking notice of how many printed lines of the alphabet they had accomplished in any given trial. This is a less refined and accurate method of determining progress, but the subject who is experimentally alert could use this as an indicator of performance improvement.

In discussing the question of knowledge of performance, the reader can well imagine how knowledge of performance can be considered to be a relative consideration. How much knowledge does one prohibit from being fed back to the organism as well as what kind of knowledge are both relevant.

8. No Practice Control (NPC)

This practice orientation is not properly speaking a type of

practice, but is meant more as a controlled condition or a basis for comparison. Questions relevant to the basic design of the experiment would best be considered here so that a correct understanding of what is meant by No Practice Control can be achieved.

Basically, for either task, subjects are randomly assigned to one of the eight practice groups. They are given one AOP trial from which is determined their pre-practice base score. Then they practice the given task according to the group to which they have been randomly assigned for a given number of trials per day for a given number of days. On the last trial of the last day, they once again use AOP. The score obtained is the post-practice score and when the pre-practice score is subtracted from the post-practice score, the amount of improvement can be noted.

No Practice Control, then, is a type of practice in which subjects participate in a pre-practice trial and a post-practice trial with no practice in between. Whatever increases in performance are noted are due to the effect of the two trials of practice.

In this way, one can compare the effects of IP which uses only two AOP trials with NPC which also uses only two AOP trials. Then the differences in performance that are noted can be considered as due to the use of imagination. The other types of practice can also be compared with NPC to note the effects of their unique characteristics on performance against the effects of NPC. Thus, in actuality, NPC is a misnomer, but it so adequately conveys the idea inferred that it is viewed as acceptable.

C. Three Lines of General Inquiry

The various types of practice discussed above will be comprehensively compared in three ways: 1) By stipulating a series of _a priori_ hypothesis

concerning the effectiveness of the various types of practice in facilitating increases in performance; 2) by inter-task comparison of the effectiveness of the different types of practice, and 3) by comparing the rate of use of input and feedback available as measured by progress per trial per day with over-all amount of improvement.

Each of these three lines of inquiry will now be presented in a little more detail.

1. Specific Hypotheses to be tested with various types of practice.

a. Hypothesis I

A question which can serve as a broad explanatory type of directive for this hypothesis can be formulated as follows: Can reductions in gross sensory reports fed back from specific muscular movements be supplanted by the concentrated use of imagination in the acquisition of the two perceptual motor tasks under consideration? A specific statement of the null hypothesis would be: Imaginary Practice is as effective as Actual Orthodox Practice in the learning of a pursuitmeter task and an upside down alphabet printing task.

It is necessary to present a subsidiary hypothesis which, if accepted would lend validity to any conclusions drawn from testing the above null hypothesis. This subsidiary hypothesis is as follows: No Practice Control subjects will not improve as much as subjects using Imaginary Practice, although both types of practice necessitate only two trials of Actual Orthodox Practice; 1) a pre-practice trial and 2) a post-practice trial.

b. Hypothesis II

In this second hypothesis, a reformulation of the basic question in Hypothesis I is posed. That is: Can a combination of gross sensory reports fed back from specific muscular movements and the concentrated use of mental practice or imagination equal the effectiveness of Actual Orthodox

Practice in the two perceptual motor tasks under consideration? The specific statement of the null hypothesis would be: A combination of Imaginary Practice and Actual Orthodox Practice is as effective as Actual Orthodox Practice in acquiring a pursuitmeter task and an alphabet printing task.

A subsidiary hypothesis which, if accepted, would lend support to findings drawn from testing the above hypothesis is as follows: Reduced Actual Orthodox Practice is not as effective as a combination of Imaginary and Actual Orthodox Practice, although, in effect, both types of practice use an equal number of AOP trials.

A second subsidiary hypothesis which it is necessary to postulate, can be stated as follows: Reduced Actual Orthodox Practice is not as effective as Actual Orthodox Practice since Actual Orthodox Practice in the design of this experiment uses twice as much practice as Reduced Actual Orthodox Practice.

c. Hypothesis III

This hypothesis also attempts to delve into a question of the comparative effectiveness of different kinds of information fed back to subjects as they learn the perceptual motor skills with certain modifications. If individuals receive a certain amount of practice, but they are not allowed indications as to how well they are doing at any time, does their improvement equal that of individuals who practice only half as much, but have indications as to how well they are doing? A specific statement of this hypothesis would be as follows: Reduced Actual Orthodox Practice is as effective as Practice with No Knowledge of Results for acquiring a pursuitmeter task and an alphabet printing task even when the over-all amount of Actual Orthodox Practice is half that of subjects with no knowledge of results.

The first subsidiary hypothesis for Hypothesis III includes the following

A combination of Imaginary and Actual Orthodox Practice is as effective as Practice with No Knowledge of Results although subjects using I+AOP would actually practice only one half the number of trials as subjects who use PNKR.

The second subsidiary hypothesis simply compares PNKR with AOP. This hypothesis therefore is: Actual Orthodox Practice is more effective than Practice with No Knowledge of Results.

d. Hypothesis IV

In this hypothesis an attempt is to be made to test the comparative effectiveness of Imitation Practice with Actual Orthodox Practice. If subjects using ImP simply emulate the movement of AOP as described in the listing of the types of practice used in this study, will they improve as much as subjects using AOP? A specific statement of this null hypothesis would be: Imitation Practice is as effective as Actual Orthodox Practice in the acquisition of a pursuitmeter task and an upside down alphabet printing task.

A simple subsidiary hypothesis is presented here to compare Imitation Practice with a control condition. This hypothesis is as follows: No Practice Control is not as effective as Imitation Practice in facilitating improvement in the two tasks at hand although both actually practice in an orthodox manner for only a pre-practice trial and a post-practice trial.

e. Hypothesis V

This last major hypothesis seeks to contrast the effects of Continually Correct Practice with that of Actual Orthodox Practice. What effect does the virtual elimination of errors in movements have on the performance of these two perceptual motor tasks? The formulation of the specific null hypothesis would thus be stated as follows: Continually Correct Practice is as effective as Actual Orthodox Practice in learning a pursuitmeter task

and an alphabet printing task.

A subsidiary hypothesis is presented here in order to compare Continually Correct Practice with the No Practice Control condition. This hypothesis is as follows: No Practice Control is not as effective as Continually Correct Practice in facilitating improvement in the two tasks at hand although in effect both actually practice in an orthodox manner for only a pre-practice trial and a post-practice trial.

2. Inter-Task Comparison of Types of Practice Effectiveness

Once the various types of practice have been arranged in a rank order of the most effective in facilitating increases in performance through least effective for the pursuitmeter task with rank ordering also being done for the alphabet printing task, a comparative relating of the inter-task effectiveness can be achieved. In this way, one can determine whether or not the human system functions similarly in different tasks when the same relative amounts and kinds of input and feedback are available for improving performance efficiency.

3. Rate of Practice in Relation to Amount of Improvement.

The essential question being asked here is this: Does the rate at which subjects use the input and feedback available to them correspond to the total amount of improvement they are able to achieve? In other words, if subjects use the input and feedback available to them at an extremely rapid rate and it is shown which type of practice increases most rapidly, will the type of practice indicating the highest achievement, according to its mode of practice correspond to the type of practice which exhibited the most amount of improvement from pre-practice score to post-practice score?

These then are the ways in which the aforementioned types of practice will be comprehensively compared for effectiveness.

CHAPTER II

REVIEW OF RELATED LITERATURE

Since there are several facets to this dissertation which would merit reviewing relevant literature it will be necessary to discuss the literature under four headings: A) literature pertinent to the types of practice being used in this study; B) literature pertinent to the use of the pursuitmeter; C) literature pertinent to the use of the alphabet printing task, and D) literature on feedback.

A. Literature Relevant to the Types of Practice Used in This Study

Of the eight types of practice under investigation in this research only two types of practice can be presented here for review because they are the only types of practice which specifically are considered in past studies. They are Imaginary Practice and Practice with No Knowledge of Results. No studies presently known of have tried to determine if the amount of improvement achieved by subjects practicing some perceptual motor task can be matched by subjects practicing the same number of trials but half of which would be Imaginary Practice and half of which would be actual practice. Also, no studies presently known of have investigated the effectiveness of Imitation Practice and Continually Correct Practice as they have been defined and described previously in Chapter I. The effectiveness of Actual Orthodox Practice has been investigated rather extensively for both pursuitmeter learning and alphabet printing and reviews of that literature can be

found in other sections of this chapter.

1. Imaginary Practice

A series of experiments have been conducted by various investigators in which mental practice or imagination have been employed to effect the learning of motor tasks.

Vandell *et al.* (1943) found that mental practice was as effective as actual practice in learning to throw darts at a target. Subjects simply sat for 15 minutes per day on 19 consecutive days in front of a dart board and imagined picking up darts and throwing them into the target. One experiment was conducted with junior high school students and another with college students. The college students benefited more from both mental practice and actual practice than did the younger subjects. For the college freshmen tested, there was a 23% gain in dart throwing scores with actual physical practice, a 22% gain with mental practice and no gain without practice.

The Vandell *et al.* study was repeated by Twining (1949) using a different task (throwing rope rings at a peg). The same design was used so that according to the author more generalization would be possible. Twining found statistically significant improvement for mental practice and actual physical practice after the three week practice period.

Start (1960) found a significant gain in the performance of the under-arm basketball free throw by using mental practice. Thirty-five boys were allowed 9 practice periods with each practice period being of 5 minutes duration. However, Start could not relate the gain in performance to initial score or to the intelligence of the thrower.

In a study conducted by Steel (1952) involving a ball-throwing task,

it was found that there was no statistically significant amount of improvement with mental practice, although in his final conclusion Steel stipulated that daily mental practice of a motor skill produces a substantial increase in that skill.

A more recent study by Mozdzierz and McConville (1963) used a design similar to Vandell et al. but they shortened the duration of the practice period to five days instead of nineteen days. They also tested for retention of the dart throwing task. The mental practice group was able to improve its dart throwing performance to a level just approaching that of statistical significance, $p = .10$. The actual practice group did improve significantly and there was no improvement in a no practice control group. The test of retention after six weeks found the mental practice group with a statistically significant amount of reminiscence, $p = .05$, over their pre-practice scores, whereas the actual practice group and the no practice group were at chance levels of improvement.

Clark (1960) tested the effects of mental practice compared with that of physical practice in the development of a motor skill (the Pacific Coast 1-hand foul shot). He equated 144 high school boys on the basis of arm strength, intelligence and varsity, junior varsity or novice experience and then divided the boys into two groups: 1) physical practice and 2) mental practice. The results indicated that mental practice was nearly as effective as physical practice under the conditions set up in Clark's experiment.

Support for the effectiveness of mental or imaginary practice does not appear to be limited to controlled experimental observations. Morrison (1940) in his book Better Golf Without Practice seems convinced that mental practice

does improve one's performance at the game of golf.

The sources quoted seem to be the only studies in the literature which specifically use mental or imaginary practice. However, Imaginary Practice has never been applied to the two perceptual motor skills under consideration here.

2. Practice with No Knowledge of Results

Studies in which knowledge of results or delay of reinforcement are variables constitute a considerable body of literature as Renner's (1964) review of that subject more than adequately illustrates. However, with regard to the controlling of knowledge of results in this study, only two studies appear to be entirely relevant.

A study by Reynolds (1951) involving a rotary pursuit task revealed that presenting a click sounding reinforcement for continuous one second time on target led to consistent superiority when compared with a control group which did not receive the click.

Reynolds and Adams (1953) investigated the effect of different continuous on-target times required for presentation of click reinforcement in a rotary pursuit task. Intervals of .10, .20, .50, 1.0, and 2.0 seconds were used. They found that all groups were superior to the control group receiving no clicks at all stages of practice with the .5 second group generally displaying the highest level of performance throughout.

In this investigation the experimenter proposes to use click reinforcement (emanating from a cumulative electric timer) for all groups using actual practice in the rotary pursuit task except the group which will practice without knowledge of results. A silent timer will be used to

record the practice times of that group.

An article by Ammons (1956) reviews a wide number of studies in which knowledge of results are hypothesized as affecting performance. This interesting survey gives eleven generalizations as to how kinds of knowledge of results affect a performer's behavior with a theoretical framework for an organized systematic approach to the processes underlying the phenomena of knowledge of performance.

B. Literature on the Pursuitmeter Task

Since the advent of the Koerth rotary pursuit apparatus, a considerable body of literature has emerged using this apparatus to investigate a wide number of experimental learning phenomena.

It is highly probable that one of the most productive investigators using the rotary pursuit apparatus has been R. B. Ammons. In an excellent paper, Ammons (1947) attempted to develop a hypothetico-deductive partial foundation for a theory of motor learning directed primarily toward handling reminiscence and spaced practice phenomena within a single motor learning system, namely that of rotary pursuit learning. From the operational experimental conditions he used, Ammons derived several "laws." He stipulated that under certain experimental conditions called "continuous practice" a certain intervening variable called inhibition, a) would increase as a function of the time elapse since the start of continuous practice and b) decrease or dissipate according to an exponential law.

Ammons (1947a) also has investigated what happens to performance on a pursuitmeter task as a result of continuous practice coming before and after a single rest pause.

He has also investigated (1950) the effects of initially distributed practice on performance on a rotary pursuit task as well (1951) as the effects of distributed practice on the number of "hits" in the acquisition of rotary pursuit skill.

An article by Ammons (1955) is an excellent source of numerous studies conducted with the rotary pursuit apparatus. The survey of relevant rotary pursuit variables he undertakes is important in reporting a standard method of operation and many studies he cites are classical in the field of pursuitmeter learning.

In studies of psychomotor performance in which periods of practice are separated by fairly long intervals of rest, it is not uncommon to find that losses in performance proficiency occur after the rest intervals. Adams (1952) used the pursuit rotor to investigate such warm-up decrements. He concluded that warm-up decrement is not related to the growth of inhibition as had been speculated by Hull oriented psychologists since warm-up decrements were found at the beginning of every practice session for both massed and distributed practice. The warm-up decrement for distributed practice displayed a trend of decreasing magnitude as practice increased whereas warm-up decrement for massed practice showed no constant trend just as Adams had predicted.

The studies quoted are not by any means exhaustive, but are cited simply to illustrate the type of research that has been conducted using the rotary pursuit apparatus.

For an excellent review of motor learning in general as well as more studies involving the pursuitmeter by Ammons and others, the reader can

consult a review of the subject by Biledeau and Biledeau (1961). Adams (1961) also has an excellent review and bibliography on human tracking behavior which is more inclusive than simply rotary pursuit performance but nevertheless encompasses it.

C. Literature on the Alphabet Printing Task

Originally Ruch and Warren (1941) described the upside down alphabet printing task. The essential format presented by them is repeated in this study. The specific method followed in this study will be described in the procedure section.

The alphabet printing task has been used to investigate a wide number of motor learning phenomena just as the pursuitmeter has been employed in the investigation of motor learning phenomena. However, the number of studies that use the alphabet printing task is considerably less than the number of studies which have used the rotary pursuit task.

Kientzle (1946) used the upside down alphabet printing task to investigate the comparative effectiveness of different lengths of rest periods on acquisition and performance. The task was simply to print the capital letters upside down, from right to left in each line on a sheet of paper so that if the sheet were inverted, the letters would appear right side up and in alphabetical order.

In another study by Kientzle (1946) the same alphabet printing task was used to show how performances change when some subjects were shifted from massed to spaced trials and others were shifted from spaced to massed trials.

Kimble (1949) tested 474 subjects in the alphabet printing task with the end in view of testing a version of Hull's two-factor theory of inhibition

modified to handle some phenomena of motor learning. The most significant deviation from Hull's formulation was the specific assumption that after a short period of practice, the amount of reactive inhibition would attain a stable constant level which would be maintained until late in learning. His results essentially supported his original assumptions.

Once again, the studies presented here are not in any sense exhaustive, but are simply presented with the purpose of illustrating the type of research which has been undertaken using the alphabet printing task.

D. Literature on Feedback

There are a few quality sources of general information on the science of cybernetics or the general application of principles of input, feedback and output to physiological and social problems. Wiener (1948) is considered to be the founder of cybernetics which comes from the Greek word meaning steersman or governor. In general, cybernetics can be thought of as the study of control processes in machines, in organisms and in social groups. It is an avenue or a mechanism of control that provides the model for these various activities.

Hilgard (1956) has pointed out that the feedback model has not been used very extensively in learning theory. This is only partially true. If one considers feedback and learning from a complete theoretical point of view, then Hilgard's statement can be considered to be true. If, however, one considers the use of feedback simply as an explanatory mechanism, then Hilgard is not quite correct in his observation. Many studies have used the notion of feedback as an extremely useful explanatory concept in describing different learning phenomena. For example, Leavitt and Mueller (1951) have shown how the old problem of knowledge of results can be treated in terms of feedback. An

experimenter attempts to communicate to a subject a geometrical form using only words. A much greater degree of success is noted if the student is allowed to ask questions and to receive answers in the form of feedback. This is one of the more obvious examples. Everyone is aware of the fact that subjects generally perform better if information as to how well they are doing is "fed back" to them.

The most comprehensive and as far as is known, the only general feedback theory of human behavior is contained in a pair of articles by Powers, Clark and McFarland (1960) and (1960a). The first of the two articles was begun from a physical and mathematical orientation. Since two of the authors are physicists they found it most natural to develop the theoretical model first and then to attempt an outline of the application of this model to language appropriate to psychology. The second article (1960a) discussed the application of the model in appropriate psychological terms.

Whether or not such a general feedback theory of human behavior will prove fruitful in any but the conceptual sense is a question which time will be able to answer.

CHAPTER III

EXPERIMENTATION WITH DIFFERENT TYPES OF PRACTICE ON THE PURSUITMETER TASK

A. Selection and Description of Subjects

Between April 13th and June 1st, 1964, one hundred twenty college males between the ages of 18 and 24 were subjects in the rotary pursuit experiment. The vast majority (about 100) of the subjects were obtained from courses in general psychology at the Lake Shore Campus of Loyola University. All general psychology students at the Lake Shore Campus are required to participate in experiments until they acquire a certain number of points. Points are awarded by undergraduate students in experimental psychology conducting various experiments, by graduate students, and by faculty members on the basis of the amount of time subjects are required to spend in experimental situations. Since subjects were to practice the pursuitmeter task for approximately 15 minutes per day for five successive days, three points were awarded for participation in the experiment. The remainder of the subjects were obtained on the basis of personal contact through former students, fraternities and the like.

Male students only were used for learning this task since Buxton and Grant (1939) found sex differences in the performance of male and female subjects in this task. The experimenter wished to keep the initial abilities of the sample as homogeneous as possible.

None of the subjects had ever participated in an experiment in which the pursuitmeter was used, but quite a number of them had seen a picture of the pursuitmeter in their textbook in general psychology.

Six subjects were not able to make five successive practice sessions so they practiced twice on one day. In such cases, the two practice sessions were seperated by about five hours. Each of the subjects was in a different practice group.

There were fifteen subjects per group with a total of eight groups with each subject being placed in a group in random fashion.

B. Apparatus

The pursuitmeter used in this experiment had been previously constructed from a Victrola Model UE-7-26K. The model was 9 inches high, 9 inches long and 9 inches wide at the base. The turntable was 13 3/4 inches in diameter with a metal circular contact 1/2 inch in diameter inset 2 1/4 inches from the outer edge of the dark brown masonite turntable. The turntable could be varied in the number of revolutions per minute, but the experimental speed was set at 60.

The stylus was constructed of 1/8 inch metal wire attached to a wooden handle. The wire was hinged at the juncture with the handle thereby making the handle flexible and thus making it impossible for subjects to apply any pressure on the turntable except the weight of the wire stylus. Any contact between the tip of the stylus and the silver disc was recorded by means of a 6 volt D.C. (supplied internally) Lafayette cumulative timer which measured time in hundreths of a second. Figure I has the electrical schematic showing the relations between the various components in this circuit.

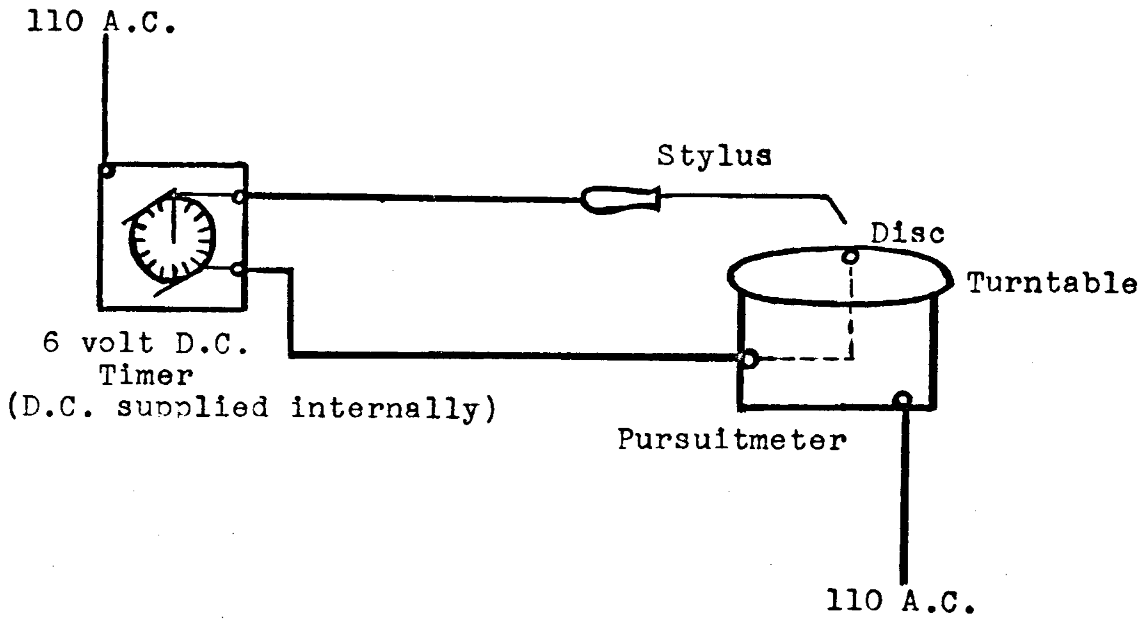

FIGURE I

SCHEMATIC OF PURSUITMETER APPARATUS FOR AOP, I+AOP, RAOP,AND NPC.

A second arrangement of apparatus was necessary for testing subjects in the group which practiced with no knowledge of results. The Lafayette timer could not be used since it gave a definite audible click which all other subjects were told indicated a "hit." A silent timer was used in its place for the PNKR group. However, the experimenter noticed two points: 1) the timer, when activated, yielded a slight motor hum which one could hear if attentive, and 2) a rather large spark occurred whenever contact was made between the tip of the stylus and the disc.

In order to eliminate the possibility of the hum of the silent timer giving unwanted feedback to the subject, the timer was placed under the table upon which the pursuitmeter rested and a color wheel was turned on to mask whatever sounds might still have emanated from the timer. Since the experimental booth was very small, the color wheel was explained to subjects of the PNKR group as a crude fan to circulate the air. It did in fact circulate a little air.

The problem of the spark, however, was a little more difficult to eliminate. It did have to be eliminated since otherwise subjects would be getting a strong additional visual feedback whenever they would make a"hit." The problem was solved with the assistance of a young physicist. There was too much electricity passing the circuit, so several modifications were necessary. The modifications of the circuit can be seen in Figure 2.

C. Procedure

All subjects were tested individually and were told that the task that they had to learn was a rotary pursuit task and that the apparatus in front of them was a pursuitmeter. They were told that the object of the task was to

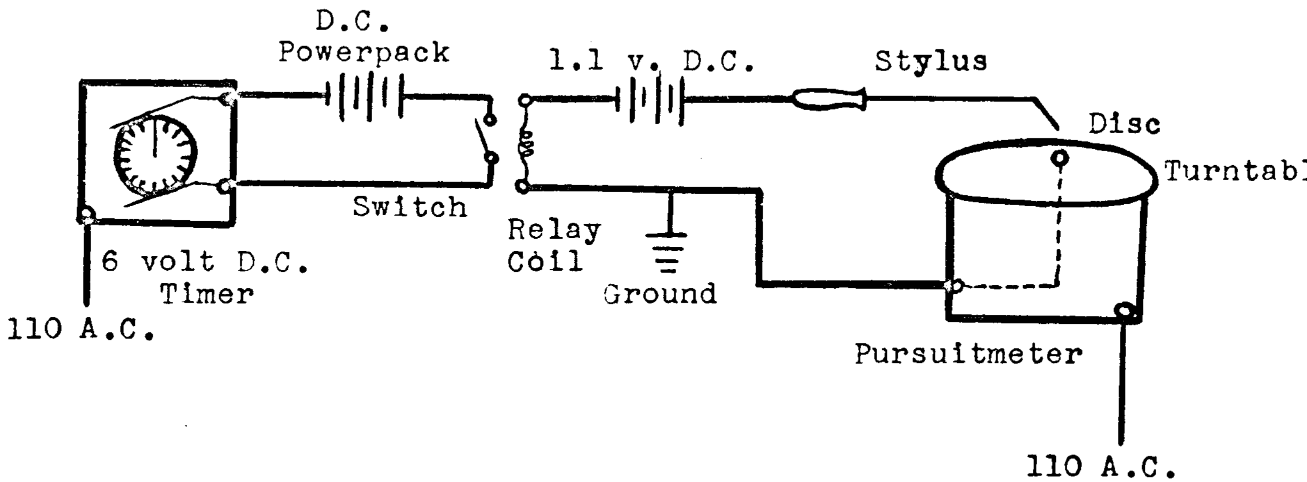

FIGURE II

SCHEMATIC OF PURSUITMETER APPARATUS FOR PNKR.

pursue the metal disc inserted in the masonite turntable top with the stylus and to make contact between the stylus and the disc. It was pointed out that when contact is made an electric circuit is completed and the timer is engaged until contact is no longer maintained between the stylus tip and the revolving disc. Each subject was to listen to the "click" of the clock as the disc was contacted by the stylus, but they were also warned that the object was not necessarily to make clicks, but to keep the sweep second hand on the clock moving for it is theoretically possible to obtain but one click and get a perfect score as long as contact between the disc and the stylus are maintained.

The experimenter demonstrated the task for about six or eight seconds and then asked if there were any questions. All questions were answered that could be except for those which pertained to the design of the experiment. The subjects were then simply informed to do as well as they possibly could at all times.

Since a time schedule of when subjects signed up for testing was kept, subjects were randomly placed in each of the eight groups without previous knowledge of their size, coordination, handedness, etc. and before they were seen by the experimenter.

The first trial was for 60 seconds. The number of seconds attained out of 60 was taken as a base score. All other practice trials were of 30 seconds duration. The last trial on the fifth day of practice was again for 60 seconds. The time for all trials and rest pauses was kept with a stopwatch.

The instructions above were given to every subject regardless of the group. However, after the first 60 second trial, the subjects of different groups were given different procedures to follow. The specific instructions

given to the various groups are given below.

1. Actual Orthodox Practice. After the first 60 second trial, subjects of this group were told that they would practice this task 10 trials per day for 5 consecutive days with each trial lasting 30 seconds with a 30 second rest pause between trials and a 1 minute rest pause between trial 5 and trial 6. A record of the number of cumulative seconds they accomplished after each trial was recorded.

2. Imaginary Practice. After the first 60 second trial, subjects of this group were told that they would practice the task 10 trials per day for 5 days with each trial lasting 30 seconds with a 30 second rest pause between trials and a 60 second rest pause between trials 5 and 6 by concentrating as hard as they could on imagining the movements that they would have to make in order to pursue the disc and maintain contact with it. They were told that they could not make any actual movements of hand or arm which would in any way simulate actual practice. They could ask any questions they wished after which practice was begun.

3. Imaginary and Actual Orthodox Practice. Once the 60 second trial was completed, the subjects were told how many trials per day and how many rest pauses, etc. that they would receive. Then they were told that they would alternate types of practice: one trial would be actual practice as they had just completed in the 60 second trial and the next trial would be imaginary in which they would imagine making the movements necessary and so forth.

4. Reduced Actual Orthodox Practice. These subjects received the same instructions as subjects in the AOP group except that they were given only 5

trials per day for 5 days with each trial of 30 seconds duration, with 30 seconds rest between trials.

5. Continually Correct Practice. After the 60 second trial was completed, the turntable was stopped and a small circular plastic disc approximately 5/8 inch in diameter was taped over the metal disc. A specially constructed stiff handle wire stylus with approximately the same dimensions as the flexible handle stylus was "plugged" into a hole in the center of the plastic disc so that as a subject would hold onto the stylus and the pursuitmeter was turned on, the subject would begin making continually correct movements at a speed of 60 rpm. This is so since the stylus is continually on top of the disc and it pivots in the hole in the plastic disc. These subjects were given 10 trials per day for 5 days with each trial of 30 seconds duration with a 60 second rest pause between trials 5 and 6.

6. Imitation Practice. The subjects practicing by this method were given the same number of days practice with same number of trials per day, etc., as the other groups except RAOP. However, a small cardboard "sleeve" was placed over the hinge area where the wire and the handle of the stylus meet. This created a stiff handle stylus. The subjects were then shown how they would be allowed to pursue the disc as it revolved. They were to keep track of the disc by following it one inch or so <u>above</u> the turntable. In this way, they "imitated" the movements of AOP but still lacked a precise knowledge of how accurate they were.

7. Practice with no Knowledge of Results. These subjects received the same type of treatment as subjects in the AOP group with the exception that the silent timing device was used and they were never told how well they were

doing.

8. No Practice Control. These subjects practiced for one 60 second trial and for a second 60 second trial 5 days later. They were allowed to hear the clicks from the Lafayette timer.

D. Random Placement of Subjects in Groups

Since a procedure of random placement of subjects in various groups was followed, it is assumed that all the group means for the base 60 second pre-practice trials did in fact arise from the same homogeneous population. In order to test for this assumption of no differences in the mean starting scores for all the eight groups, a simple two-way classification analysis of variance was conducted. Table I summarizes the computations and the necessary elements of the analysis of variance. It can be seen that the Variance Ratio = $\frac{.2589}{.2901}$ = .892 which is not significant. Variance ratio tables show no ratio significant below a value of 1.00 regardless of the number of degrees of freedom. The significance of this variance ratio is such that the likelihood of these groups not having arisen from the same population is for all practical purposes nill. This essentially means that all of these groups began with the same mean scores with only chance differences existing between the means. (Guilford, 1950).

E. Results and Analysis

1. Analysis of Improvements Noted in Each Group

Now that it has been established that all subjects were in fact randomly distributed among the eight groups, it would be well to determine whether or not each of these groups was able to increase its mean score to a statistically significant degree.

TABLE I

ANALYSIS OF VARIANCE OF PRE-PRACTICE MEAN SCORES TO DETERMINE IF ALL GROUPS IN THE PURSUITMETER TASK DID ARISE FROM THE SAME HOMOGENEOUS POPULATION.

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance
Between Groups	1.8120	7	.2589
Within Groups	32.9420	112	.2901
Total	34.7540	119	

Variance Ratio $= \frac{.2589}{.2901} = .892$ which is not significant.

Reference to Table 2 will reveal all the essential components necessary to compute t-ratios for the differences between the pre-practice mean score and post-practice mean score for each group. The t-ratios have in fact been computed and as indicated in Table 2 all the groups improved beyond the .01 level of confidence. Surprisingly enough, even the No Practice Control group was able to achieve a statistically significant amount of improvement.

2. Analysis of Differences in Mean Amounts of Improvement.

Before any of the hypotheses previously established on an *a priori* basis can be put to statistical test, it will be necessary to test if the over-all differences between all the mean amounts of improvement are significant or not. This can very easily be accomplished by conducting a simply two-way classification analysis of variance of the mean amounts of improvement.

On the initial assumption that the eight groups making up the entire series of measurements are random samples from a homogeneous population, one can expect the two estimates of variance to differ only within the limits of chance fluctuations. This null hypothesis is tested by dividing the variance between the groups, by the variance within the groups. Reference to Table 3 indicates that when the between group variance of 640.05 is divided by the within group variance of 8.15, a variance ratio of 85.75 is found for the appropriate degrees of freedom. This variance ratio is significant well beyond the one per cent level of confidence.

The stipulation of the null hypothesis must then be rejected since the significantly greater variance between the groups than within the groups excludes the likelihood of chance and must, therefore, be explained in terms of real differences existing among the effects of the different types of

TABLE II

NECESSARY COMPONENTS FOR CONDUCTING t TESTS TO DETERMINE IF EACH GROUP IN THE PURSUITMETER TASK IMPROVED TO A SIGNIFICANT DEGREE.

Group	Mean Score Pre-Practice Trial	Standard Deviation Pre-Practice Trial	Mean Score of Post-Practice Trial	Standard Deviation of Post-Practice Trial	Difference Between Mean Pre & Mean Post Trials	$S.E._{D_M}$	t
AOP	.47	.74	17.19	4.31	16.72	1.151	14.54*
IP	.24	.29	1.72	1.18	1.48	.326	4.48*
I AOP	.39	.48	15.81	3.54	15.42	.956	16.13*
RAOP	.38	.48	13.23	3.70	12.85	.996	12.90*
CCP	.31	.40	12.29	3.52	3.00	.654	4.59*
ImP	.55	.53	4.51	2.10	3.96	.578	6.85*
PNKR	.65	.59	3.65	2.38	11.98	.945	12.68*
NPC	.48	.54	1.77	1.01	1.29	.306	4.22*

* Probability is less than .01 for 28 degrees of freedom.

TABLE III

ANALYSIS OF VARIANCE OF POST-PRACTICE MEAN SCORES FOR GROUPS IN THE PURSUITMETER TASK

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance
Between Groups	4480.3170	7	640.0452
Within Groups	912.3038	112	8.1456
Total	5392.6208	119	

Variance Ratio $= \frac{640.0452}{8.1456} =$ 85.754 which is significant beyond the one per cent level of confidence.

practice as manifested in the mean amounts of improvement. Only when the variance ratio is significant can one justifiably compute the ratios for the differences between two specific mean amounts of improvement. Now the *a priori* hypotheses can be tested on the basis of *t*-ratios.

3. Statistical Testing of Specific *a priori* Hypotheses

a. Testing of Hypothesis I

Hypothesis I reads: Imaginary Practice is as effective as Actual Orthodox Practice in the learning of a pursuitmeter task. On the basis of this null hypothesis, one could expect no statistically significant difference between the mean amount of improvement for Actual Orthodox Practice and the mean amount of improvement for Imaginary Practice. The essential components necessary to conduct a *t*-test for the significance of the difference between the mean amounts of improvement for the above two groups can be found in Table 4.

The *t* of 14.06 indicates that the difference in amount of improvement in learning the pursuitmeter task by Actual Orthodox Practice and by Imaginary Practice is a real difference and not a difference which happened on the basis of chance. The null hypothesis must, therefore, be rejected.

Subsidiary Hypothesis I i reads: No Practice Control subjects will not improve as much as subjects using Imaginary Practice, although both types of practice necessitate only two trials of Actual Orthodox Practice: 1) a pre-practice trial and 2) a post-practice trial.

Reference to Table 4 will reveal all the necessary components to test for the differences between the two mean amounts of improvement. On the basis of the t obtained, .464, the above hypothesis must be rejected. There is no

TABLE IV

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS I.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	S.E.$_{D_M}$	t
	Group 1	Group 2			
Hypothesis I	AOP 16.72	IP 1.48	15.24	1.08	14.06*
Subsidiary Hypothesis Ii	IP 1.48	NPC 1.27	.21	.452	.464

*Probability is less than .01 for 28 degrees of freedom.

difference between the amount of improvement for NPC and for IP.

What has transpired in an analysis of Hypothesis I is this: Imaginary Practice apparently does not yield adequate or appropriate input and feedback information to allow subjects to improve as much as subjects practicing with Actual Orthodox Practice. The improvement that was noted in subjects using Imaginary Practice is actually only as effective as the amount of improvement noted in subjects in the No Practice Control condition.

One can only suggest speculations as to why Imaginary Practice is not as effective as Actual Orthodox Practice, but it would seem as though the speculations ventured are fairly well grounded.

Reductions in gross sensory reports fed back from specific visual-motor coordinated patterns of movement with the supplented use of imagination does not allow an organism the sufficient quantity or kind of input and feedback necessary to effect marked performance improvement.

It must be assumed that when the subjects participated in Imaginary Practice they did in fact concentrate on the movements necessary. At any rate, they appeared to follow the instructions and that is the only observation one can make. We can assume, then, that the internal input and feedback which are theorized as being operative in other studies of the use of imagination in learning were operative here, but apparently were not of sufficient strength to develop the complex degree of continuous coordination between input, feedback and output which would be necessary to effect the degree of coordination manifested in Actual Orthodox Practice in the pursuitmeter task.

b. Testing of Hypothesis II.

Hypothesis II reads: A combination of Imaginary Practice and

Actual Orthodox Practice is as effective as Actual Orthodox Practice in acquiring a pursuitmeter task.

Table 5 has the components necessary to conduct a test of the significance of the difference between the mean amounts of improvement in the above two groups. The $\underline{t}$ of .920 indicates that a chance difference exists between the mean amount of improvement of the AOP group and the I+AOP group.

Apparently, then, subjects who practice one half of the time in an orthodox fashion and one half of the time with imagination can effect a degree of performance improvement which, as far as probability is concerned, equals the performance improvement of subjects who practice twice as much in an orthodox manner. The hypothesis must, therefore be accepted.

In order to lend more support to the above hypothesis, Subsidiary Hypothesis II i was formulated as follows: Reduced Actual Orthodox Practice is not as effective as a combination of Imaginary and Actual Orthodox Practice although in effect both types of practice use an equal number of Actual Orthodox Practice trials.

Essentially, then, in the above hypothesis, the mean amount of improvement for the I+AOP group is being predicted as greater than the mean amount of improvement for RAOP. This, in fact, is what was observed. Table 5 reveals that the $\underline{t}$ of 1.94 obtained is significant at about the .06 or .07 level of confidence. Although the difference between the mean amounts of improvement is in the expected direction, it does not reach the necessary probability level. It must, therefore, be concluded that RAOP is as effective as I+AOP in learning the pursuitmeter task.

Subsidiary Hypothesis II ii reads: Reduced Actual Orthodox Practice is

TABLE V

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS II.

Hypothesis in Question	Mean amounts of Improvement		Difference between Means	S.E.$_{D_M}$	t
	Group 1	Group 2			
Hypothesis II	AOP 16.72	I+AOP 15.42	1.30	1.41	.920
Subsidiary Hypothesis IIi	I+AOP 15.42	RAOP 12.86	2.56	1.32	1.94
Subsidiary Hypothesis IIii	AOP 16.72	RAOP 12.86	3.86	1.39	2.78*

* Probability is .01 for 28 degrees of freedom.

not as effective as Actual Orthodox Practice since AOP uses twice as much practice as RAOP. The above null hypothesis is in fact accepted on the basis of the t test, the necessary components of which can be found in Table 5, conducted between the mean amounts of improvement for the two groups in question. The t of 2.78 is significant at exactly the .01 level of confidence.

It appears as though Imaginary Practice, when coupled with Actual Orthodox Practice yields enough input and feedback to match the performance improvement of a group practicing the same total number of trials, all of which are Actual Orthodox Practice. However, the input and feedback which are operative in facilitating such performance improvement appear to be largely derived from Actual Orthodox Practice since, in terms of probability, RAOP improves performance as much as I+AOP. In effect, it is as though in this task Imaginary Practice yields internal input and feedback which are of little benefit to the O utilizing them.

c. Testing of Hypothesis III

Hypothesis III reads: Reduced Actual Orthodox Practice is as effective as Practice with No Knowledge of Results for acquiring the pursuitmeter task even though the over-all amount of actual practice for the RAOP group is half that of subjects practicing with no knowledge of results of their performance. The t test conducted between the above two mean amounts of improvement can be found in Table 6. On the basis of the obtained difference, the hypothesis must be accepted, namely, that RAOP is as effective as PNKR even though PNKR actually practices twice as much.

Subsidiary Hypothesis III i reads: A combination of Imaginary and Actual Orthodox Practice is as effective as Practice with No Knowledge of Results

TABLE VI

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS III.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	S.E. $_{D_M}$	t
	Group 1	Group 2			
Hypothesis III	PNKR 11.98	RAOP 12.86	.88	1.29	.68
Subsidiary Hypothesis IIIi	PNKR 11.98	I+AOP 15.42	3.44	1.33	2.59*
Subsidiary Hypothesis IIIii	PNKR 11.98	AOP 16.72	4.74	1.40	3.39**

* Probability is less than .05 for 28 degrees of freedom.

** Probability is less than .01 for 28 degrees of freedom.

although subjects using I+AOP would actually practice only one-half the number of trials as subjects in the PNKR group. Table 6 contains the components for the t test conducted between the mean amounts of improvement noted in the above two groups. The t of 2.59 is significant at the .05 level of confidence. Thus, although subjects actually practice twice as much, when feedback information as to how they are doing is held back from them, they do not improve as much as subjects who actually practice half as much with the other half of their practice being in terms of Imaginary Practice.

Subsidiary Hypothesis III ii reads: Actual Orthodox Practice is more effective than Practice with No Knowledge of Results. This hypothesis is thus gauged to test the relative effectiveness of the "click" feedback when "hits" are made. Otherwise, the two groups practiced in like manners. Table 6 reveals that the t test conducted between the mean amounts of improvement for these two groups is significant beyond the .01 level of confidence.

What, then, does an investigation of Hypothesis III indicate concerning PNKR? From all apparent indications, it is not necessarily amount of feedback entering into a system that yields effective output, but the kind of feedback which is important. The phrase "from all apparent indications" is used because in Hypothesis II it was learned that RAOP tends not to be statistically significantly different from I+AOP. In Hypothesis III it was learned that I+AOP is statistically more effective than PNKR, but PNKR is as effective as RAOP.

If the above observations are summed, one can discover that it is the kind of feedback which is entered into a system that is the most important element in the input-feedback-output circuit. A double amount of incomplete

feedback and input as PNKR does not seem as effective as half an amount of complete feedback - input as in RAOP.

Based on information gleaned from the first three hypotheses, it appears that when knowledge of performance improvement is prohibited from being fed back into the O, he receives less help in improving performance than the use of imagination can contribute to his performance improvement in this task.

d. Testing of Hypothesis IV.

Hypothesis IV reads: Imitation practice is as effective as Actual Orthodox Practice in the acquisition of a pursuitmeter task. Table 7 reveals that ImP is not at all close to matching the effectiveness of AOP. The *t* of 11.18 indicates that the true differences between their mean amounts of improvement is definitely not zero. The null hypothesis must, therefore, be rejected.

Subsidiary Hypothesis IV i reads: No Practice Control is not as effective as Imitation Practice in facilitating improvement in a pursuitmeter task. In Table 7 can be found the components of the *t* test necessary to test the above hypothesis. The t of 5.13 obtained is significant well beyond the .01 level of confidence. One can accept the hypothesis that NPC is not as effective as ImP in facilitating improvement in the pursuitmeter task.

Merely imitating the movements involved in a pursuitmeter task by tracking the disc above the turntable without actually touching the disc facilitates a very meagre amount of performance improvement when compared with AOP. The difference in means between ImP and AOP is over 11 standard errors removed from a hypothetically true mean difference of zero. However, when contrasted to the improvement derived by NPC the effects of ImP are considerable. The

TABLE VII

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS IV.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	$S.E._{DM}$	t
	Group 1	Group 2			
Hypothesis IV	ImP 3.97	AOP 16.72	12.75	1.14	11.18*
Subsidiary Hypothesis IVi	ImP 3.97	NPC 1.27	2.70	.526	5.13*

*Probability is less than .01 for 28 degrees of freedom.

difference in the means between ImP and NPC is over 5 standard errors removed from a hypothetically true difference of zero.

The results of statistically testing this hypothesis indicate that some degree improvement is affected by the muscular feedback derived from the movements of pursuit being practiced in an imitated fashion. It seems that only a small amount of improvement is actually noted because there is only rough feedback information as to how accurate pursuit movements are. The distance between the revolving disc and the pursuing stylus immediately above the disc does not allow sufficiently accurate corrective patterns between input, feedback and output to be effected.

e. Testing of Hypothesis V

Hypothesis V reads as follows: Continually Correct Practice is as effective as Actual Orthodox Practice in learning a pursuitmeter task. Table 8 shows the t test components for testing the differences between the mean amounts of improvement for the above two groups. The t obtained equals 11.63 thereby indicating that CCP is not as effective as AOP in learning the pursuitmeter task. The hypothesis must be rejected.

Subsidiary Hypothesis Vi reads as follows: No Practice Control is not as effective as Continually Correct Practice in facilitating improvement in a pursuitmeter task. The t test conducted on the mean amounts of improvement for the above groups yields a t of 2.88. This is significant beyond the .01 level of confidence. The components necessary to conduct the t test can be found in Table 8.

What type of conclusions can be drawn from the results of testing Hypothesis V?

TABLE VIII

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS V.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	S.E. $_{D_M}$	t
	Group 1	Group 2			
Hypothesis V	CCP 3.00	AOP 16.72	13.72	1.18	11.63*
Subsidiary Hypothesis Vi	CCP 3.00	NPC 1.27	1.73	.60	2.88*

*Probability is less than .01 for 28 degrees of freedom.

Apparently the human organism is extremely restrictive in which types of input and feedback contribute toward effective large amounts of performance improvement. If the input and output patterns are coordinated by a stereotyped correct visual-motor pattern, there is no opportunity for the system to operate in a "modifying" error-reducing capacity. Apparently, the injection of error into the system is a necessary and basic component in effecting a degree of improvement even grossly resembling the improvement of AOP.

The feedback emanating from the continually correct movement of muscles and eyes doesn't establish the correct pattern of movement. The reduction of error and discrepancy apparently do establish stabilized coordination of input, feedback and output.

In learning a perceptual motor skill, an "error free" human organism is apparently a less efficient perceptual system than one which can gauge the effect of error and initiate movements on the basis of perceived error.

CHAPTER IV

EXPERIMENTATION WITH DIFFERENT TYPES OF PRACTICE ON THE ALPHABET PRINTING TASK

A. Selection and Description of Subjects

Between June 17th and August 9th, 1964, approximately four hundred college students were tested in the alphabet printing task. The vast majority of the four hundred students was in attendance at Loyola University, although about one hundred twenty students were in attendance at another university. Testing was accomplished for the most part in classroom situations or in small private groups. Whenever a group was tested, all individuals in the group practiced the alphabet printing according to only one of the eight types of practice.

Of the four hundred male and female college students tested, only one hundred twenty males between the ages of 18 and 24 were used in the compilation of the data for the dissertation. The two hundred eighty college students remaining were not used because of their sex, age, physical condition or attendance. A few explanatory remarks concerning the basis for excluding various individuals from consideration in the data would be appropriate.

To begin with, only males were used as subjects in order to make the results obtained in this task somewhat comparable to the results obtained in the pursuitmeter task. This naturally excluded all feamle subjects from consideration.

In the vast number of people tested, several were older than 24 years of

age. They were excluded since age would definitely cut down on an individual's speed of printing the letters in the manner called for by the experiment.

Several individuals had neurological disorders which did not impair mental functioning, but definitely did impair muscular coordination. One person had been taking heavy doses of medication and was not completely "normal" in muscular coordination. These individuals were excluded from consideration in the data because they were definitely deemed as not belonging to the homogeneous sample of the population selected for testing.

The final consideration for the exclusion of subjects from consideration in the data was attendance. In this task, subjects either attended for one session of testing per day for three consecutive days or they were automatically excluded from the data.

One may ask how all eight experimental groups of subjects received exactly 15 subjects apiece. In three classes tested, there were exactly 15 male subjects in the desired age range. Three experimental groups were comprised of the subjects in those three classes. When other classes were tested and there were less than 15 subjects fitting the desired characteristics, the experimenter solicited the number of subjects necessary to complete a group from the union. The subjects solicited in this manner were extremely cooperative.

None of the subjects tested had ever participated in a situation calling for printing the letters of the alphabet upside down. During the course of the three days of practicing, subjects were earnestly requested to disqualify themselves if they violated the instructions which explicitly requested them not to practice the task or even think of the letters in an upside down

fashion outside the time allotted in the practice session.

B. Apparatus

All alphabet printing was conducted on sheets of paper specially prepared for this task. The paper was 8 1/2" by 11" and had 10 rows of 3/8" by 3/8" squares with 26 squares per row, one square for each letter of the alphabet. A sample sheet can be found in the appendix. All subjects were requested to and did in fact, use ball point pens, and only the capital letters of the alphabet were to be printed upside down.

C. Procedure

A general set of instructions was given to all subjects. They were told that the task that they had to perform was to print the letters of the alphabet, but not in a regular manner. They were told to print the capital letters of the alphabet upside down from the right hand corner of the page nearest to them to the lefthand corner of the page nearest to them, printing only one letter in each of the 26 squares in a line.

Furthermore, they were instructed to work for speed and accuracy, since both are considered important. They were told that if they finished one complete line of the alphabet before time was up, they were to cover up the entire line just completed with an extra sheet of paper that they already had been instructed to have ready. The line just completed was to be covered in order to make certain that the subjects would not merely copy the letters already printed. The instructions were repeated a second time and questions were allowed. The instructions were also repeated at the beginning of each of the other two practice sessions.

The first trial and all trials afterwards were for 60 seconds. Two measures were recorded by the experimenter: 1) the total number of letters

printed and 2) the total number of correct letters printed. All of the letters were scored by the same experimenter thus his criteria for correctness was universally applied. The letters had to be definitely recognizable as the letter intended before it could be considered correct. The most common mistakes were J, N, Q, S and Z.

All subjects received the same general instructions for the first trial from which base, pre-practice scores were derived. Specific instructions given to the various groups are given below.

1. Actual Orthodox Practice. After the general instructions the members of this group were told that they would practice this task six trials per day for three consecutive days. Each trial was of 1 minute's duration, with a 1 minute rest pause between trials. After each trial the subjects were asked to count the total number of characters printed and to indicate that total in the margin next to the lines used in that trial. They were then told to relax until the ready signal was given. The process was then repeated for five more trials.

2. Imaginary Practice. After the general instructions were given to subjects of this group, they were told that they would have only 1 actual practice trial and that the remainder of their practice trials would be accomplished with the use of imagination. These subjects were instructed that they were to imagine printing the capital letters of the alphabet upside down. They were not to simply picture what a letter looked like, but imagine printing it, which in fact means to imagine making all the movements necessary to print it. This was to be accomplished without actually making any movements of the hand or arm. They were to imagine printing one letter in each square

until one entire alphabet was finished. They were to start over again until told to stop. At the end of each imaginary trial they were told to indicate on the back of the sheet of paper the total number of letters they had imagined making in the course of the trial. If for example a subject imagined making all the letters in the alphabet in the time alotted his score for that trial would be 26. After the first actual practice trial a new sheet of paper with the standard squares on it was given to each subject and then the imaginary practice trials would begin. The subjects in this group practiced the same number of trials per day for 3 consecutive days as the AOP group.

3. Imaginary and Actual Orthodox Practice. Once the general instructions of the task were given, the subjects were told that they would alternate trials using AOP and IP. They were told what was requested of them in the imaginary practice trials and in the regular practice trials as described above. The subjects kept track of their score on each trial with the same number of trials practiced per day and the number of days practice as for subjects in the AOP group.

4. Reduced Actual Orthodox Practice. The subjects of this group were given the same instructions as the subjects in the AOP group except for the fact that they practiced each day for half the number of trials as the AOP group.

5. Continually Correct Practice. After the subjects of this group completed their pre-practice trials, they were told to take the second sheet of special paper and print the letters of the alphabet right side up from left to right on the page. Then they were instructed to turn the sheet around so that all of the letters were upside down in front of them. The letters were all

correctly printed right side up so when the sheet upon which they are written is turned around, all of the letters appear in their correct upside down positions. At the beginning of each trial, the subjects simply traced on top of the upside down letters. At the end of a trial they were instructed to record how far they had gotten. They received the same number of trials per day as the AOP group.

6. Imitation Practice. After the subjects of this group completed their pre-practice base trial, they were told that they would practice the alphabet printing by making the upside down figures of the letters with their pens without actually making any marks on the test sheet of paper. They were creating phantom letters as described in Chapter I. They were to concentrate on speed as well as accuracy and they were also to keep track of how far they were able to get during each trial. They received the same number of practice trials as the AOP group.

7. Practice with No Knowledge of Results. The subjects of this group practiced in the same manner as the subjects of the AOP group with the exception that immediately after each trial they were told to turn their sheet of printed letters over so that they could not see the letters or know how many they had printed. If they completed a line in the time alloted they were to cover that line and begin over. Although a specific knowledge of how many letters were being printed was not available to these subjects, they still had a rough indication as to how well they were doing if they would note the number of lines that they were able to accomplish during each succeeding trial.

8. No Practice Control. The subjects in this group on day number one simply took one 60 second trial of AOP and on day number three took another

60 second trial of AOP.

D. Random Placement of Subjects in Groups

The same procedure of randomly selecting subjects for the various groups that was followed in the pursuitmeter task was followed here. In other words, it is assumed that all the group means for the base 60 second pre-practice trials did in fact arise from the same homogeneous population. In order to make the assumption of no differences in the mean number of correctly printed upside down letters per group during the pre-practice trial more of a certitude, a simple two way classification analysis of variance was conducted. Table 9 summarizes the necessary elements of the analysis and the Variance Ratio obtained. The Variance Ratio of .663 obtained is not significant. Significance tables for Variance Ratios do not indicate any significant ratio for even an infinite number of degrees freedom that is less than 1.00.

It is therefore relatively safe to assume that all of these groups are starting out with the same mean ability to print the letters of the alphabet upside down and that differences which exist between the group mean starting scores are due to chance fluctuations.

E. Results and Analysis

1. Analysis of Improvements Noted in Each Group

Since it has been established that all subjects were in fact randomly distributed among the eight groups, it would be well to determine whether or not each of these groups was able to increase their score to a statistically significant degree.

Reference to Table 10 will reveal all the essential components which are necessary to compute <u>t</u> ratios for the significance of the difference between

TABLE IX

ANALYSIS OF VARIANCE OF PRE-PRACTICE MEAN SCORES TO DETERMINE IF ALL GROUPS IN THE ALPHABET PRINTING TASK DID ARISE FROM THE SAME HOMOGENEOUS POPULATION.

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance
Between Groups	261.6375	7	37.3768
Within Groups	6314.1190	112	56.3761
Total	6541.2996	119	

Variance Ratio $= \frac{37.3768}{56.3761} = .6629$ which is not significant.

TABLE X

NECESSARY COMPONENTS FOR CONDUCTING t TESTS TO DETERMINE IF EACH GROUP IN THE ALPHABET PRINTING TASK IMPROVED TO A SIGNIFICANT DEGREE. ALL MEANS ARE BASED UPON ONLY THE NUMBER OF CORRECTLY PRINTED LETTERS.

Group	Mean Score Pre-Practice Trial	Standard Deviation Pre-Practice Trial	Mean Score of Post-Practice Trial	Standard Deviation of Post-Practice Trial	Difference Between Mean Pre& Mean Post Trials	S.E.$_{D_M}$	t
AOP	23.00	6.98	66.27	12.16	43.27	3.82	11.33*
IP	24.87	7.76	48.40	6.99	23.53	2.78	8.46*
I AOP	23.40	7.03	58.80	12.02	35.40	3.72	9.52*
RAOP	24.40	5.16	60.67	8.90	36.27	2.75	13.19*
CCP	25.66	7.90	43.60	14.26	17.94	4.35	4.12*
ImP	27.26	8.75	54.07	11.66	26.81	3.90	6.87*
PNKR	27.26	6.91	64.67	7.15	37.41	2.66	14.06*
NPC	25.13	7.01	33.33	8.54	8.20	2.92	2.81*

* Probability is less than .01 for 28 degrees of freedom.

the pre-practice mean score and the post-practice mean score for each group. The *t* ratios have been computed and as indicated in Table 10 all the groups improved beyond the .01 level of confidence.

2. Analysis of Differences in Mean Amounts of Improvement

In order to be able to test statistically the *a priori* hypotheses set concerning the various comparisons, it will be necessary to test if the over-all differences between all the mean amounts of improvement are significant or not. A simple two-way classification analysis of variance can easily indicate whether or not the over-all differences are significant. For a more elaborate discussion of the rationale behind this analysis of variance, the reader can consult the section of Chapter III which corresponds to this chapter.

Table 11 indicates that the variance ratio obtained is significant beyond the .05 level of confidence. Therefore, the differences existing between the mean amounts of improvement for the eight groups must be explained in terms of the effects of the different types of practice rather than to chance differences.

3. Statistical Testing for Specific *a priori* Hypotheses

Since it has been established that the over-all differences between mean amounts of improvement are significant there is some degree of justification for proceeding with the testing for the significance of the differences between specific mean amounts of improvement.

a. Testing of Hypothesis I

Hypothesis I reads: Imaginary Practice is as effective as Actual Orthodox Practice in the learning of an upside down alphabet printing task.

TABLE XI

ANALYSIS OF VARIANCE OF POST-PRACTICE MEAN SCORES FOR GROUPS IN THE ALPHABET PRINTING TASK.

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance
Between Groups	14,350.0740	7	2050.0157
Within Groups	10,194.8940	112	91.025
Total	24,544.9680	119	

Variance Ratio $= \frac{2050.0157}{91.025} = 2.252$ which is significant beyond the five per cent level of confidence.

The essential components necessary to test the above null hypothesis can be found in Table 12. The t of 5.74 indicates that there is a real difference in the amount of improvement to be derived from learning the alphabet printing by the use of imagination and by the use of actual practice. The null hypothesis must, therefore, be rejected.

Subsidiary Hypothesis Ii reads as follows: No Practice Control subjects will not improve as much as subjects using Imaginary Practice, although both types of practice necessitate only two trials of Actual Orthodox Practice: 1) a pre-practice trial and 2) a post-practice trial. The essential elements necessary to conduct a t test for the significance of the difference in the above two means can be found in Table 12. The t of 6.16 is significant beyond the .01 level of confidence. The above hypothesis can be accepted.

Through the testing of Hypothesis I, Imaginary Practice has been shown to be an effective agent in producing sufficient amounts and kinds of internal input and feedback necessary to learn the alphabet printing task. The IP group was able to improve to a statistically significantly better degree than the NPC group. The amount of improvement noted was achieved without AOP.

It seems as though the internal input and feedback available are of sufficient strength to effect the simple form of coordinated output called for, namely printing. The reader will recall that in the pursuitmeter task IP was only as effective as NPC. Undoubtedly, then, what the O is being called upon to do in the pursuitmeter task is much more difficult and required more complete and coordinated input and feedback than is needed in the alphabet printing task.

b. Testing of Hypothesis II

TABLE XII

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS I.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	S.E.$_{D_M}$	t
	Group 1	Group 2			
Hypothesis I	AOP 43.27	IP 23.53	19.74	3.44	5.74*
Subsidiary Hypothesis Ii	IP 23.53	NPC 8.20	15.33	2.49	6.16*

*Probability is less than .01 for 28 degrees of freedom.

Hypothesis II reads: A combination of Imaginary Practice plus Actual Orthodox Practice is as effective as Actual Orthodox Practice in acquiring an alphabet printing task. Table 13 reveals the _t_ test for the difference between the mean amounts of improvement and it will be noted that there is no statistically significant difference in the two types of practice in terms of their effecting increases in performance. The hypothesis is accepted.

Subsidiary Hypothesis II i reads as follows: Reduced Actual Orthodox Practice is not as effective as a combination of Imaginary plus Actual Orthodox Practice in learning an alphabet printing task although in effect both types of practice use an equal number of Actual Orthodox Practice trials. In Table 13, a _t_ test for the difference between RAOP and I+AOP has been conducted. The t obtained indicates no difference in mean amounts of improvement. Thus far in this hypothesis, the results have been identical with those of the pursuit-meter task.

Subsidiary Hypothesis II ii reads: Reduced Actual Orthodox Practice is not as effective as Actual Orthodox Practice since AOP uses twice as much practice as RAOP. Reference to Table 13 reveals that the above hypothesis must be rejected. No statistically significant difference is indicated between the two types of practice. It appears as though with a total of only 8 one minute practice trials subjects begin reaching an asymptote of performance in this task which subjects practicing for 16 one minute trials have already reached.

It thus seems as though the combining of IP with AOP adds little (in terms of exceptionally useful input and feedback) to improving performance both in the alphabet printing task and the pursuitmeter task.

TABLE XIII

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS II.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	$S.E._{D_M}$	t
	Group 1	Group 2			
Hypothesis II	AOP 43.27	I AOP 35.40	7.87	3.80	2.07
Subsidiary Hypothesis IIi	I AOP 35.40	RAOP 36.27	.87	3.39	.256
Subsidiary Hypothesis IIii	AOP 43.27	RAOP 36.27	7.00	3.56	1.94

In terms of the combination of IP with AOP the human perceptual motor system reacts in very similar ways in two tasks. However, in terms of the effectiveness of IP, the human perceptual motor system reacts quite differently.

c. Testing of Hypothesis III

Hypothesis III reads as follows: Reduced Actual Orthodox Practice is as effective as Practice with No Knowledge of Results for acquiring an alphabet printing task even though the over-all amount of actual practice for the RAOP group is half that of subjects practicing with no knowledge of their performance. Table 14 indicates that there is no difference between the two mean amounts of improvement. The question to be posed here is this: Are these two groups so similar in the amounts of performance improvement noted because of the prohibitive aspects of no knowledge of results or because of the speed with which this task is acquired? The more conservative answer and the more realistic one is the latter of the two alternatives. It appears as though subjects rapidly approach a performance asymptote in this task which makes it extremely difficult to detect differences in practice efficiency between PNKR and RAOP.

Subsidiary Hypothesis III 1 reads: A combination of Imaginary and Actual Orthodox Practice is as effective as Practice with No Knowledge of Results although subjects using I+AOP would actually practice only one half the number of trials as subjects in the PNKR group. Table 14 indicates that there is no difference in the two mean amounts of improvement. Once again, information obtained in testing the other hypotheses suggests that the facilitating aspects of combining IP with AOP are negligible as are the prohibitive aspects of witholding information in PNKR. The effects of these types of practice

TABLE XIV

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS III.

Hypothesis in Question	Mean Amounts of Improvement		Difference Between Means	$S.E._{D_M}$	t
	Group 1	Group 2			
Hypothesis III	PNKR 37.40	RAOP 36.27	1.13	3.45	.327
Subsidiary Hypothesis IIIi	PNKR 37.40	I AOP 35.40	2.00	3.69	.542
Subsidiary Hypothesis IIIii	PNKR 37.40	AOP 43.27	5.87	3.83	1.53

must still be viewed upon in terms of the actual visual-muscular input and feedback available for effective use in acquiring the task.

Subsidiary Hypothesis III ii reads: Actual Orthodox Practice is more effective than Practice with No Knowledge of Results. The results of the t test indicated in Table 14 necessitate that this hypothesis be rejected. Although the difference is in the expected direction, the probability of this difference having arisen on the basis of chance is quite high (approximately .20).

For all of the aspects of Hypothesis III, it appears as though the level of the difficulty of the task camouflages the diverse effectiveness of the different types of practice. It also appears as though the prohibitive aspects of what has been described as PNKR have been minimal if not negligible. In reality, it appears as though this should have been referred to as Practice with some Knowledge of Results, for in all perceptual motor learning, a subject must have at least some indication as to the propriety of his actions, otherwise he would simply function at a level of probability. Subjects certainly know at least in a gross way that they have printed more letters from one trial to the next by noting approximately the number of alphabets printed and the letter stopped at--if it is in beginning, middle or end of the alphabet.

Hypothesis IV reads: Imitation Practice is as effective as AOP in the acquisition of an alphabet printing task. The results of the t test conducted in Table 15 force the conclusion that ImP is definitely not as effective as AOP.

Subsidiary Hypothesis IV i reads as follows: No Practice Control is not

TABLE XV

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS IV.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	S.E. $_{D_M}$	t
	Group 1	Group 2			
Hypothesis IV	ImP 26.80	AOP 43.27	16.47	3.62	4.55*
Subsidiary Hypothesis IVi	ImP 26.80	NPC 8.20	18.60	2.74	6.78*

*Probability is less than .01 for 28 degrees of freedom.

as effective as Imitation Practice in Facilitating improvement in a pursuit-meter task. The *t* test conducted for the differences in improvement can be found in Table 15 and the results indicate that the hypothesis be accepted.

Merely making the outlines of the letters, thus creating "phantom" impressions of them, does seem to facilitate improvement to a considerable degree although the amount of improvement does not reach that attained by AOP. It appears as though some degree of coordination between input, feedback and output can be achieved by this method, even though the subjects do not receive an opportunity to see the results of what they think should be printed except in "phantom" form.

Hypothesis V reads: Continually Correct Practice is as effective as Actual Orthodox Practice in learning an alphabet printing task. Reference to Table 16 reveals that the *t* of 18.63 obtained from testing for the differences between the mean amounts of improvement indicates that CCP is definitely not as effective as AOP in facilitating performance improvement in an alphabet printing task. The hypothesis must, therefore, be rejected.

Subsidiary Hypothesis V i reads: No Practice Control is not as effective as Continually Correct Practice in facilitating improvement in an alphabet printing task. Table 16 reveals a *t* of 2.71 which was obtained in testing the above hypothesis. The t is significant at the .05 level of confidence.

What conclusions can be drawn from testing Hypothesis V? Compared to AOP, the effects of CCP in facilitating performance improvement are not very great. If the input and output patterns of remembering given letters and printing them upside down are coordinated by correct fixed patterns, there is apparently little opportunity for the perceptual motor system to operate in its more natural error-modifying capacity. "Giving" the *O* correct pattern to be

TABLE XVI

NECESSARY COMPONENTS FOR COMPUTING t RATIOS TO STATISTICALLY TEST ALL PARTS OF HYPOTHESIS V.

Hypothesis in Question	Mean Amounts of Improvement		Difference between Means	S.E.$_{D_M}$	t
	Group 1	Group 2			
Hypothesis V	CCP 17.93	AOP 43.27	25.34	1.36	18.63*
Subsidiary Hypothesis Vi	CCP 17.93	NPC 8.20	9.73	3.59	2.71**

* Probability is less than .01 for 28 degrees of freedom.

** Probability is less than .05 for 28 degrees of freedom.

practiced makes the O more passive to input and feedback which are yielded and, in being more passive, the effects of the feedback and input are sterilized.

The same general conclusion applied to Hypothesis V in Chapter III can be applied here: "In learning a perceptual motor skill, an 'error-free' human organism is apparently a less efficient perceptual system than one which can gauge the effect of error and initiate movements on the basis of perceived error." Real movements, real printed forms and real error make for better coordination between input, feedback and output than imitated movements, phantom printed forms and hypothetical error.

CHAPTER V

INTER-TASK COMPARISON OF PRACTICE EFFECTIVENESS HIERARCHIES

A. Purpose

The purpose of this chapter is to determine if the types of practice applied to the alphabet printing task and to the pursuitmeter task yield comparable amounts and kinds of input and feedback information. Phrased differently, the essential question presented here is this: Does the human system essentially derive comparable amounts and kinds of input and feedback information from the same type of practice orientation applied to the two different kinds of tasks being used?

If the most effective through the least effective means of practice in the pursuitmeter task in terms of the amount of improvement noted in the difference between pre-practice and post-practice scores is compared with the most effective through the least effective means of practice in the alphabet printing task, an index of the extent to which these hierarchies agree can be obtained.

B. Method

The perfect measure to determine the index of relationship or correlation between the ranks of the types of practice in terms of effectiveness is the rank order correlation coefficient, *rho*.

Table 17 shows the rank order of the various types of practice from most effective through least effective. The necessary calculations are also shown. In this case, P = .881 which is significant at the .01 level of confidence (Underwood, Duncan, Taylor and Cotton, 1954, Table E).

But what precisely does this measure of correlation indicate as opposed to a Pearson product moment coefficient of correlation? When <u>rho</u> is determined for data of ranked measurement, it has the same value that <u>r</u> would have and therefore, it may be interpreted as a measure of the amount of linear correlation between ranks. (Olds, 1938, 1949; Underwood, Duncan, Taylor and Cotton, 1954; and Thornton, 1943).

In order to obtain a rough index of how a scatter diagram of points representing the various types of practice for the alphabet printing task and the pursuitmeter task, Figure 3 has been constructed. Note that the points seem to distribute themselves in an approximately linear relationship.

C. Conclusions:

The most effective means of practice for the alphabet printing task is the most effective means of practice for the pursuitmeter task and generally speaking that is the case on down the line. Although not perfectly linear, the rank relationships have a remarkable degree of similarity and do show significance as mentioned above.

From the observations made here, it appears as though the human perceptual-motor learning system derives comparable benefits from similar forms of input and feedback in two different realms of endeavor. The amounts and kinds of information necessary for the organism's perceptual-motor learning system to effect certain levels of performance efficiency in different tasks seem to be

RANK DIFFERENCE CORRELATION BETWEEN EFFECTIVENESS OF VARIOUS TYPES OF PRACTICE IN THE PURSUITMETER TASK AND THE ALPHABET PRINTING TASK.

Type of Practice	Rank in Rotary Pursuit Task	Rank in Alphabet Printing Task	D	D^2
AOP	1	1	0	0
IP	7	6	1	1
I AOP	2	4	2	4
RAOP	3	3	0	0
PNKR	4	2	2	4
ImP	5	5	0	0
CCP	6	7	1	1
NPC	8	8	0	0

$\Sigma D^2 = 10$

$$\text{Rho} = \rho = 1 - \frac{6 \Sigma D^2}{N(N^2 - 1)}$$

$\rho = .881$ Which is significant at the .01 level of confidence

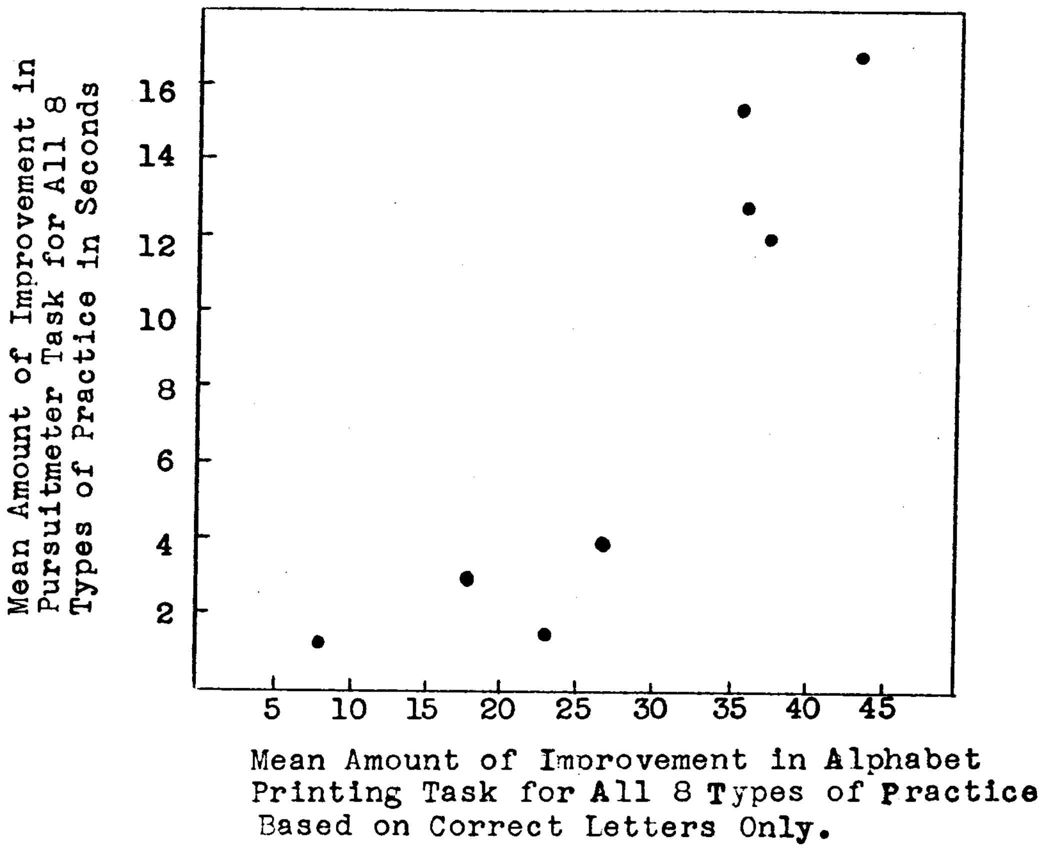

FIGURE III

A SCATTER DIAGRAM OF THE MEAN AMOUNTS OF IMPROVEMENT DERIVED BY THE EIGHT TYPES OF PRACTICE IN THE ALPHABET PRINTING TASK AND THE PURSUITMETER TASK.

constant. Thus the organism obtaining input and feedback of a certain kind in one task tends to utilize similar input and feedback in another task to a comparably effective degree.

It would be well to make the above conclusions with certain qualifications. It must be remembered that there are differences in the starting level of proficiency between the two tasks used. Any sort of paper and pencil task already involves highly developed writing skills whereas in the pursuitmeter task this does not seem to be the case. Thus the improvements derived by the subjects for all types of practice in both tasks must be considered in the light of the different starting levels of proficiency subjects utilize in alphabet printing and rotary pursuit.

CHAPTER VI

THE RELATION OF PRACTICE ACCELERATION TO PERFORMANCE IMPROVEMENT

A. Purpose

This chapter is designed to consider certain questions concerning the relationship between the rate at which the various groups practice and the over-all amount of performance improvement they were able to achieve.

In Chapter V it was noted which types of practice were most effective and which were least effective in facilitating performance improvement from the pre-practice trial to the post-practice trial. The major question to be asked here is this: In the alphabet printing task, for example, does the mean rate at which the subjects of a group use the input and feedback available to them in producing characters according to their unique practice output (such as the phantom letters of ImP or the completely correct letters of CCP or the imaginary letters of IP) correspond with the group which achieved the greatest over-all amount of improvement? Does the fastest rate of increasing performance in practice trials according to the various practice orientations correspond with the group which achieved the greatest amount of improvement from the pre-practice trial to the post-practice trial?

The most natural inclination is for one to suggest that the group with the fastest rate of practicing will make the greatest amount of improvement noted in the difference between pre-practice and post-practice scores. The

first integral element necessary to determine if the relationship between rate and improvement is direct, inverse or non-existent is an indication as to the comparative rates at which the various types of practice are able to produce letters according to the characteristic modes of orientation being used.

B. Method

Before the rates of output for these various types of practice are presented, the limitations of the data must be considered. There are only four types of practice which can be compared for rate in the pursuitmeter task, because there was no genuine way to record daily trial by trial improvement for the CCP, the ImP, the IP and the NPC. Therefore, the rate of increase will be presented for only AOP, RAOP, PNKR and I+AOP; however the statistical treatment to be applied to the relationship between the ranks of the practice improvement and the ranks of the over-all improvement cannot accommodate a small number of only four elements. Thus the analysis will have to be limited to a consideration of the alphabet printing task for which there are records of the number of letters accomplished per trial from trial number two through trial number seventeen for six of the eight groups. There are no practice trials for the NPC group and the data from the RAOP group cannot be compared for rate with groups which practiced for twice as many trials. Thus only six groups will be considered.

In Figure 4 can be found the mean number of seconds that each of the four groups remained on target for day number one through day number five. According to the rough indications apparent in the figure, AOP has the over-all highest rate of acquisition and it also had the greatest amount of performance improvement although for the first two days of practice I+AOP seemed to

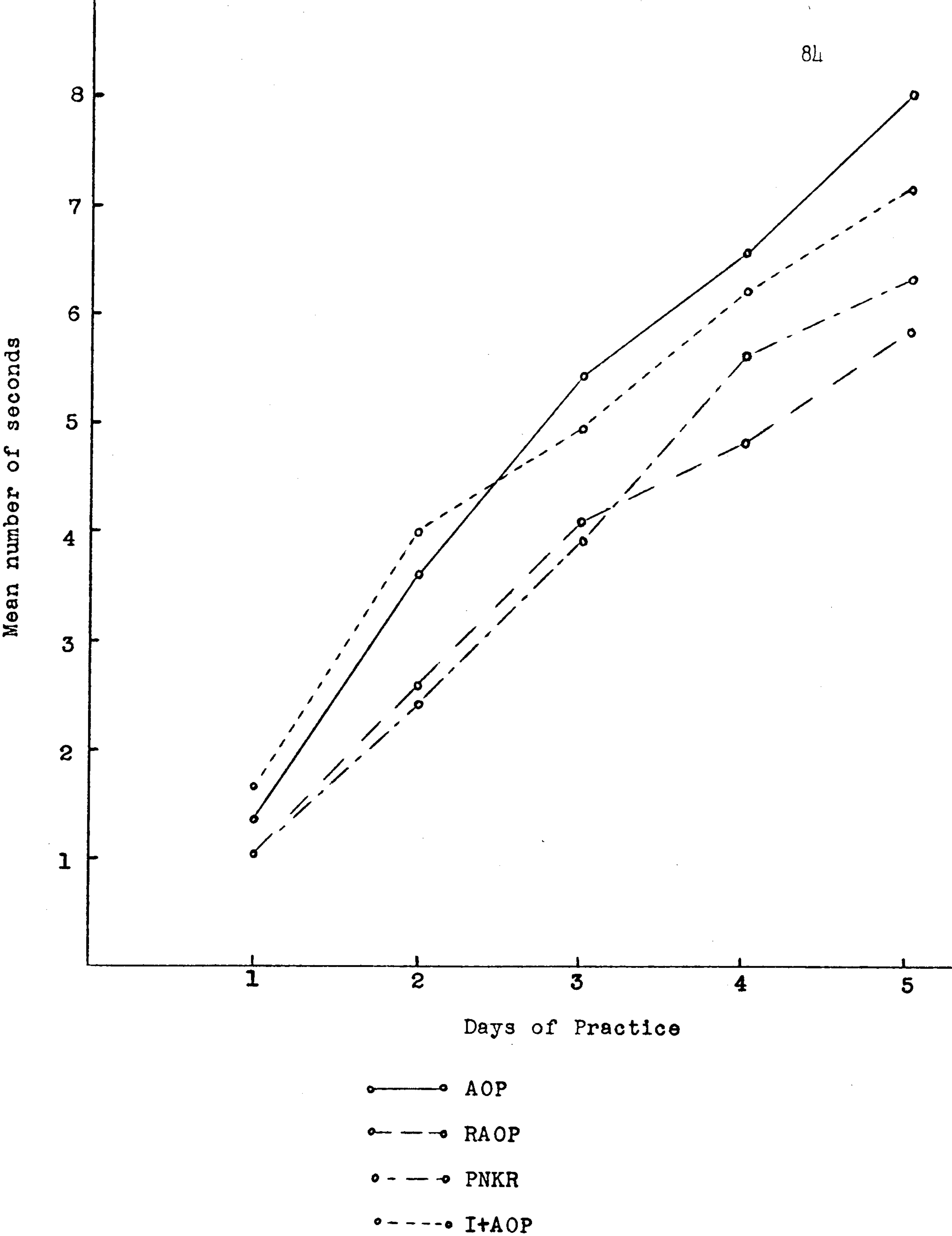

FIGURE IV

MEAN NUMBER OF SECONDS ON TARGET PER DAY OF PRACTICE

out-accelerate AOP. The lowest rate of acceleration, RAOP, had the third largest amount of improvement of all eight groups which seems to slightly indicate an inverse relationship. The type of over-all relationship to be derived here between rate and amount of improvement must remain an unanswerable question because of the data limitations.

C. Results and Conclusions

In Figure 5, are represented the mean number of letters accomplished per trial per day for the six groups which readily lend themselves to analysis. However, as the graph is in its present form, it would be next to impossible to actually determine the over-all highest rate of practice and the next highest rate and so on. Therefore, the following method of determining a hierarchy of rates of acceleration was devised. The mean number of letters accomplished per trial was recorded for each of the six groups in question. The group which accomplished the most letters on, for example, trial number two was given a rank of 1 and the next highest group was given a rank of 2, and so on. This process was repeated for each trial from 2 to 17. The ranks that a given group had obtained on all sixteen practice trials were summed for all six groups and the group which had the lowest total was the group with the highest rate of over-all acceleration. It therefore received a rank of 1. The next lowest total received a rank of 2 and so on down the line. Thus, a measure of the ranks of the highest through the lowest over-all rate of acceleration was obtained. It was a simple matter to rank the groups according to the greatest amount of improvement through least amount of improvement. The two sets of ranks were then analyzed for the amounts of correlation between them according to the Spearman rank difference coefficient of

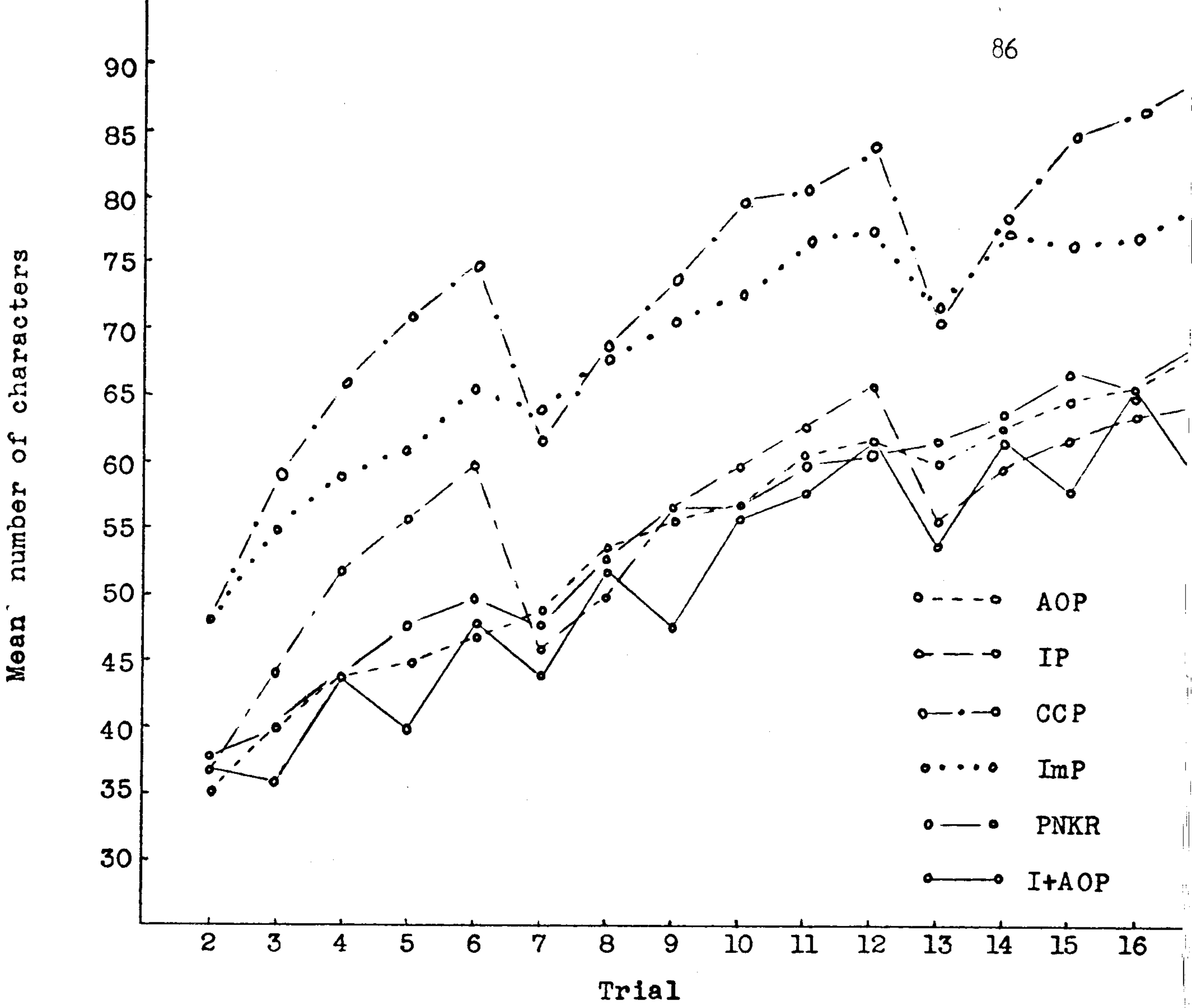

FIGURE V

MEAN NUMBER OF CHARACTERS COMPLETED PER TRIAL

of correlation, rho.

The calculation of rho as well as the ranks discussed above can be found in Table 18. The ρ of -.60 obtained is not significant for the number of paired rank differences that are available.

It appears, then, from all indications that in the alphabet printing task, the human system is functioning with an inverse relationship between rate of practice and over-all amount of improvement for the types of practice investigated. It seems as though the input and feedback available while practicing allows for rapid output in terms of whatever is called for but that the rapid output is of little significance in facilitating performance improvement from pre-practice to post-practice scores. The information available to one group allows rapid acceleration according to a particular mode of practice, but the human perceptual motor learning system is apparently extremely selective as to what will and what will not become performance increasing, effective input and feedback.

TABLE XVIII

RANK DIFFERENCE CORRELATION BETWEEN VARIOUS TYPES OF PRACTICE IN TERMS OF OVER-ALL AMOUNT OF IMPROVEMENT AND RATE OF PRACTICE ACCELERATION.

	Trial →																Column →				
Type of Practice ↓	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	*	A	B	C	D	D^2
AOP	6	4.5	5	5	6	3	3	5	4.5	4	4.5	4	4	4	5	4		71.5	5	1	4	16
IP	4.5	3	3	3	3	5	6	3.5	3	3	3	5	6	5	6	5		67	4	5	1	1
I+AOP	4.5	6	5	6	5	6	5	6	6	6	4.5	6	5	6	3.5	6		86.5	6	3	3	9
PNKR	3	4.5	5	4	4	4	4	3.5	4.5	5	6	3	3	3	3.5	3		63	3	2	1	1
ImP	1.5	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2		29.5	2	4	2	4
CCP	1.5	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1		18.5	1	6	5	25

$\Sigma D^2 = 56$

Column
- A-Sum of all ranks for all trials.
- B-Overall rank in alphabet printing task in terms of acceleration.
- C-Rank in terms of amount of over-all amount of improvement
- D-Difference between ranks.
- D^2-Difference between ranks squared.

$$\text{Rho} = \rho = 1 - \frac{6 \Sigma D^2}{N(N^2 - 1)}$$

$\rho = -.60$ which is not significant.

CHAPTER VII

A THEORETICAL ORIENTATION

Ernest R. Hilgard (1956) has pointed out some interesting problems relating to the concepts of reinforcement, provisional try and feedback. An attempt will be made here to weave the information collected in this research into the framework of the problem pointed out by Hilgard. To quote Hilgard:

> Many learning problems require the selection of one or another possible mode of action in order to reach a goal. Because alternative responses appear one after another until the correct one is stumbled upon, this learning is commonly described as trial and error. This designation is descriptively appropriate to several standard laboratory experiments. In motor-skill experiments, acceptable responses have to be discovered within a range of movement possibilities; in the problem box, there is usually one correct response among many unspecified possibilities; in discrimination experiments, selection is to be made from among fixed alternatives; in the maze and multiple-discrimination experiments, successive choices must be integrated in proper order. Two main theoretical problems arise: the problem of the nature of the original adjustment ending in the correct act, and the problem as to how this adjustment is facilitated when the situation is repeated.
>
> (Hilgard, 1956, p. 469 - 470)

The first of the two explanations offered by Hilgard is that of Edward L. Thorndike's. Thorndike's approach was to separate the two problems with the original adjustment of the organism being considered as a result of the "law of multiple response." This law simply intimates that the organism has a predisposing tendency to vary its responses in a given problem situation with a wide variety of the acts existing within it. These various responses are executed in a semi-random fashion until a correct one is chanced upon.

Then, according to Thorndike, a second principle becomes operative and that is the "law of effect." This law simply stipulates that when the same situational problem is repeated, the response that was rewarded has a better position in comparison with the rest of the possible variety of responses, and thus it would tend to become operative at an earlier point than before. Although a situation may be comparatively novel, prior experiences will have established some preferential orders of response, thus the multiple responses occurring will never be truly random. An example of this might be a cat in a closely compact puzzle box. His first reaction may be that of scratching and biting to get out. He very probably would execute the same response if he were put in a shoe box or if he were caught in some exceptionally thick bushes. The analysis of the sequence of steps taken by learning organisms is what Hull attempted to formulate.

Hilgard has also proposed the alternative answer to the problem of the original act of adjustment and how it is facilitated. According to this alternative, the act of original behavior is <u>not</u> simply the application of earlier habits to the new situation, but rather it is a "genuine attempt at discovering the route to the goal." (Hilgard, 1956, p. 470) The previous experiences of the organism are used but within a manner which is appropirate to the present. This kind of an interpretation, according to Hilgard, renders the original act of adjustment a <u>provisional try</u> which is to be confirmed or negated by its ultimate success or failure. Hilgard is quick to note that the <u>provisional try</u> is very much analogous to the "hypothesis" behavior of Tolman and Krech. According to Hilgard, "the theory supposes that a provisional behavior route is kept in suspension until its consequences

change its provisional status; if it is confirmed it is an appropriate path of action to be followed under like circumstances." (Hilgard, 1956, P. 470).

In 1948, when Hilgard first presented the concept of the provisional try the concept of feedback had not gained any wide degree of popularity. What is being implied by the provisional try is simply that there is feedback that corrects provisional attempts according to the consequences derived. The role of reinforcement under the conceptions of provisional try and of Feedback assimilates an informative role. When a correct response is made, the information fed back to the organism indicates no discrepancy or error between the desired state and the present state. The goal has been reached.

The concept of the provisional try with its resulting feedback and either confirmation or denial of an appropriate goal seems definitely more applicable to the tasks which have been investigated and the data obtained, than the two-part process which Thorndike outlined.

In the pursuitmeter task, the performance which is called for is a series of circular arm movements coordinated in a particular direction. The unique fumbling of a subject is not blind responding from a bag of semi-random responses, but rather is a closely knit continuous series of attempts to reduce error or discrepancy between the goal desired and the present state. The seemingly random series of movements are easily explained on the basis of new attempts to coordinate feedback and input into a more efficient on-target output. In being subjected to different kinds of practice rather than orthodox methods, the subjects involved were being farther and farther removed from the most optimum conditions for a provisional try.

In one type of practice, CCP, the provisional try was eliminated and the

result was a rather complete inability of subjects to profit very much in either task. When the correct mode of attack is imposed on an organism, performance is inhibited and information being fed back from the visual images and muscles flexions is being superficially imposed upon the organism and is thus useless rather than being internally assimilated and thus effective in increasing performance efficiency.

In IP in the pursuitmeter task, an organism may be mentally assuming a continuous series of provisional trys, but until they are in some way implemented or put to the task, they remain hypothetically provisional rather than actual trys.

The concept of the provisional try is equally applicable to the alphabet printing task. Both the type of input available to the organisms and the feedback available to them in learning are active ingredients in implementing or inhibiting provisional trys.

The organism must use his memory of the letters as a basis for printing the letters upside down according to the instructions. The initial input in this case thus arises from inside the organism. When the signal to start is given, the subjects uses past knowledge of the letters in their normal positions to print them in the inverted order. As _O_ prints a letter, visual and motor feedback are available to him. If there is no discrepancy or error between the inverted engram (as devised by the subject) and the visuo-motor feedback concerning what has been printed, he can continue to the next letter.

Error can enter into the system in two ways, 1) when a letter is incorrectly inverted as it becomes input into the system, in which case motor coordination or output which prints the letter will find no error; and

2) when a letter is correctly inverted as it becomes input but coersion of muscular pattern by virtue of habituation causes an incorrect character to be printed. The system may or may not detect the error depending on speed of output, which if slow would make the system more likely to be sensitive to incongruities between input, output and feedback.

Since the alphabet printing task is apparently a simpler task and the motor habits necessary to perform it are developed to a great extent, the provisional trys are much more easily facilitated in IP than they were in the pursuitmeter task, hence the rather large amount of over-all improvement for IP in the printing task. CCP, however, is about as efficient in the alphabet printing task as it was in the pursuitmeter.

Thus, depending on the degree to which the provisional try is implemented, and the amount and kind of feedback available greater or lesser facilitation of efficient performance output can be achieved.

According to the orientation presented here, it would seem as though Hilgard's concept of the provisional try is definitely justifiable.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

This study sought to investigate the comparative effectiveness of different types of practice involving different amounts and kinds of input and feedback information in the acquisition of a pursuitmeter task and an upside down alphabet printing task.

There were eight types of practice orientations investigated with all eight types of practice being applied to both tasks. The eight types of practice were: 1) Actual Orthodox Practice, 2) Imaginary Practice, 3) Imaginary plus Actual Orthodox Practice, 4) Reduced Actual Orthodox Practice, 5) Continually Correct Practice, 6) Imitation Practice, 7) Practice with No Knowledge of Results and 8) No Practice Control.

These various types of practice were to be comprehensively compared along three general lines of inquiry by first stipulating a series of *a priori* hypotheses concerning the effectiveness of the various types of practice in facilitating increases in performance; secondly by inter-task comparison of the effectiveness of the different types of practice and; thirdly, by comparing the rate of use of input and feedback available as measured by progress per trial per day with over-all amounts of improvement.

The various *a priori* hypotheses will be presented below along with the results of the statistical testing of the hypotheses for each of the tasks.

Hypothesis I reads: Imaginary Practice is as effective as Actual

Orthodox Practice. In both the pursuitmeter task and the alphabet printing task, this hypothesis was rejected. Subsidiary Hypothesis I i reads: No Practice Control is not as effective as Imaginary Practice, although both types of practice necessitate only two trials of Actual Orthodox Practice; 1) a pre-practice trial and 2) a post-practice trial. NPC was just as effective as IP in the pursuitmeter task, but not in the alphabet printing task.

Hypothesis II reads: A combination of Imaginary Practice and Actual Orthodox Practice is as effective as Actual Orthodox Practice. In both tasks this hypothesis was accepted. Subsidiary Hypothesis II i reads: Reduced Actual Orthodox Practice is not as effective as a combination of Imaginary and Actual Orthodox Practice although, in effect, both types of practice use an equal number of AOP trials. This hypothesis must be rejected since in both tasks no significant differences were found between RAOP and I+AOP. Subsidiary Hypothesis II ii reads: Reduced Actual Orthodox Practice is not as effective as Actual Orthodox Practice since AOP uses twice as much practice as RAOP. In the alphabet task, AOP was not more effective than RAOP, but there was a significant difference in the amount of improvement derived from these two types of practice in the pursuitmeter task.

Hypothesis III reads: Reduced Actual Orthodox Practice is as effective as Practice with No Knowledge of Results even when the over-all amount of practice given to the RAOP group is half that of the PNKR group. This hypothesis was accepted for both groups. Subsidiary Hypothesis III i reads: A combination of Imaginary and Actual Orthodox Practice is as effective as Practice with No Knowledge of Results although subjects using I+AOP would

actually practice only one half the number of trials as subjects who use PNKR. The hypothesis must be generally accepted for both tasks since in the alphabet task there was no difference in the two types of practice and in the pursuitmeter task I+AOP was more effective than PNKR. Hypothesis III ii reads: Actual Orthodox Practice is more effective than Practice with No Knowledge of Results. This hypothesis was accepted for the pursuitmeter task but not for the alphabet printing task, in which the predicted direction was found but significance was not quite reached.

Hypothesis IV reads: Imitation Practice is as effective as Actual Orthodox Practice. This hypothesis was rejected for both tasks. Hypothesis Iv i reads: No Practice Control is not as effective as Imitation Practice. This hypothesis was accepted in both tasks.

Hypothesis V reads: Continually Correct Practice is as effective as Actual Orthodox Practice. This hypothesis was rejected in both tasks. Hypothesis V i reads: No Practice Control is not as effective as Continually Correct Practice. The hypothesis was accepted in both tasks.

An inter-task comparison of the effectiveness of the types of practice in the two tasks was conducted and it was found that the correlation of the ranks of the practices in terms of effectiveness between the two tasks is .881 which was significant at the .01 level of confidence.

A non-significant correlation of -.60 was found between the ranks of the rates of practice for six of the eight groups of the alphabet printing task and the ranks of the over-all amount of performance improvement noted. The rate of practice does not, therefore, necessarily indicate the amount of improvement derived.

Also, an attempt was made to relate the learning of the tasks at hand to the concept of the provisional try as described by Hilgard. It was agreed that the tasks studied and the types of practice used could very easily be given the provisional try - feedback orientation.

The general conclusions to be presented here are derived from observations of the effectiveness of the various types of practice as applied to both tasks.

To begin with, any attempt to reduce the input - feedback information of Actual Orthodox Practice in either of the two tasks studied by any of the types of practice used constitutes a removal of the practice from the optimum. The orthodox manner of practicing supplies the organism with the most efficient and effective means of improving performance. An interesting question which results from studying Actual Orthodox Practice is this: Is there some way to make Actual Orthodox Practice still more efficient? By careful analysis of the various elements comprising the tasks at hand, would it be possible to instruct subjects to attend to certain of these elements while using AOP, thereby heightening, focusing, and clarifying certain beneficial aspects of AOP?

An example of what is meant by this instructed attention, as it will be called, in the pursuitmeter task might be this. Carefully instruct subjects to have an easy, relaxed grip on the stylus and be especially careful not to apply any downward pressure on the stylus since this simply does not enhance pursuit movements, but probably inhibits them. Also instruct subjects to develop a rhythmic bodily motion to their pursuit practicing. It is probably true that most subjects develop these two techniques after they have been

practicing for some time, but by instructed attention, would it be possible to bring them to a performance asymptote sooner or are these two elements simply components of Hilgard's provisional try which must be achieved by the subject through experiences of input - output- feedback -output? It is an interesting question for future research.

The use of Imaginary Practice in learning these two tasks does not render univocal results. The reader will recall that IP was just about as effective as NPC in learning the pursuitmeter task. Why should IP yield three times the amount of improvement as NPC in the alphabet printing task and just equal the amount of improvement yielded by NPC in the pursuitmeter task? Why has IP been shown to be effective in dart throwing, in basket ball free throws and throwing rope rings at a peg, but not in pursuitmeter learning? The conclusion arrived upon is that in only pursuitmeter learning as in none of the other tasks where IP has been shown to be effective is such a continuous and rapid interplay and coordination of input - output - feedback - output necessary to effect significant improvement. The other tasks require discrete movements which start at some specificable moment and end in another moment. The internal input and feedback hypothesized as existing in IP seems capable of effecting increases in performance only in tasks where discrete movements are called for. An interesting proposal for future research might consider whether or not IP would be effective in learning to trace a star shape from a mirror image. This is a task in which a continuing series of movements seems to be operative. It is an interesting question.

Now for a consideration of combining IP with AOP and its relative effectiveness. All apparent indications point to AOP doing the vast majority

of the work in pursuitmeter learning. In the alphabet printing task it appears as though a performance asymptote is too rapidly reached to determine whether or not IP combined with AOP is more effective than RAOP. By reducing the total number of trials used, it may be possible to note whether or not IP coupled with AOP is more effective than a RAOP condition which would use an equal number of AOP trials.

The application of CCP proved to be one of the most interesting aspects of the entire study. In both tasks, subjects using CCP improved, but the amount of improvement was quite negligible when contrasted with that of AOP. From the observations made, it can be concluded that any attempt to give an organism all the patterned movements which it would normally develop in the process of provisionally trying, inhibits the proper assimilation and coordination of input and feedback into the organism so that performance improvement is minimal. The passive imposition of the necessary movements on the muscles involved does not begin to compare with the active movement of muscle groups deriving feedback by which further movements can be made.

PNKR is definitely a limiting element in the acquisition of these two tasks although its prohibitive aspects seem more pronounced in the pursuitmeter task than in the alphabet printing task. This is probably so because of the relativity of the knowledge being limited in the alphabet printing task. The subjects had an approximate indication as to how well they were doing rather than a precise indication. In further studies involving PNKR it might be well to consider the specificity of the knowledge being witheld from a practicing subject. Diverse degrees of specificity of knowledge of performance undoubtedly effect performance to diverse extents.

When subjects imitate the movements of the two tasks investigated, the feedback derived from those imitated movements does not have sufficient informative value to be as effective as AOP. The imitated movements yield only coarse feedback information regarding the effectiveness of outputs executed.

The experiment has shown the feasibility of applying a feedback model to an inter and intra-task study of diverse methods of practice in the acquisition of two perceptual motors skills, and has suggested certain questions which may warrant future research along these lines.

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APPENDIX I

APPROVAL SHEET

The dissertation submitted by Gerald John Mozdzierz has been read and approved by five members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content, form, and mechanical accuracy.

The dissertation is therefore accepted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

1/21/65
Date

Signature of Adviser