THE ROLE OF INSTRUCTION AND TASK VARIABILITY IN TRANSFER OF CHILDREN'S PURSUIT ROTOR MOTOR LEARNING

by

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Abstract

This study examined the effects of Instruction in transfer of children's Pursuit Rotor motor learning. In addition, the validity of the schema theory was examined. Two learning variables were employed during the learning activities : Instruction with two treatment levels (LTI vs. LIO), and Task Variability with three types of task variations (SPV vs. SV vs. PV). The performance of the learners were measured in terms of the Amount of Time on Target and the Number of Hits on Pursuit Rotor. A 2 (Instruction) by 3 (Task) by 4 (blocks) repeated measure design was adopted for analysing data of the learning activities. Two additional moderator variables of Rest Interval (5 minutes vs. 30 seconds) and Shift of Hands (shifted vs. not-shifted) were included in the design for evaluating transfer effects. The effects of learning and moderator variables were examined. The LTI treatment groups performed the transfer task significantly better than the LIO. There was no significant main effect for the task variability. Only the interaction of Task, Rest, and Shift of Hands was statistically significant. It means that the predicted effect of the task variability is observable only under the limiting condition of 30 seconds period and with hand not shifted (i. e., unilateral transfer). It is concluded that the observed effects of Instruction and Task Variability can be explained by the schema theory.

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Chapter I. Research Problem

A. Statement of the Research Problem

The purpose of this study was twofold. Primarily, this research was designed to investigate the effects of instruction on unilateral and bilateral transfer of motor skills. Secondly, the validity of the practice variability hypothesis of the schema theory was examined. Instruction and practice are the most important variables in any educational setting. Instruction refers to one of the inputs that a learner receives prior to learning. Instructions in motor skill learning can be given verbally, by demonstrating the task or by combining these two methods. Whether verbal instruction or demonstration is more efficient depends on the task to be acquired and performed. Tasks with highly cognitive loading require verbal instruction, while tasks which are predominantly motor in nature are often best learned by demonstration. The concept of transfer refers to the process in which the learner uses old learning that has occurred in one situation for a new or different situation. Such a process is an important part of our educational training.

In many real world learning settings, the task to be learned has more than one dimension. In fact, task difficulty may be considered as a function of the dimensional properties of the task. For example, considering learning a two dimensional task such as an inside of the foot pass in the game of soccer may reveal the way in which task variety expands. Performing this task in general involves at least two variables, that is, a learner, and a ball. The condition of the performer during the execution of the task is one of the major dimensions of the task. A performer may execute the task in a stable(fixed) or in a moving position. The former position itself may vary indefinitely. In addition, the ball also can have similar conditions. A learner may have to contact the ball while the ball is in a motionless state, or to pass the ball while the ball is in a moving state. Considering the variability in the speed with which the ball is received plus state in which the player is in may reveal the extent of the variability of the performance of such a simple skill.

Attempt to learn such a skill by practicing all the possible combination of the instances of the task is impractical and almost impossible. Therefore, a practitioner has to choose a limited number of instances of the task to teach and give instruction about the possible incoming situation, and hope that the learner will form a rule during learning to apply to variations of the situation.

The study of motor learning in general and transfer in particular, being of secondary importance with the framework of traditional psychology until recently, is now taking place not only in experimental psychology, but also in numerous other related fields including industrial and educational psychology. The area of motor learning is an expanding field, in which theoretical prospectives are changing. Although the notion of 'practice makes perfect' is still favored, this is not the only view toward learning. There are other ways, such as different techniques of instruction including demonstration, imitation, verbal instruction in rules and principles, and mental practice which can affect motor learning, but which do not involve overt practice.

Through instruction, the attention of the subject can also be focused on various aspects of the task (Keele, 1973). There are the research findings, showing that tasks requiring speed and accuracy instructions play an important role (Livesey and Laszlo, 1979). The well known speed-accuracy trade-off phenomenon can be influenced by instructions. According to these authors, there is a negative correlation between speed and accuracy, that is, the greater the accuracy demand imposed by the task, the slower is the performance; and the faster a task is performed, the less accurately it is done. The trade-off effect is not task-specific, it is a general trend across most tasks. Individuals show characteristic preference for fast or accurate performance (Pew, 1969). According to Kay (1970), the limiting factor in speed of performance is the subjects' individual rate of information processing, and this can not be affected by instructions. Goodman (1979) reported that instruction can induce a speed or accuracy bias in performance.

There are three distinctive phases in a motor learning task. Fitts(1964) identified two types of processes as cognitive and non-cognitive process of motor learning. He distinguished an "early" stage, in this phase, subjects learned what was required of them from an intermediate or associative phase which could involve the learning of the cognitive sets. In the late phase of learning the skill becomes automatized, and cognitive processes are no longer evident. Cognitive process refers to those which involve specific conscious experience and/or symbolic representation of crucial aspects of the task. Annett(1985) described two kinds of cognitive processes, those which involve analogue and those which involve symbolic representations. For instance, the overt action of jumping may be cognitively represented by visual or kinaesthetic images of jumping and also by symbolic representations such as words like "jump", "hop", "leap", and so on. He suggests that both of these processes can be manipulated to produce measurable improvement in overt performance.

B. <u>Theoretical Background and Rationale</u>

In the study of motor learning, the issue of transfer is of primary importance. Educators assume transfer. In many learning situations, the primary objective of the instructor may not be the task in hand but rather the real concern may be for some other tasks believed to be related to this activity. The importance of transfer becomes even more evident when "time" becomes a critical factor. In many instructional settings, there is a fixed amount of time that can be devoted to practice and the instructor has the task of making the most efficient use of time to maximize the amount of learning.

The study of motor learning and interlimb transfer started from the beginning of this century. A theory of the mechanism of interlimb transfer of training is generally one of Thorndike and Woodworth(1901) "common elements" variety. Based on this theory, common elements vary from strictly cognitive such as self-instruction through non-specific motor (e.g., postural adjustments) to task specific motor components(e.g., identical and mirror image responses). In motor learning tasks, it has been assumed that when one limb is trained, and the opposite limb is subsequently trained in an identical task, the performance in the second task reaches criterion after fewer trials than were needed for the first task.

Hicks (1982) summarized the central mechanisms which are suggested for the occurrence of interlimb transfer as follow:

1. Submotor activity amounting to practice in the control center of the test limb at the time of initial training.
2. Partial assumption of control of the test performance by the control center of the

initially trained limb.

3. Transfer of some elements of the motor program to the test limb at time of transfer test.

Among the aforementioned mechanisms, the last one has been the focus of most research in the area of motor learning. The idea of motor program is attributed to Lashly(1917). It was suggested that the human being has a set of stored muscle commands ready for action at any time. Keele (1968) defined motor program as a sequence of stored commands that is "structured" before the movement begins and allows the entire sequence to be carried uninfluenced by peripheral feedback.

Schmidt (1975) states that the idea of the motor program is largely a default argument. However, he suggests that the original idea of motor program that requires a separate motor program for every movement be modified to a generalized motor program for a given class of movements. He suggests the concept of schema to describe the modified version of his motor program. The concept of schema is originally attributed to Head(1932), and has been modified several times. Evans(1967) described a schema as a characteristic of some population of objects which consist of a set of rules serving as instruction for producing a population prototype.

In his description of schema, Schmidt(1975) states that when the individual makes a movement attempting satisfy some goals, s/he stores four things:(a) the initial conditions which refers to the information received from the various receptors prior to the response, (b) the response specification which is referred to the variation of elements, such as changing the speed with which a movement is run off or the force involved in the movement, (c) the sensory consequences of the response produced, which is referred to the information stored after the response is made, (d) and the outcome of that movement. According to Schmidt(1975), these four sources of information are stored together after the movement is produced. After a number of such movements have been made, the learner begins to abstract the relationship among these four sources of information. With each successive movement of the same general type, the strength of relationship among the four stored elements increases with increased accuracy of feedback information from the response outcome. Schmidt(1975) suggests that this relationship is structured as the schema for the movement type under consideration, and is more important to the subject than is any one of the stored instances.

The schema theory of motor learning was proposed to alleviate two problems which the earlier theories (Adams, 1971; Henry & Rogers, 1960) were facing. One of the problems was "the storage problem". According to these theories, for every movement to be made there must be either a motor program or a reference against which to compare feedback, and that there is a one-to-one mapping between stored states and movement to be made. Schmidt(1975) states that this presents problems for the central nervous system in terms of the amount of material that must be stored. The second problem also, in companion with the storage issue, was "the novelty problem". If the performer has a motor program for every moment, then how are the novel movements executed?

In order to alleviate the shortcomings of the motor program theory, Schmidt(1975) theory presented the concept of schema. This theory postulates two independent states of memory, recall and recognition schemata as noted earlier. The recall schema is responsible for response production, and the recognition schema is concerned with movement evaluation (Piggot and Shapiro, 1984). It is hypothesized that the more practice trials with varied tasks (or schema instances) accompanied by knowledge of results, the stronger the relationship of schemata. The major prediction of the schema hypothesis is that practice will facilitate the acquisition of a schema, that is, rule learning.

In regard to the content of the motor program, it should be pointed out that we do not yet know what particular characteristics of movement might be controlled by motor programs. Schmidt (1977) suggests that motor program may specify the speed, force, and spatial patterning of movement. More recently, however, there has been some evidence to suggest that motor programs may be simpler than previously conceived and that certain characteristics of movement may be functions of the muscles themselves (Kelso& Holt, 1980; Nichols, 1980; Schmidt, 1980).

Most of the researchers in the area of transfer of training focus on the task rather than on the subject. A typical transfer paradigm includes an experimenter presenting a task to the learner; demanding the learner to learn the task ; then examining to see whether the learner shows any transfer of training. There is a lack of evidence in regard to the role of the learner's awareness for the transfer task and the effects of such awareness on the transfer of training. In other words, the effects of the learner's awareness for the transfer task has not been investigated.

C. Instruction as a Motivational Parameter of Schema Formation

The present study was designed to determine the role of the learner's awareness on the transfer of training. One of the major research questions is: if the learner receives instruction about the transfer task prior to the learning of a motor task, then would his/her performance on the transfer task be significantly improved? The second question also in conjunction with the schema theory is : if a learner learns a task by practicing on more varieties of the task, then would his/her performance on the transfer task be better than a learner who learns the task with less variability? Both of these questions can be conceptually treated by the schema theory. The schema theory would predict the occurrence of the positive transfer of training as a result of the performer's awareness about the transfer task. Such prediction is derived from the hypothesis that instruction can have an important effect on the recall schema. That is, a learner who receives instruction about the transfer task will recall the appropriate motor program, in contrast to a learner who has not benefited from such instruction. Once the learner receives instruction about instances of a given task for transfer and performs on some of the instances, s/he begins to abstract the necessary information about the relationship among the four sources described previously. More specifically, instruction may have a significant effect on at least two sources of information involved in the construction of a given schema. These sources are the initial condition of the participating limbs and the response specification which is referred to as the selection of appropriate speed and force of contraction.

The learner given instruction has the critical information about the positioning of his/her participating limb on subsequent tasks and thereby locates his/her limb on appropriate locations. In addition, once a performer knows the required speed for contraction of a group of muscles to be remained active on a known target, s/he possesses the critical information for selecting the desirable response. In that circumstance, a learner sends the appropriate impulses to the appropriate muscles. Under the instruction condition, the learner constructs a schema which is applicable to the known instances of a motor task. 'Known instances' refers to those tasks which belong to the same class of movements. For example, a pursuit rotor revolving at 45 RPM is an instance of pursuit rotor task, a rotation of 60 RPM would be considered as another instance of the same class of movements. However, Schmidt(1975) has not specified the criterion, on which one decides whether movements are in the same class or not (Smyth & Wing, 1984).

In summary, giving instruction about some particular instances of a task may have a training-like-effect on the formation of the schema related to that motor task. More specifically, receiving instruction about specific instances for transfer may be equal to overt practice of the given instances. Such an assumption is in agreement with what was proposed by Annett(1985), who suggested that manipulating cognitive processes of a motor task leads to improvement in overt performance in the absence of overt practice.

It is noteworthy here for some conceptual clarity that the schema theory is central oriented, whereas the motor program theory is peripheral oriented. For example, the motor program theory suggests that a certain group of muscles are involved in a given task and only a motor program would activate these muscles. In other words, a motor program controls a motor unit or a group of motor units, with the end results being a specific action ; while another motor program produces a different type of response. A shift in the speed of rotation of pursuit rotor would require the performer to abandon one motor program in the favor of another. This is not the case with the schema theory. According to this theory, a schema is stored in long term memory and the schema for a class of movements is not specific for a single instance of the motor task, but rather it includes motor commands for a category of movements. Therefore, tasks which are within the same class of movements have the same schema. When a learner is instructed for what s/he is expected to perform subsequent to what s/he is learning, the learner not only will form the schema for that given task during learning, but s/he will prepare the same schema for the task to come.

The motor program theory is unlikely to predict the occurrence of any transfer of training effect. According to the motor program theory, the performer has a set of stored commands for a given motor task that ultimately indicates which muscles shall act at what intensity. Once a learner establishes a motor program, that program can be retrieved to perform a specific task. Practice with one of the instances of a given task would establish the order and sequence of the parameters within a motor program. When the learner is informed about the variations in the parameters of a motor program for performing different instances of a given class of movements, it is not clear whether s/he would establish a motor program with flexible parameters; a motor program not only for one instance of a motor task, but for other known instances as well.

Such a difference in performance level of the group that receives instruction was assumed to be caused by the motivational level of the learners in the group. When the learners in this group received instruction about the learning and transfer task, it was expected that these individuals established a goal for their learning activities. In other words, the learning activities were assumed to become goal directed. Under such circumstances, the learners were expected to pay more attention to the critical dimensions of the task. Performing the learning task which happened to be the pursuit rotor task requires sustained attention (i. e., motivated). Performing this task under the instruction condition was predicted to enhance the learners's sustained attention. The reason for such prediction was that if the learners in this group learned more due to motivational factor on the learning trials, also transferred more to the transfer test. The learners in the learning-transfer-instruction group who were primed for the transfer task were expected to benefit from the knowledge that the transfer task were forthcoming. A superior performance for the group that is more motivated and is more attentive to the task is predictable by the schema theory.

A well motivated goal oriented learner would be well aware of the critical actions that are taking place during each learning trials. Consequently, on each subsequent trial the learner would employ the information obtained from the previous trials to make the necessary adjustment for the ongoing activities. More specifically, a learner under such circumstances is expected to be well aware of the location of his/her limbs prior to the execution of the task and also be more aware of his/her response selection (the speed and force of muscular movements).

D. Task Variability as a Schema Formation Parameter

For the purpose of investigating task variability in the present study, the pursuit rotor task was employed. This instrument makes it possible to produce responses with highly similar movements which are considered to be within the same class of movements. This task, since its introduction by Koerth (1922), has been widely used to study various parameters of motor acquisition. In addition, the motor task chosen for this experiment was a closed skill. In contrast to open skills where the performer faces environmental and situational uncertainty, in a closed motor skill the performer needs only learn one movement that satisfies the goal.

The observable change in performance on this task due to instruction would indicate that learning has occurred. Since learning can not be observed directly, the occurrence of learning can only be inferred from observable change in performance (Drawatzky, 1981). Obtaining an adequate performance measure requires specific criterion. The measures most commonly used to assess performance and motor learning include the amount of response, latency of response, rate of response, number-kind-location of errors, reminiscence, number and time of trials, and retention. Drowatzky (1969) states that no single measure fully meets all requirement for optimal measurement. He suggests that learning skills such as mirror tracing performance must be evaluated on the basis of more than one measure. The present experiment intended to employ two measures which would satisfy the criterion stated by Drowatzky(1969). These measures were the Number of Hits and the amount of Time on Target.

The theoretical importance of selecting a closed skill for this study rests on the suggestion made by Schmidt (1975) that, in closed skills, the learner develops the schema rule so that s/he makes finer and finer prediction on the basis of rule, and the expected sensory consequences becomes more and more accurate estimate of that one movement. The performance of this task requires eye-hand coordination. The learner has to trace a moving target with a pre-established path. The movement of the target can be set to a clock or counter-clockwise rotation. Two types of variables are of critical importance in performing this task. These are the speed of rotation and the path of the moving target. In fact, this is one of the strength of the schema theory and has been demonstrated experimentally with bean bag throwing tasks. In a recent study by Piggot and Shapiro (1984), the structure of the variability of practice session and its subsequent influence on transfer performance to a novel variation of the task was examined. In their experiment they employed children to toss a weighted bean bag to a fixed target location. Three groups experienced variability in practice with four bean bags of varying weight (3,4,5, and 6 oz) versus a fourth group that practiced only a single weight. Following 24 practice trials, all subjects transferred outside the range of previous experience, receiving three trials with one of two possible test weights (2 or 7 oz). Their results indicated that the variability in practice led to superior performance at transfer to novel variation of the task.

This experiment may explain the way that a learner learns to select a parameter for a motor program. The task employed in this experiment had a single response variable. The experiment could have been structured by employing two response variables by including distance as a second variable. In most motor skill tasks the novel task varies in more than one dimension. The present experiment, though different in nature of the task, included at least two independent variables (speed and path). A learner had to establish at least two parameters for a motor program to be executed correctly. In the training task, it was expected that the instruction group would start to build the schema for the transfer task. The reason for such a prediction was that instruction facilitates selection of parameters such as the duration, overall force, and the movement size for a given task. In response selection (recall-schema), the effect of instruction becomes more evident. When a person makes a decision to perform a motor task, the two types of error may occur, which determine the outcome of the action. These are error in selection, and error in execution. Knowledge about the parameters of a task would assist the performer to select the appropriate parameters to be employed in the program, and therefore would reduce the possibility of making error in response selection.

The learning task for the present experiment included two levels of variation in speed and path of rotation. The levels of speed include 30, and 45 rotation per minute (RPM). The variations in path included triangle, and square path. Three treatment groups practiced three different types of tasks. One group practiced with various speeds and different paths. The second group practiced with a constant path (square) but with two different speeds. The third group practiced with a constant speed (45) but with different paths.

According to the schema theory, the task condition with more various dimensions during learning would be conducive to the acquisition of a schema than the task with less various dimensions. Therefore, it was expected that the task with more variability (task 1:both speed and path varied) would facilitate transfer of training more than the other two levels of task variability. The other two tasks had either the path as a variable or the speed as a variable. However, these two dimensions are not equally salient dimensions. The path variable is probably a more salient dimension to a novice learner than the speed variable. A change in the speed of rotation may not be detected by a learner to a certain point. For example, it is much harder for a learner to recognize that the speed of rotation is shifted from 30 RPM to 45 RPM than to notice that the path is changed from a triangle to a square. Though the path parameter of the task was expected to be detected by all the participants, such was not the case for the speed parameter. The performers in the learning-transfer-instruction group were expected to know the speed parameter as well as the path parameter prior to the start of the transfer task. The learning-instruction-only group were left out to find out the quantity of the speed parameter. According to the schema theory, the learning-transfer-instruction group would benefit from the instruction that was given and would recall the appropriate motor program with the appropriate speed parameter.

This task variability hypothesis would predict that the task with more variability would be learned qualitatively different than the other two tasks. Under this condition of both path and speed varied, the learners are expected to store more information related to the execution of the task which are essential for the schema formation. Secondly, from the standpoint of task difficulty, it was expected that the second task with less salient dimension(path fixed and speed varied) would be easier to perform than the third task(path varied & speed fixed). The reason for such a prediction was based on the assumption that the learners performing on the second task were unlikely to detect any changes in the task throughout the learning trials, and consequently maintained their attention on the task. In contrast, the group performing on the third task were faced with a major adjustment of their activities on the task. Such a discrepancy in the discriminability of the dimensions of the tasks was expected to produce different results. The learners on the task with fixed path and varied speed were assumed to continue their effort even though one of the dimension of the task was changed while they were on the task. A motor program that was activated for the first few trials would probably be active throughout the trials. Only minor changes for adjusting the speed parameter of the motor program were necessary.

While for the third task, it was assumed that a change in the path of the task demanded a major adjustment for the motor program if not recall of a new motor program. Performance of a learner on a square path seems to be a linear positioning task, very much similar to a circle path, whereas performance on a triangle path seems to be non linear at least in the first few trials of learning. Due to the apparent differences between the two paths, the same motor program may not be appropriate for both paths. When the new path was introduced halfway between the trials for the third group, it was assumed that the learner had to recall a new motor program or at least become engaged in a conscious effort to change the parameters of the motor program which was active for the previous path. In addition, the nature of producing variation in the path itself could be more pronounced than that of speed. A change in the speed parameter requires minimum intervention in the testing apparatus while changing the path parameter demanded a replacement of a major component of the testing facility. This difference in the nature of task variation was predicted to lower the performance of the learners in task with path varied group in contrast to the performers in the task with speed varied.

For the present experiment, the experimental group received instruction for the learning task plus instruction for the transfer task (LTI group) prior to the learning of the original motor task. The other group received instruction for the learning task only (LIO group). The instance employed as the transfer task included a hexagon path of rotation at the speed of 65 RPM. Thus, the transfer task was constructed by introducing one variation in the speed of rotation and one variation in the path of rotation.

E. Rest Intervals and Hand-Shiftedness as Moderator Variables

Since learning practice trials were involved, it was thought that some performance variables, such as reactive inhibition may be built up, that retards the transfer of the presumably acquired schema. In addition, another performance variable of handedness was presented to determine whether bilateral transfer as well as unilateral transfer occurs. Therefore, two more variables referred to as the moderator variables were introduced prior to the transfer test. The two variables were rest interval and the shifting of hand. The learners were given two types of rest interval prior to the transfer test. Half of the learners in every learning condition were given 30 seconds of rest and the other half were given 5 minutes of rest before moving on the transfer task. Since immediate and delayed responses have been an important concept in the study of motor performance, this variable was included in the design.

In respect to the role of the rest interval prior to the performance, there are two competing hypotheses ; one is the reactive inhibition theory, and the other one is that of the consistent practice hypotheses. The reactive inhibition hypotheses was proposed by Hull (1943), it suggests that, whenever an organism makes a response, there is an increment of reactive inhibition that works against the reaction potential for the ongoing response and lowers performance. According to this theory, reactive inhibition dissipates as rest interval between responses increases. Reactive inhibition theory is a peripheral oriented theory that considers the active responding limb as the main factor that determines the quality of the performance. The consistent practice hypotheses is a central control oriented theory.

It assumes that higher brain centers are the primary determinator of the quality and quantity of the performance. According to this theory once the motor control center is activated to control the active limb, performance level remains steady, as long as the ongoing performance is not unduly interrupted by unnecessary breaks.

These two different hypotheses lead to making two opposite predictions. According to the reactive inhibition hypotheses the group that received 5 minutes rest prior to the transfer test was expected to perform better than the groups with 30 seconds rest. In contrast, the consistent practice hypothesis predicts that the groups with 30 seconds rest perform the transfer task better than the 5 minute rest groups. It would be so because thirty second rest interval can be regarded as the continuation of the ongoing activities that originated during the learning trials.

The second variable of the shifting versus no shifting of hand was introduced to determine whether bilateral or unilateral transfer of training occurred. It was predicted that the the non-hand-shifted group would naturally perform the transfer task better than the hand-shifted group. Such a prediction was based on the assumption that preferred hand performance on the task would be superior to the shifted group hand due to prior experience. It should be mentioned that unilateral or bilateral transfer effects will be confounded with that of hand preference in the present study.

Finally, the interaction of the learning and moderator variables were investigated. It was important to determine how the experimental variables effect transfer performance. Considering the two opposing views of the reactive inhibition and consistency hypothesis, two different interactions between the task variable and moderator variables can be expected. If the reactive inhibition hypothesis is at work, then the shifted-hand group would do better on the 30 second rest than non-shifted. Such prediction can be explained by careful consideration of the nature of the reactive inhibition hypothesis. The concept of reactive inhibition build-up refers to a local resisting build-up that works against the working limb ; in the case of this experiment, the non-shifted hand. At the time of transfer test if the hand is shifted, then the reactive inhibitory factor would be avoided or at least be reduced considerably. In the other hands, if the consistency hypothesis is true, then it would be expected that the learners with the two hand shifting conditions, regardless of shifting condition, do the transfer test equally well.

F. <u>Performance Measures</u>

For the present experiment, two response measures were recorded to quantify the performance of the learners on the task. These measures were the amount of Time on Target and the Number of Hits. The amount of time on target refers to the number of seconds that a performer can track the moving target, a rectangular bright spot on the surface of the pursuit rotor machine. The second performance criterion, referred to as the Number of Hits, is a measure that may quantify the precision of performance. This measure marks the number of time a performer goes off the target. Conceptually in a computation sense, the two measures are negatively correlated, as the amount of Time on Target goes up, the Number of Hits goes down. An idealistic perfect performance of 20 seconds out of 20-second time interval would nearly result in zero Number of Hits. However, in real practice situation the relationship between the two measures happens to be quite complicated.

Chapter II. METHODOLOGY

A. Subject and Design

The subjects for the present experiment were drawn from boys and girls in grade 5 to 6 of the elementary schools of Richmond, British Columbia. The children of the two grade levels were used in the view of some empirical evidence that children of this age could successfully perform the experimental task. In addition, from the maturation point of view, these children are capable of bilateral transfer. This capability is believed to result from the completion of corpus collosum. The fiber of corpus collosum is the major fiber bundle connecting the two cerebral hemispheres believed to result in an increase in the efficiency of transfer of information between the hemispheres. It was reported to be almost completed by the age 8 (O,Leary, 1980). There are also reports showing that the interhemispheric transfer of information occurring normally in animals and human fails to occur after surgical disconnection of the cerebral hemisphers (Sperry, Gazzaning, and Bogen, 1969).

In a study using the pursuit rotor task with children ranging in age 9 to 18 years, Alprin and Ammons(1955) found that youths 15 to 18 years of age performed satisfactorily at the speed of 60 revolutions per minute (RPM), but that Time on Target for the 9 and 12 years olds deteriorated sharply. Simensen(1973) successfully used speed of 45 RPM in the study of the normal and retarded 12-and 14-year-olds.

In the study of speed of rotation on the pursuit rotor task, performance of children from kindergarten to the fifth grade, Davol(1968) reported that, whereas Time on Target consistently increased as a function of age, the variable of speed was the most predominant determinant of performance, with score at 30 RPM strikingly superior to those at 45 RPM. Such a finding may be explained by the fact that older children benefit more from their muscular development.

Reports on the difference in the performance of male versus female has been controversial. Simensen(1973) reported sex differences significantly in favor of male, whereas Davol(1968) found no consistent differences between the sexes in six-to eight-year-old children at either 30 or 45 RPM. The findings of these studies provide strong support for the appropriateness of the task selected for the present study.

A total of 82 subjects was randomly assigned to 26 independent groups, of which 24 groups resulted from factorial variation of four factors : instruction, task variability, rest intervals, and hand shiftedness. Two additional treatments were defined as the learning practice control, one performing with non-preferred and one with preferred hand.

The factorial design was essentially a 2 by 3 by 2 by 2 design; where each factor represents levels of Instruction

(LTI vs. LIO groups), 3 levels of Task variety (SPV vs. PV, vs. SV), the 2 levels Rest interval (5 minutes vs 30 seconds), and the 2 levels of Shiftedness of hand (preferred vs non-preferred). Thus, the experimental design includes 24 cells. There were 3 subjects assigned to each cell. The total number of subjects added up to 72. Each control group was made up of 5 subjects, which resulted from the same sampling process, but by adding 2 more subjects from the same subject pool. The total number of cells for the experimental and the control group added up to 26. The total number of subjects in the experiment summed up to 82 (i. e., 72 for the LTI and LIO groups, and 10 for the control group). The schematic representation of the experimental design and procedures is demonstrated in Appendix A and B.

Thus, the first 36 children were given instruction for both learning and the transfer task (LTI). The second group of 36 children received instruction for the learning task only (LIO). The third group participated in the transfer task and served as the control group (CONT). It should be noted that, for this experiment, there were, in a way, two types of control treatments. The LIO group served as the control group with respect to the LTI group to determine whether instruction produced any significant effects on the performance of the first group. The CONT group served as the control group to determine whether the transfer of training occurred at all. It was expected that the performance of first two instructional groups on the transfer task be superior to the CONT group. Most of the evidence in the area of the study of transfer of training have been obtained through this type of experimental designs.

The task variability as a learning variable is manipulated in terms of three variants, as described in the sequel. Rest interval as a transfer mediating variable was varied in terms of 5 minutes or 30 seconds before the transfer task was given; hand shiftedness in terms of of shifting to nonpreferred and nonshifting for the transfer task both from preferred hand used during learning. More specifically, Two types of rest interval were introduced between the training task and the transfer task for both experimental groups. Subjects in the first rest interval were given a 5-minute rest interval and then were asked to perform on the transfer task. The subjects in the second rest interval were given a 30-second rest interval and then were asked to perform on the transfer task. This rest interval procedure was employed to determine whether the amount of rest between the training and transfer task had any significant effects on the performance of the task at the time of transfer. The amount of time elapsed between the learning session and transfer performance is an important variable in the area of motor performance as discussed earlier. The automaticity of performance which is believed to occur in the third phase of motor learning in a consistent manner occurred during learning of the motor task in this experiment. If this is the case, then the subjects in the 30-second rest interval block would perform the task better than the subjects given the other rest interval. Such a discrepancy in performance may be explained by the fact that the subjects in the 5-minute rest interval may not be able to retrieve the recall-schema for the task as fast as the subjects in the 30-second rest interval.

B. Learning Task

The learning task for this experiment included two types of variation in the experimental variables. These variations were defined in term of the two kinds of paths (triangle and square) and the two levels of speed of rotation (30 and 45 RPM) of the pursuit rotor task. Three types of tasks were created by manipulating the task variables within a total set of 12 trials. In one task, the speed and path of rotation was varied (SPV) ; therefore, creating four sub-tasks. In the second task, path was varied and the speed was kept constant (PV); and in the third task the path was constant and the speed was varied(SV).

In the SPV task condition, the subjects practiced four different sub-tasks (SPV). In the beginning the path was set to a triangle at the speed of 30 RPM for three trials and then the speed was changed to 45 RPM. On the next two subsequent sub-tasks the path was set to a square and the speed was shifted from 30 to 45 RPM after three trials.

Every subject went through 3 trials on each sub-task. In the SV task condition, the speed of rotation was set to 30 RPM while the path of rotation was changed from a triangle in the first sub-task to a square for the second sub-task. In the PV task condition the speed was set to 45 RPM with a triangle path for the first sub-task and then the path was changed to a square for the second sub-task. The subjects in the SV and PV condition went through 6 trials on each sub-task. Thus, the total number of trials for every subject in each task added up to 12 trials, as was mentioned earlier. The subjects were informed about the shift from one task to another prior to the start of the training task. After the completion of each task, the experimenter established the appropriate task by replacing the current path with the new path. The pursuit rotor task provides such a facility for the exchange of the path. The change in the speed of rotation was established by resetting the speed adjuster provided by the testing apparatus.

C. <u>Transfer Task</u>

The transfer test for the experiment included either a unilateral transfer test or a bilateral transfer test. Half of 72 subjects, 12 cells (i. e., 3 per cell) took a unilateral transfer test (did not shift hand) and the other half took a bilateral transfer test (shifted hand). The task for both groups was the same (hexagon with 65 RPM). The two control groups took either a unilateral or a bilateral transfer task.

If the two substantive hypotheses of this study were true, then the learning-transfer-instruction group would perform the transfer task significantly better than the learning-instruction-only group. Secondly, considering the schema hypothesis concerning task variability, the SPV task condition would perform the transfer task better than the SV and PV task conditions. According to the schema theory, learners in the learning-transfer-instruction and learning-instruction group would perform superior to the control group on the transfer task. Given that instruction has no effect, various stages of the learning task would serve as a variability in the practice session and, therefore, facilitate the formation of the appropriate schema for the motor task. Thus, prior to the transfer tasks, the LTI and LIO groups in comparison with the control group had the opportunity to practice with various paths and speeds. This condition was similar to that of Piggot and Shapiro's experiment (1984).

The motor program theory may predict some improvement in bilateral transfer only if the transfer task is an exact replicate of the learning task. In situation where the transfer task is not an exact replicate of the learning task, like the task employed in this experiment, the motor program theory would not provide a satisfactory base for predicting the occurrence of bilateral transfer. In such a situation the transfer task is considered as a novel task. The motor program theory may predict performance of a task under the retention condition where the primary objective is to measure how much a learner can reproduce after the original learning. Lashley (1917), one of the pioneers of the motor program theory, reported that a patient with gunshot wound that eliminated sensation could reproduce movements accurately. Similarly, Taub and Berman (1968) showed that monkeys that were surgically deprived of normal proprioceptive feedback could still carry out skillful reaching and locomotor movements. Numerous investigations have been reported by other investigators working with a wide range of species (Keele, 1968; Evarts, Bizze, Burke, Delong, and Tach, 1971). The implication from these studies is that once an organism learns a skill, the reproduction, or in other words, retrieval of that skill can be attributed to the existence of a motor program which is independent of sensory feedback. These studies provide no support for prediction of producing novel skillful movements (transfer).

In summary, instruction would affect performance in different ways, depending on what theory is applied. The motor program theory would predict that the performer on the transfer task will call a new program to be executed or will use the same program as was employed on the training task. If indeed a new program were selected, the question remains as to how the new program would have been created. This is in fact the novelty problem that the motor program is facing. But if the old program is used, the possibility of error in response will exist. The schema theory would make a different prediction when instruction is given to the subject. According to this theory, the learner will form a schema which is applicable to several instances of a task. In the case of bilateral transfer, the performer will recall the same schema but will change the parameters of that schema and, therefore, his/her performance will be improved.

Apparatus and Procedure

A Lafayette Photoelectric Rotary Pursuit Model 54517 was employed in this experiment. The pursuit rotor machine was connected to a Gulton NP-7 Printer which transformed the performance score of the learners from a digital display to a printed output. The pursuit rotor was also connected to Repeat Cycle Timer Model 51013 which set the appropriate periods of activities of the machine. The external control procedure designed for this model of pursuit rotor provides appropriate facilities to manipulate the duration of rest and activities of the machine. A Seiko stop watch was also employed to keep track of the rest intervals. Periodic monitoring of the speed of rotation was done to assure the accuracy of the testing instrument.

The LTI and LIO group received instruction for the learning task. This instruction included a verbal explanation of the learning task and then a demonstration of it. The experimenter explained to the participants in these groups that the task had two important dimensions. These dimensions were the speed and the path of rotation and were shown to the learners. The experimenter set the Pursuit

Rotor task to a circle path at the speed of 30 RPM. Then, while the apparatus was activated, the speed of the moving target was set to different speeds in order to show the learner the nature of variability of the speed of rotation. Then the machine was turned off and the circle path was replaced with another path (e.g., a square). The subject was informed that his/her task was to trace the moving target with a stylus on a pre-established path. S/he was asked to hold the stylus with her/his preferred hand so that there were no variations among the subjects in regard to the use of their hands during the learning trial.

The experimental group (LTI) also received instruction for the transfer task. The experimenter gave the instruction to each group according to the type of task that they were expected to perform. The experimenter told the learners that were assigned to the Shift of hand condition :

" you are going to learn two to four tasks now (depending on the task group) , but I will ask you to learn another task after you learn these tasks. That task will be identical to these tasks you are going to learn now, but you will have to use your other hand to learn that task. The task to come later will have a higher speed and different path than the tasks you are to learn now. The present tasks have speed of 30, and 45 rotation per minute but the one you will be doing later with the opposite hand will have a speed of 65 rotation per minute which is faster than the one you will be learning first plus the path of the rotation will be set to a hexagon path (the shape of hexagon was shown to the subjects in this group so that they knew what a hexagon looked like)."

The LTI-No-Shift group received the same instruction but they were told that they were expected to perform the transfer task with the same hand. The Control group received only the standard instruction for the performance of pursuit rotor task prior to the transfer task. The learning and transfer instruction were given to the subjects after the warm-up task. All subjects took a three-trial warm-up training with a circular path at the speed of 65 RPM before the start of the main training session.

All subjects were met at their school and were tested individually in a testing room. After the standard instructions were given and the experimenter was convinced that the subjects understood the procedures, testing began. The subject performed the task in a standing position.

The learning task began with a triangle path at the speed of 30 RPM with a clockwise rotation. Trial durations was maintained for 20 seconds. Each trial was interspaced by 20 sec. of rest intervals. The timing for the trials was established through the appropriate timing device installed on the pursuit rotor. It is possible to set the desirable time period for practice on the PR-14A pursuit rotor. The rest intervals interpolated between trials were determined by an other independent timer. The appropriate speed of rotation was produced by setting the speed adjuster installed on the pursuit rotor. Variation of speed of rotation was made possible through this facility and ranged from zero to 100 RPM. After every trial, the score of the subjects was recorded on a printing device connected to the pursuit rotor. Subjects were informed about their score on every trial (Number of Hits, and the amount of Time on Target). A total of 12 trials made up the entire testing session for every group, as described earlier. The entire learning session lasted for 8 minutes. A 5 minute or 30 sec. rest interval separated the original training task from the transfer task. At the time of transfer testing all subjects took the same task which was a hexagon path at the speed of 65 RPM. The trial durations and rest intervals were identical to that of the original training test. The subjects participated in a 6 trial test for the transfer task. The entire transfer task lasted for about 4 minutes. The total testing session took 20 minutes.

Chapter III. RESULTS

A. An Overview of Data Analysis

The learners' performance was observed in terms of two criterion measures. These response measures were the amount of Time on Target and the Number of Hits. Since the quality of performance was a function of two dependent variables, it was necessary to determine whether these two response measures were independent of one another. A statistical test for the amount of Time on Target and the Number of Hits on learning trials showed that these measures were significantly correlated during the learning ($r=.62$). Consequently, it was necessary to consider simultaneously both variables in the analysis. Multivariate analysis of variance (MANOVA) was used to test the hypotheses of the study. The experimentwise Type I error for the examination of the learning data and transfer performance was set to .15. Since the two factors of Instruction and Task were tested separately (2 tests), the error rate for each major multivariate test of significance was set to .075. Only if the multivariate F-statistics was statistically significant, the univariate F-tests for the amount of Time on Target and the Number of Hits were examined for the analysis and each were tested at .033.

The nature of the response measures required careful consideration for interpretation of the performance of the learners. Performance of the learners on the pursuit rotor task can be conceived in terms of four possible types. A learner with high score on the amount of Time on Target and minimum score for the Number of Hits would demonstrate the best performance. Next to this performance is performers who has high score on the amount of Time on Target but also has a high score on the Number of Hits as well. Subsequent to this performer is a performer with high score on the Number of Hits and low score on the amount of Time on Target. And finally, the worst performance is the performance of a learner with low score on both measures.

MULTIVARIANCE program was used to perform the multivariate and univariate analysis of variance on the experimental variables. The present data structure required a doubly multivariate multifactorial repeated measure analysis of variance (MANOVA) to be performed on the learning as well as transfer performance measures.

B. <u>Examination of Learning Performance</u>

The examination of the performance of the learners during the learning trials included the test of main effects of Instruction, Task and their interaction. Twelve learning trials of the learning performance were blocked into four blocks for a parsimonious detection of learning phase. The average of every three trials was obtained to make up a block. Such a blocking procedure was considered to be meaningful in the sense that for the SPV group every block represented performance of the learners on one of the sub-task variations, for example, Triangle & 30 RPM, Triangle &

45 RPM. On the other hand, the blocking procedure reduced the number of measured responses involved in the learning trials to four occasions. Such a reduction in the number of trials was considered to facilitate the interpretion of the learning performance. The reduction procedure employed for this experiment reduced the polynominal trend components to a cubic degree. Kirk (1982) suggests that in experiments involving many treatment levels, the test beyond the cubic degree be treated collectively. In cases where trends in data go beyond the cubic degree, according to our current knowledge of motor learning processes, it is unlikely that tests of trend components beyond the cubic degree would add materially to the experimenter's understanding of the data.

A 2 (Instruction: LTI vs. LIO) by 3 (Task: SPV, PV, SP) by 4 (Trial Blocks: 1-4) factorial analysis was performed on the data structure of the two response measures of learning performance. Various combined means derived from Table 1 for both the Number of Hits and the amount of Time on Target are presented for both between-subject and within-subject factors in Table 1, and 1a through 1c. They are also presented in Figure 1a for easy visual inspection.

Insert Tables 1, 1a through 1c, and Figure 1a

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1. Performance by Two Instructional Groups

A repeated measure design was employed to evaluate the between-subject factor as well as within-subject factors effects. MANOVA for the first between-subject factor revealed that the effects of Instruction on the learning task was statistically significant, multivariate $\underline{F}$ (2, 65)=4.99, $\underline{p}$<.009 ; univariate $\underline{F}$s (1, 66)=10.02 and 4.99, $\underline{p}$s<.002 and .029, for the amount of Time on Target and for the Number of Hits, respectively. This test result means that for the two response measures averaged over the learning blocks, there was a significant differences between the performances of the LTI and the LIO group. The observed means were 4.86 and 3.76, 43.39 and 37.91 for the two measures, respectively. The LTI group stayed on the moving target longer and hit it more frequently than the LIO group. These test results was expected. It was predicted that the LTI group would be involved in a goal directed activities during the learning trials, and therefore, would perform the task better than the LIO group.

The overall trend analysis was performed on data on the four blocks (see Table 1a and Figure 1a). The orthogonal polynominal tests showed that there were overall significant linear, quadratic, and cubic trends across the learning blocks, multivariate $\underline{F}$s (2, 65)=6.04, 7.52 and 3.58; $\underline{p}$<.004, .0012, and .034, respectively. The observed linear and quadratic trends are expected of any learning trials effects, that is, an initial discriminable progress followed by a temporary stationary phase, the cubic trend is most likely due to breakpoints of 12 trials by changes in task varieties.

2. Performance by Task Variability

The effects of task variation was also examined given the data presented in Table 1b. There were two task contrasts in the analysis. In the first contrast, the effects of task with speed and path varied (SPV) versus task with speed varied (SV) and task with path varied (PV) was tested. MANOVA revealed no significant effect for the SPV task versus the SV and PV task combined. This test result means that the learners' performance on average over the four learning blocks SPV task was similar to those on the other two tasks.

The second contrast for the between-subject effect for the SV task versus the PV task also showed no significant differences between the performance of the learners on these two tasks. In addition, there were no significant trends across the learning blocks for these two tasks. The implication of these findings is that the Task factor did not have any significant effect on the performance of the learners during the learning activities. This finding is not surprising in view of the nature of blocks confounded with tasks and differing number of practice trials.

Following the test of main effect of the two factors, the tests of interaction for the two factors, given the data presented in Table 1c, were made. In the first test of interaction, Instruction and the first contrast of tasks were examined. The test result indicated that there was no significant interaction between Instruction and the contrast of SPV task versus SV and PV task, multivariate F (2, 65)=1.87, p>.075. In addition, no significant polynominal trend was present for this interaction contrast.

The second test of interaction was made between Instruction and the contrast of SV task versus the PV task. Again, MANOVA showed no significant interaction for this part of data analysis. In addition, there was no significant polynominal trend across the learning blocks for this contrast.

C. Analysis of Transfer Performance

The two measures of transfer performance were recorded and analyzed using MANOVA. An overall correlation of .545 was found between the two measures across the trials. A statistical test of significance showed that correlation was statistically significant, which indicates their being far from multicolinearity, hence, the multivariate analyses were performed. Similar procedures were employed to perform the statistical tests for the performance on the transfer task. However, to improve the interpretability of the results, the trend analysis for the within-subject factor was limited to the cubic degree. The blocking procedure employed for the learning data was not considered to be appropriate for this part of analysis. The application of the blocking procedure for the smaller number of trials on the transfer test would mask the sensitivity of the transfer performance measures.

A 2 (Instruction: LTI vs. LIO) by 3 (Task: SPV, PV, SV) by 2 (Rest: 5 Minute vs. 30 Second) by 2 (Shift: Preferred vs. Non-Preferred) by 6 (Transfer Trials: 6 Trials) factorial design analysis was performed on the data structure of the two response measures. Cell means for the amount of Time on Target and the Number of Hits for the between-subject factors in Table 2, from which various marginal and combined means are derived for illustrative purposes, are shown. They are also presented in Figure 2a through 2b for easy visual inspection.

Insert Tables 2, and 2a through 2f and Figures 2a 2b

about here

The data analysis for the transfer performance was also made according to the main hypotheses of the study. In the first step, the effects of the learning treatment factors were evaluated. Prior to conducting the test of significance for the learning treatment factors, it was necessary to confirm if any transfer has occurred at all. Therefore, performance of the experimental groups was compared with the control groups. Second, the contrast for the learning treatment factors were made to evaluate the various effects predicted. Third, the effects of the moderator variables were evaluated. Finally, the interaction of the learning and transfer variables were examined.

1. <u>Analysis of the Overall Transfer Effect of Training</u>

This part of the data analysis was particularly under scrutiny to address the research question. In the first contrast, the effects of the learning variables, Instruction and Task were determined by comparing the performance of the learners in those conditions with that of the two control groups. It was predicted that the all subjects given training on 12 learning trials would benefit from practices on tasks under the two levels of instruction (LTI and LIO) and consequently performed the transfer task better than the control groups. Also, it was expected that some bilateral transfer should occur as a result of 12 learning trials on various tasks, although it may not be as much as unilateral transfer.

The combined weighted total means of Time on Target and the Number of Hits for evaluating these predictions are presented in Table 2a. The estimation of the effects desired necessitates estimating the mean squares of errors for the two dependent variables, being pooled from those from 24 treatment conditions involving a total of 10 subjects. How the original means squares of errors from both sources can be pooled is shown below Table 2a. It should be noted here that they are too disparate to be a cause for serious concern because of heterogenity of variances observed (see the bottom of the Table 2a), even though a quite large sample size (i. e., N=82) with the majority of 26 equal cell sizes (i. e., 3 for the experimental groups and 5 for the control groups) are equal. However, such concern may be alleviated by using the Welch-Aspin t^*-test (Welch, 1947) as the one-tail test.

The first contrast was made between the overall means of the experimental treatment groups and those of the control groups (see the last column of Table 2a : 4.12 vs. 11.13/sec., 49.28 vs. 87.75 for Time and Hits, respectively). The learning treatments help the learners stay on target longer with more contacts (Hits) on the target very significantly, $\underline{t}^*$ (25)=3.66 and $\underline{t}^*$ (15)=4.42, ps<.005, for Time on Target and the Number of Hits, respectively. Two further contrasts were made to ascertain the questions of whether or not unilateral and bilateral transfer occurred. The analysis showed that those who learned with the preferred hand transferred significantly to the transfer task (i. e., 11.73 vs. 5.03/sec., 92.82 vs. 53.97 for Time and Hits, respectively); $\underline{t}^*$ (13)=2.43 and $\underline{t}^*$ (8)=3.21 ; ps<.025 and .01, respectively. Under the condition of hand shifted, that is, performing the transfer with the hand shifted, the training with 12 learning trials led to significant gains (i. e., 10.53 vs. 3.20/sec. and 82.67 vs. 44.58 Hits), $\underline{t}^*$ (13)=2.47 and $\underline{t}^*$=3.15, ps<.025 and .01, respectively, for Time on Target and the Number of Hits. Since the latter contrast effects represent bilateral transfer with hand shifted an confounded with performing by non-preferred hand, it is necessary to estimate the bilateral effect with preferred handedness effect taken off.

This contrast required is essentially the difference between the two preceding contrasts effects (i. e., the latter - the former=.32 and .38 for Time and Hits), which turned out to be not statistically significant, $\underline{t}^* < 1.0$. This means that the bilateral transfer occurred in as much as the unilateral transfer.

2. The Instruction effects and its Interaction

The main effect of Instruction was evaluated in order to determine the effectiveness of instruction. It was expected that the LTI group would perform the transfer task better than the LIO group. The marginal means for LTI and LIO were 5.13 and 3.95/sec. for Time and 38.7 and 32.94 for Hits, respectively. The test statistics corresponding to the main effects of the first between-subject factor was found to be statistically significant, multivariate $\underline{F}$ (2, 47)=2.797, $\underline{p}<.071$; univariate $\underline{Fs}$ (1, 48)=3.87 and 4.89, $\underline{ps}<.055$ and .032, for the amount of Time on Target and the Number of Hits, respectively. This test result demonstrates that the LTI group performed the transfer task significantly better than the LIO condition. These findings were in agreement with the prediction of the schema theory.

It was expected that the LTI condition would be more motivated on the learning task and, therefore, would be cognitively more involved in the process of forming the schema during learning. The visual inspection of Figure 2a reveals the superiority of the LTI in contrast to the LIO on the transfer task. However, despite the difference in the performance of the two groups on each transfer trials, the two instructional treatments showed no differentially significant linear trends across the transfer trials, although there is an overall linear trend over the six trials, multivariate $\underline{F}$ (2, 47)=2.89, $\underline{p}$<.066 (see Table 2b).

The test of interaction of Instruction with the task variability was conducted. Two interaction contrasts were made and tested : an interaction between the instructional groups and the first contrast comparing the SPV with the SV and PV tasks and another one with the second contrast comparing the SV with the PV task. These findings showed that the learners under the LTI condition performed the transfer task like the learners on the LIO condition. It is contrary to the expectation that the SPV task condition would be more conducive to schema formation under the LTI condition than any other treatment conditions.

However, the test of the interaction contrast in term of the linear trend revealed that there was a significant interaction across the transfer trials, multivariate $\underline{F}$(2, 47)=3.16, $\underline{p}$<.051. The examination of the linear trends on both measures showed that SPV task condition appear to lead to initial growth over the transfer trials, while other task conditions failing to show the same trends. More specifically, the inspection of combined means for these contrasting groups (see Table 2c) reveals a complex pattern. While the SPV task group in LTI condition performed the first three trials better than the SV and/or the PV task or both combined, this group failed to show the same pattern in their performance on the LIO condition and performed worse than the average of the performance of SV and PV task conditions later.

The presence of such complex fluctuation in the performance of the SPV task on transfer test may be due to the difference in quality of cognitive involvement of the two contrasting task groups. The SPV task may try different strategies on the learning trials on each sub-task and carry over the same type of approach to the transfer task, whereas the other two tasks may maintain a consistent strategy throughout the learning and transfer trials.

The second test of the interaction also showed no significant interaction between the instructional groups and the SV task versus the PV task. The results of this test means that the learners in the LTI condition on the SV task condition performed the transfer task like the learners in the LIO condition on the SV task condition. The absence of interaction between these two factors is an indication of the consistency of performance of the learners on the LTI condition. That is, performers in the LTI groups performed the tasks better than the performers in the LIO groups.

3. <u>The Effects of Task Variation on the Transfer Performance</u>

The marginal means for the learners' performance under the training conditions with the SPV, SV, and PV tasks were observed to be 4.05, 5.03, and 4.54 for Time on Target and 32.39, 36.75, and 38.31 for the Number of Hits, respectively. It was predicted that the learners on SPV task would perform the transfer task better than the learners on SV or PV task. This was mainly the prediction implied by the schema theory. According to the theory, the learners who practice more varieties of the task during the learning activities were expected to perform the transfer task better than the learners who practiced fewer varieties of the learning task. Two task contrasts were made to determine whether there was any significant differences between the performance of the learners in the different tasks conditions. The first contrast comparing the learners' performance under the SPV task was compared with those under the SV and PV task condition combined, as mentioned earlier. The second contrast comparing, the performance of the learners under SV task condition with that under the PV task.

Though the SPV task condition subjects considerably performed the transfer test better than the other two task groups, however, the difference in performance was not statistically significant. Also, various trends over the transfer trials for this contrast were non-significant. These test results did not agree with what were expected. It should be said that the learners given the SPV tasks performed the transfer task just like any other learners given the SV and PV tasks combined.

The result for the second contrast of the task variation also showed no significant differences between the performance of the SV task versus the PV task nor were there any significant trends over the six transfer trials. The results of these findings were inconsistent with what was expected. It was predicted that the SV task would perform the transfer task better than the PV task.

4. The Effects of Rest Conditions and Shift of Hands

The marginal means of the learners' transfer performance following 5 minutes and 30 seconds rest intervals were observed to be 4.83 and 4.25 for Time on Target and 38.95 and 32.69 for the Number of Hits, respectively. There were no significant differences between the learners' overall performance, given the two rest intervals throughout the transfer trials except for a significant quadratic trend scores (see Table 2d). That is to say, the learners given five minutes rest showed a up-down convex quadratic trend, while those given only 30 seconds showed a down-up concave quadratic trend. This difference was significant, multivariate $\underline{F}$ (2, 47)=3.70, $\underline{p}$<.033; univariate $\underline{Fs}$ (1, 48)=7.43 and 2.36, $\underline{p}$<.009 and .13 for Time on Target and the Number of Hits, respectively. This finding appears to be consistent with what was predicted from the theory of reactive inhibition.

The marginal means of the learners' transfer performance with hand shifted and not shifted were observed to be 3.52 and 5.56 for the Time on Target and 31.94 and 39.70 for the Number of Hits, respectively (also see Table 2e). It was expected that the learners who did not shift hand on the transfer task would perform the transfer task better than the learners who did shift hand on the transfer task. MANOVA showed no significant differences between the performance of the two groups when the transfer trials were averaged over the trials. The transfer performance level of the learners who shifted their hand on the transfer task is similar to that of the learners who did not shift hand. However, the analysis of the six transfer trials revealed that there was a significant cubic trend across the transfer trials, multivariate $\underline{F}$ (2, 47)=5.70, $\underline{p}<.006$. This means that the learners with hand not shifted showed the initially rising pattern of the cubic trend (i. e., up-down-up) more clearly than those who did shift hand on the transfer task with lack of any pattern. This finding is not surprising, considering the learners who would try to establish their performance baseline with the shifted hand.

5. Interaction Between Learning and Transfer Variables

In addition to the test of main effects of the task factor, the interaction of task and the remaining two factors, that is, Rest Intervals and Shift of Hands, were also tested. The main purpose of these tests was to explore whether there was any significant interaction between each parameter of the task and rest interval or the shifting of hand conditions, separately or collectively. These tests were considered to be important in the sense that they could provide additional insight into the nature of variability in practice with tasks and the schema formation.

The test of the second order interaction between Task, Rest Interval, and Shift of Hand revealed that there was a significant interaction effects among these factors. The combined means for this interaction is shown in Table 2f and Figure 2b. MANOVA showed a significant interaction between the first contrast of the Task, Rest, and Shift of Hand, multivariate $\underline{F}$ (2, 47)=3.01, $\underline{p}$<.058 , univariate $\underline{Fs}$ (1, 48)=4.19 and 5.24, $\underline{p}$<.001 for Time on Target and the Number of Hits, respectively. The examination of the combined means in Table 2f reveals the main source of the interaction. That is, the superiority of the SPV task condition to the SV and PV is clearly shown in the condition of 30 second rest interval, especially with shifted hand. When the learners had 30 seconds of rest prior to the transfer test, they performed the task with the non-preferred hand significantly better than the preferred hand. First of all, this finding is as what was predicted from the schema theory, but with limiting conditions, that is, including the condition of 30 second rest interval, and better yet with hand shifted. Second, this finding is contrary to what the reactive inhibition hypothesis would predict. As was mentioned earlier, the reactive inhibition build-up is partially a local phenomenon that retards the involved limb on repetitive performance. These findings demonstrated that the non-shifted hand on 30 second rest performed the transfer task better than those with the shifted-hand. This may be interpreted as evidence for the validity of the consistency hypothesis. When the task is continuous, it seems that there is a connection between the peripheral and central control devices which continues uninterrupted. This interrelation preserves the quality of performance regardless of the location of the connection.

In addition, there was a significant linear trend for this interaction, multivariate $\underline{F}$ (2, 47)=8.07, $\underline{p}$<.001 ; univariate $\underline{F}$ (1, 48)=8.77, $\underline{p}$<.004 for the Number of Hits only. The results of this test showed that the performance of the learners on the 30 second rest interval with preferred hand had a consistent upward improvement in contrast to the 5 minutes rest intervals.

Finally, the last test of interaction was performed on all four factors in the design. There was no significant between-subject factor interaction between the Instruction, first contrast of the Task, Rest Intervals, and the Shift of Hand conditions. However, the same was not true for the within-subject factor interaction. The results of the trend analysis showed that there was a significant quadratic trend interaction, multivariate $\underline{F}$ (2, 47)=3.25, $\underline{p}$<.047 ; univariate $\underline{F}$ (1, 48) =5.96, $\underline{p}$<.018 for the Number of Hits only for the recent interaction test.

A careful examination of the cell means over the transfer trials reveals that the learners in the LTI condition with the SPV task given the Rest Interval of 5 minutes who shifted their hand performed the transfer test on trials 3 and 4 significantly better than the learners on the LIO condition, SPV task, with 5 minutes rest interval who shifted their hand. The learners on the LTI with the SV task allowed the Rest Interval of 5 minute condition who did not shift their hand on the transfer task performed on all the transfer trials similar to that counterpart group on the LIO condition.

The next test of interaction for the second contrast of the Task, Instruction, Rest Interval and Shift of Hand showed no significant interaction for the between subject nor for the within subject factors. The results of this test mean that the learners in the LTI condition on the SV task with 5 minutes rest who shifted to their non-preferred hand scored on the transfer test like those in the LTI on the PV task with similar rest and shift of hand condition. The similarity of performance also remained unchanged for the within-subject factor. There was no significant trend over the transfer trials.

Chapter IV. Discussion and Conclusion

A. The Role of The Learning Variables

The analysis of learning performance indicates that unilateral and bilateral transfer of training occurred. The base of contrast for teasing out the presence of transfer of training was the control groups. The control groups did not take part in the learning trials. They were only given the warm-up task and were requested to perform the transfer task. One of the control groups shifted hand on the transfer task and the other group performed the task with the preferred hand. The results of the analysis showed that though the non-shifted group performed the task better than the shifted group, however, the difference in performance was not statistically significant.

The unilateral and bilateral transfer of training was demonstrated by comparing learning treatment groups with the control groups on the transfer task. The trained groups with 12 learning trials performed the transfer task significantly better than did the control groups. The general findings of the present experiment in regard to the role of practice were consistent with the findings of Hicks (1974), Boswell and Irion (1975), Kohl and Roenker (1980), Fumoto (1981), Shaffer and Pyne (1982), Hicks (1982), Hicks (1983). The results of the experiment showed that learning the original task improves the performance of the learner on a novel task.

1. Effectiveness of Instruction

The trained groups' significantly better performance on the transfer task, as compared to the control groups', implies that they gained these superiorities during the learning trials. The examination of learning performance demonstrated that a substantial amount of learning took place during the twelve trials. The occurrence of learning was inferred from the analysis of the performances of the two instructional treatments (i. e., LTI and LIO). The effect of Instruction was also present on each learning block. The Learning-Transfer-Instruction groups performed the learning task better than the Learning-Instruction-Only on each learning block.

This finding is consistent with what was predicted from the schema theory. It predicted that the learners who received instruction for the transfer task would perform the learning task better than the group who did not benefit from such instruction. It was hypothesized that the learners in the Learning-Transfer-Instruction condition would engage in goal oriented activities and consequently would be more motivated to learn the task than the learners in Learning-Instruction-Only condition, while presumably being in the process of forming a schema. The results of the analysis of the learning performance of the two groups confirmed the implication of the hypothesis. The difference in performance of these two groups is most likely to be attributed to the difference in the quality of the cognitive activities of the two groups.

More specifically, it may be suggested that instruction for the transfer task led to a deeper level of processing of information provided on every instance of the learning task; the information such as the position of the limbs, the speed and force parameter employed during the execution, and feedback reception which are crucial for the schema formation. According to the schema theory, the learner receives and integrates four type of information on performing a given motor task. However, detection and integration of these sources of information may not be an automatic process. Contrary to the Thorndike's (1935) statement that learning is an automatic process without intervention of conscious awareness, a learner has to detect the presence of such information to benefit from them in subsequent performance. A learner has to remember the positioning of his/her limb in one instance of a given task in order to use this information in subsequent execution of that task. If the learner was a passive operator in the process of learning a given task, then the cognitive ability and involvement of the learner in acquiring such a skill would probably be insignificant.

The results of this experiment with respect to the role of instruction demonstrated that learners in the Learning-Transfer-Instruction condition were indeed better learners because they were given the instruction for the transfer task. The superiority of performance of the learners in that circumstance may be attributed to the difference in the quality of cognitive involvement of this group during the learning activities. In summary, the learners in the instruction condition, as was predicted, were more motivated, therefore, paid more attention to the information provided on each instance of the task and used that information more effectively to perform the following instance of the task. These findings provided the unique and new evidence suggesting that the strength of schema formation can be effected by a qualitative variable such as instruction.

2. Effectiveness of Task Variability

According to the task variability hypothesized based on the schema theory (Schmidt, 1975), the learners on the task with more variability during the learning trials should perform the transfer task better than the learners on tasks with less variability. For this particular experiment, the learners on the SPV task were expected to demonstrate a better performance on the transfer task. The implication of this hypothesis is that the learners on the SPV condition also perform the learning task better than the other tasks. The performers on the task with more task variability are expected to learn the target task qualitatively differently than the performers on the task with less task variability.

For the present experiment, comparing the Speed and Path Varied task with the other two tasks should reveal some important aspects of the task that contribute to the better performance of the learners on the Speed and Path Varied task either during learning or transfer. The learners on the SPV task practiced four varieties of the pursuit rotor task. Considering the schema theory notations, at least four types of unique information in respect to the positioning of the limbs prior to the start of each variety of the task was provided for the learners, in contrast to two types of information for other learners. The same condition was true for the other sources of information, such as the speed and force parameter, feedback, and the quality of the outcome. In addition, considering the strategy adaptation that may occur on each version of the Speed and Path Varied task reveals the nature of the difference in the cognitive involvement of the learner in Speed and Path Varied versus the learners in the other two task conditions.

The results of the examination of the learning performance showed that the learners on the Speed and Path Varied task performed the learning task better than the other two tasks. Careful inspection of the performance of the learners is necessary to detect the superiority of the performance of the learners in Speed and Path Varied task. This is partially due to the unique nature of the performance measures. While the Speed Path Varied group stay on the target almost as long as the other two groups, they hit it less frequently than the other two groups.

Further, the difference between the transfer performance of the Speed Path Varied task versus the other two tasks was statistically significant, but only under the 30 second rest interval condition performing with hand shifted. These finding are partially consistent with the findings of Cummings and Caprarola (1986) who found that there was no significant differences between the performance of the learners who learned a task under varied practices with tasks within the schema range and those who learned the task under constant practice.

The results of the present findings about task variability are consistent with the previous findings reported by Clifton (1985), Piggot and Shapiro (1984), Carson and Weight (1979), Kerr and Booth (1977), and Moore (1981). The reason for the lack of straight forward main effect of the task variability in the present experiment might have been due to the nature of learning trials that the learners went through. That is, for the present experiment, the constant trial procedure with 12 learning trials was employed. Such procedure was employed to avoid interruption in the regular academic activities of the students participating in the study. An alternative to this procedure would have been setting the mastery criterion for the learning trials. In addition, a limited variety of the task within the schema range was employed. The results of the present experiment suggest that the task variability alone may not be a sufficient condition for the transfer of training to occur, rather the variability condition interacts with other conditions such as the amount of rest allowed between the learning trials and the transfer task.

Another possible explanation for the lack of the main effect of the task variability in the present experiment may well be due to the nature of the learning task. For this particular experiment, it is possible that the other two tasks also served as tasks with the task variability and consequently all the three tasks might have caused schema formation to the same degree, though the strength of the schema formation for the Speed and Path Varied task was more distinguishable from the other two tasks.

The Effectiveness of the Transfer Variables and Their Interaction With The Learning Variables

The analysis of data for the rest intervals showed no simple effect to be explained. The overall performance of both rest interval groups are similar. Instead what emerged from this analysis demonstrated that rest interval prior to the transfer test has an interaction effect with the type of activities that the learners have been involved earlier. The prediction of the consistency hypothesis was true only if the learners were on the LTI condition engaged on the Speed and Path Varied task performing with the preferred hand.

The presence of such interaction relationship among the learning and transfer trials demonstrates that performance of the learners on the transfer task is not really effected by the reactive inhibition build-up; for if that was the case performance of the learners in 30 second rest interval, especially the preferred hand condition would suffer. Secondly, this interaction shows that the task variability condition indeed improves transfer to the novel task within the schema range, only if the activity is not interrupted. This finding appear to indicate that schema formation is a function of task structure, decay(elapse of time between original learning and transfer performance), and limb involvement.

C. Summary and Conclusion

The results of the present investigation demonstrated that the qualitative learning variable of the Learning-Transfer-Instruction had a significant effect on the transfer of training. This finding was expected and was predicted by the schema theory. Only informing the learner about the objective of the learning activities showed to make such a difference not only on the learning task, but also on the transfer task. In retrospect, this finding was assumed to be caused by the motivational level of the learners. Further, it was assumed that when a learner is instructed about the objectives of the learning activities, s/he would establish a goal for her/his activities which consequently must improve her/his performance on the final stage of performance.

Though the importance of transfer of training has been recognized by all sectors of the educational community and the study of transfer of training has been around for decades, there has been unclear or weak theoretical justification for their application. Only recently, through the advancement of the schema theory (Schmidt, 1975), a new horizon appears to have been opened to this line of inquiry. This study also in line with the new approach, attempted to incorporate the task variability as its quantitative variable to study the occurrence of transfer of training.

The results of this study demonstrated that the effects of learning variable of task variability for this particular experiment is not simple. Rather the effect of this variable is a function of other variables such as the amount of rest elapsed between the original learning and transfer test. However, the finding of this experiment in this regard should be considered carefully. Due to the external restrictions that was beyond the control of the experimenter, this study had to choose a constant trial method in its learning trials; a method that may not be ideal in producing the desired mastery of learning. More research is needed to determine the effects of the task variability under different learning conditions, such as the desired level of mastery criterion for learning.

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Table 1. Cell Means for the amount of Time (sec.) on Target and the Number of Hits for the Learning Conditions, Task Variants, and Learning Blocks

(N=72)

Learning Condition	Tasks	Time Hits	#1	#2	#3	#4
LTI	SPV	Time on Target	4.92	4.82	5.68	4.64
		Number of Hits	36.47	39.34	40.04	37.25
	SV	Time on Target	4.57	5.88	4.23	4.67
		Number of Hits	44.86	50.19	42.44	43.36
	PV	Time on Target	4.54	5.04	4.64	4.66
		Number of Hits	40.88	43.05	45.05	43.97
LIO	SPV	Time on Target	3.68	2.86	3.47	2.74
		Number of Hits	32.05	35.63	35.02	30.52
	SV	Time on Target	2.93	4.95	3.89	4.32
		Number of Hits	29.75	45.41	40.66	42.91
	PV	Time on Target	3.49	4.30	4.00	4.51
		Number of Hits	37.00	40.63	40.55	40.83

MSEs (66)=8.647 and 439.321 for average Time on Target and average Number of Hits, respectively.

Table 1a Marginal Means for the amount of Time (sec.) on Target and the Number of Hits for Tasks by Learning Block

Response Measures	#1	#2	#3	#4	MSE	df
Time on Target	4.02	4.65	4.32	4.26	1.361	198
Number of Hits	36.85	42.73	41.35	41.69	48.701	198

Table 1b. Marginal Means for the amount of Time (sec.) on Target and the Number of Hits for Tasks by Three Task Variants

Response Measures	SPV	SV	PV
Time on Target	4.10	4.43	4.40
Number of Hits	38.27	42.45	41.24

Table 1c. Combined Means for the amount of Time on Target (sec.) and the Number of Hits for Two Instructional Conditions and Task Variations

Instructional Condition	Response Measures	Learning Trials SPV	SV	PV
LTI	Time on Target	5.01	4.72	4.84
	Number of Hits	43.24	41.73	45.14
LIO	Time on Target	3.19	4.08	4.02
	Number of Hits	33.31	40.75	39.68

Table 2 Cell Means for the amount of Time on Target (sec.) and the Number of Hits on the Transfer test by the Three Instructional Treatment by Task Variants, Rest Intervals and Shift of Hand (N=72 plus 10 Controls)

Time on Target for LTI

			Transfer Trials					
Task	Rest	Shift	#1	#2	#3	#4	#5	#6
SPV	5 Min.	Hand Shifted	3.82	4.71	5.16	5.40	4.67	4.05
		No-Hand Shifted	5.90	5.52	5.17	4.43	6.13	5.98
	30 Sec.	Hand Shifted	2.20	2.84	2.68	3.26	1.78	2.86
		No-Hand Shifted	8.32	8.69	8.98	7.96	8.68	8.03
SV	5 Min.	Hand Shifted	5.12	5.90	5.47	7.50	6.48	7.26
		No-Hand Shifted	5.43	6.57	5.97	6.98	6.25	5.86
	30 Sec.	Hand Shifted	3.23	2.78	3.85	3.12	2.75	2.72
		No-Hand Shifted	5.88	4.66	4.37	4.79	4.83	5.22
PV	5 Min.	Hand Shifted	4.22	3.56	4.46	3.40	3.95	4.79
		No-Hand Shifted	5.44	5.50	5.71	5.16	5.11	5.88
	30 Sec.	Hand Shifted	4.61	4.70	5.94	3.80	2.90	5.35
		No-Hand Shifted	7.16	5.22	5.42	5.18	4.70	7.07

Table 2 (....Continued)

Time on Target for LIO

Task	Rest	Shift	Transfer Trials #1	#2	#3	#4	#5	#6
SPV	5 Min.	Hand Shifted	1.70	1.88	1.49	1.59	2.12	1.73
		No-Hand Shifted	3.09	2.97	2.86	3.59	3.13	5.67
	30 Sec.	Hand Shifted	0.38	1.41	1.24	1.11	1.27	1.21
		No-Hand Shifted	3.79	3.47	3.99	6.04	6.25	5.19
SV	5 Min.	Hand Shifted	4.21	7.25	5.18	6.97	7.19	7.63
		No-Hand Shifted	3.28	5.13	7.43	6.06	2.38	4.48
	30 Sec.	Hand Shifted	2.26	2.89	2.22	2.05	2.38	2.72
		No-Hand Shifted	4.25	5.31	5.94	5.92	6.22	6.66
PV	5 Min.	Hand Shifted	2.93	3.21	2.72	3.25	2.55	2.94
		No-Hand Shifted	5.61	5.68	6.60	6.14	5.97	5.82
	30 Sec.	Hand Shifted	1.69	2.40	3.15	1.78	3.04	2.42
		No-Hand Shifted	4.96	5.66	5.15	4.83	4.64	5.94

Table 2 (......Continued)

Number of Hits for LTI

Task	Rest	Shift	Transfer Trials #1	#2	#3	#4	#5	#6
SPV	5 Min.	Hand Shifted	31	36	40	45	38	38
		No-Hand Shifted	41	40	35	29	38	40
	30 Sec.	Hand Shifted	27	29	39	21	26	29
		No-Hand Shifted	31	36	41	40	41	36
SV	5 Min.	Hand Shifted	52	59	44	41	44	47
		No-Hand Shifted	46	48	42	50	48	45
	30 Sec.	Hand Shifted	29	22	33	26	24	29
		No-Hand Shifted	41	28	35	33	42	38
PV	5 Min.	Hand Shifted	54	34	39	31	34	34
		No-Hand Shifted	45	52	36	42	49	45
	30 Sec.	Hand Shifted	40	32	49	32	30	41
		No-Hand Shifted	43	41	39	41	35	47

Table 2 (.....Continued)

Number of Hits for LIO

Tasks	Rest	Shift	#1	#2	#3	#4	#5	#6
SPV	5 Min.	Hand Shifted	21	24	31	25	32	26
		No-Hand Shifted	29	46	31	44	36	40
	30 Sec.	Hand Shifted	4	15	15	14	18	17
		No-Hand Shifted	44	27	26	38	44	41
SV	5 Min.	Hand Shifted	16	43	44	40	37	36
		No-Hand Shifted	34	29	25	31	30	33
	30 Sec.	Hand Shifted	34	29	25	31	29	23
		No-Hand Shifted	34	29	25	31	30	33
PV	5 Min.	Hand Shifted	53	42	49	42	21	25
		No-Hand Shifted	20	25	28	22	46	50
	30 Sec.	Hand Shifted	40	50	45	39	31	25
		No-Hand Shifted	34	38	38	40	36	43

(Columns #1–#6: Transfer Trials)

Table 2 (.....Continued)

Time on Target (sec.) and

Number of Hits for CONT

Hand Condition	Response Measures	Transfer Trials #1	#2	#3	#4	#5	#6
Shifted	Time on Target	.99	.92	.87	1.08	1.78	2.17
	Number of Hits	14	13	13	15	24	29
Not-Shifted	Time on Target	1.11	1.20	2.72	2.43	2.23	2.60
	Number of Hits	15	14	24	25	24	27

Table 2a. Weighted Total Means for the amount of Time (sec.) on Target and the Number of Hits for the Two Instructional Treatment Conditions on the Transfer task

Treatments	Response Measures	Shifted	Non-Shifted	Overall
CONT (n=10) (df=8)	Time on Target	3.20	5.03	4.12
	Number of Hits	44.58	53.97	49.28
LTI and LIO (n=72) (df=48)	Time on Target	10.53	11.73	11.13
	Number of Hits	82.67	92.82	87.75

MSEs (48)=39.108 and 734.135 for average Time on Target and average number of Hits, respectively.

MSEs (8)=3.682 and 257.533 for average time on Target and average number of Hits, respectively.

Table 2b. Marginal Means for the Amount of Time (sec.) on Target and the Number of Hits by the Two Instructional Treatments by Transfer Trials

Treatment Condition	Time Hits	Transfer Trials #1	#2	#3	#4	#5	#6
LTI and LIO	Time on Target	4.15	4.50	4.63	4.60	4.49	4.87
	Number of Hits	34.31	36.08	36.27	35.31	35.51	36.41
CONT	Time on Target	1.05	1.06	1.80	1.75	2.00	2.37
	Number of Hits	14.90	14.20	19.20	20.20	24.20	28.00

Table 2c. Combined Means of Time on Target (sec.) and the Number of Hits across Transfer Trials by Two Instructional Treatments and Task Variability

Inst.	Task	Time Hits	Transfer Trials #1	#2	#3	#4	#5	#6
LTI	SPV	Time on Target	5.06	5.44	5.49	5.26	5.31	5.23
		Number of Hits	32.83	35.41	38.16	36.41	35.91	36.08
	SV	Time on Target	4.94	4.98	4.91	5.60	5.07	5.26
		Number of Hits	42.33	39.75	38.91	37.91	39.83	39.83
	PV	Time on Target	5.36	4.74	5.38	4.38	4.17	5.77
		Number of Hits	45.83	40.08	41.08	36.75	37.33	42.16
LIO	SPV	Time on Target	2.24	2.43	2.39	3.08	3.24	3.45
		Number of Hits	25.00	28.08	26.08	30.75	32.83	31.16
	SV	Time on Target	3.50	5.14	5.19	5.25	5.11	5.37
		Number of Hits	29.41	36.50	34.75	35.16	33.50	33.16
	PV	Time on Target	3.80	4.24	4.41	4.00	4.05	4.17
		Number of Hits	36.50	36.66	38.66	34.91	33.66	36.08

Table 2d. Marginal Means for the Amount of Time (sec.) on Target and the Number of Hits by the Rest Conditions

Rest Intervals	Response Measurers	Transfer Trials #1	#2	#3	#4	#5	#6
5 Min.	Time on Target	4.24	4.82	4.85	5.04	4.86	5.17
	Number of Hits	25.33	35.00	31.16	35.16	34.66	33.16
30 Sec.	Time on Target	4.06	4.17	4.41	4.15	4.12	4.58
	Number of Hits	24.66	21.16	21.00	26.33	31.00	29.16

Table 2e. Marginal Means for the Amount of Time (sec.) on Target and the Number of Hits by the Shift of Hand Condition

Shift Condition	Response Measurers	Transfer Trials #1	#2	#3	#4	#5	#6
Hand Shifted	Time on Target	4.03	3.63	3.63	3.60	3.42	3.80
	Number of Hits	31.77	31.27	34.36	31.52	30.66	32.02
No-Hand Shifted	Time on Target	5.26	5.36	5.63	5.59	5.56	5.94
	Number of Hits	38.85	40.88	38.19	39.11	40.36	40.80

Table 2f. Combined Means for the amount of Time (sec) on Target and the Number of Hits by Rest, Task, and Shift of Hand Conditions on the Transfer task

Tasks	Shift Conditions	Response Measures	5 Min	30 Sec.
SPV	Shifted	Time on Target	3.19	1.85
		Number of Hits	32.55	22.05
	Not-Shifted	Time on Target	4.55	6.61
		Number of Hits	37.69	37.27
SV	Shifted	Time on Target	6.35	2.75
		Number of Hits	42.94	29.02
	Not-Shifted	Time on Target	5.67	5.34
		Number of Hits	40.72	34.33
PV	Shifted	Time on Target	3.50	3.48
		Number of Hits	33.52	31.52
	Not-Shifted	Time on Target	5.72	5.46
		Number of Hits	46.27	41.91

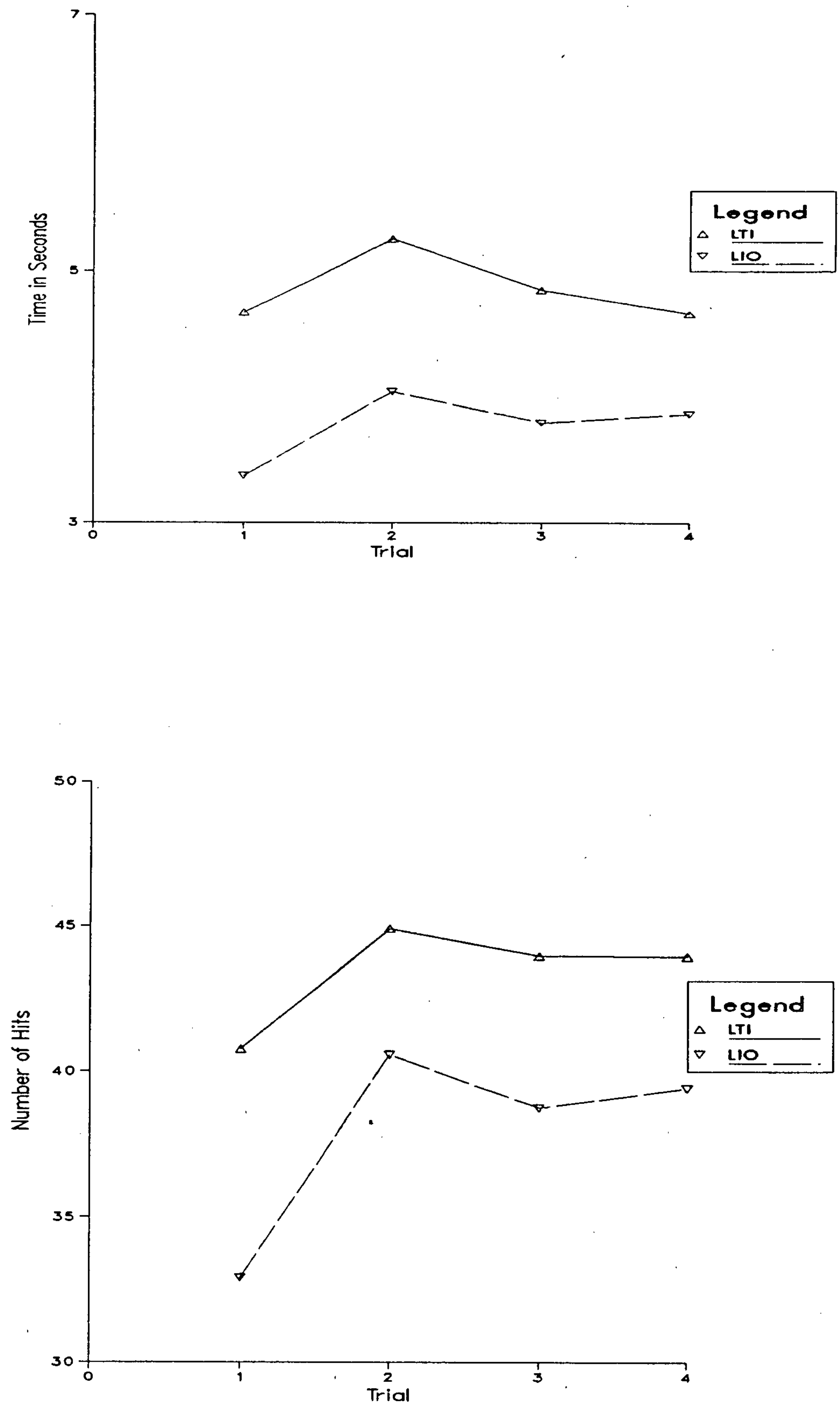
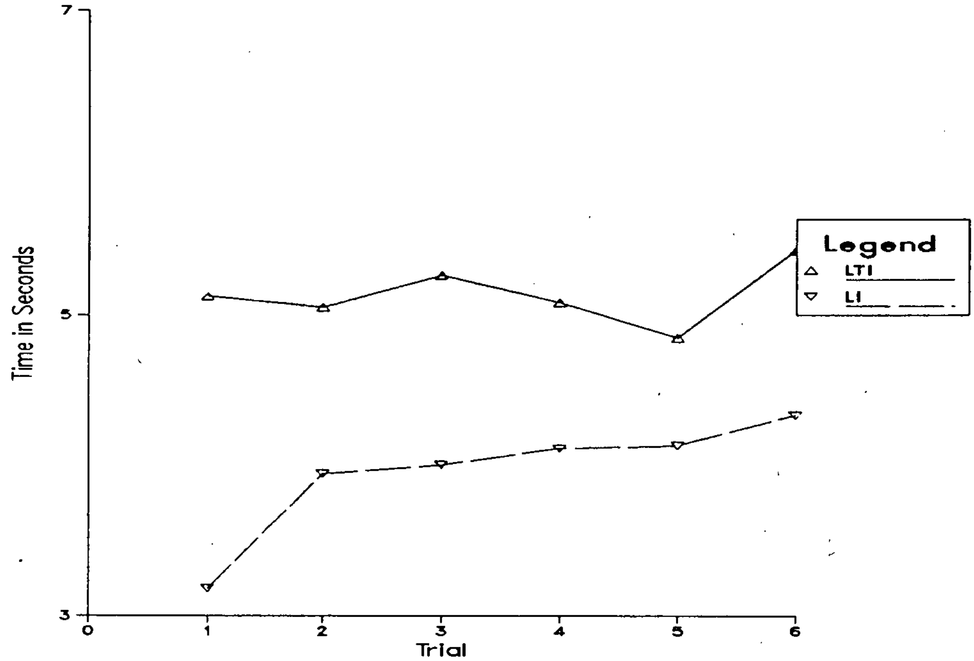


Figure 1a : Mean Time on Target and Number of Hits for Four blocks of Three Learning trials under LTI condition versus the LIO condition N=72



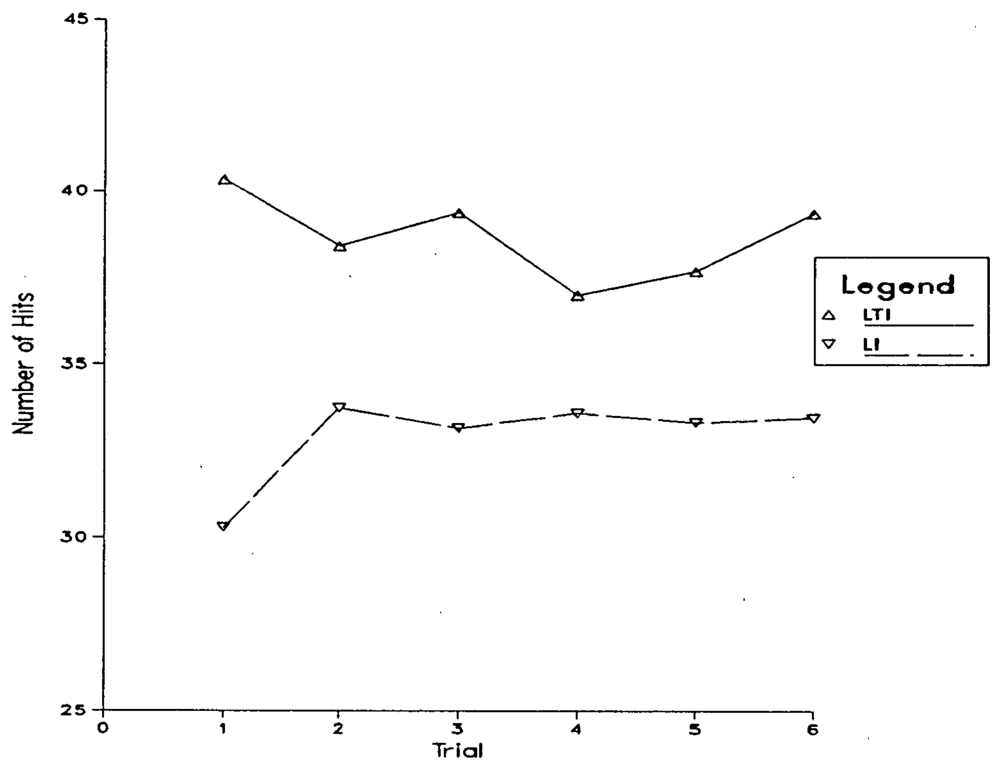


Figure 2a : Mean Time on Target and Number of Hits for Six trials of Transfer test for the LTI group Versus the the LIO group for Transfer Task, N=72

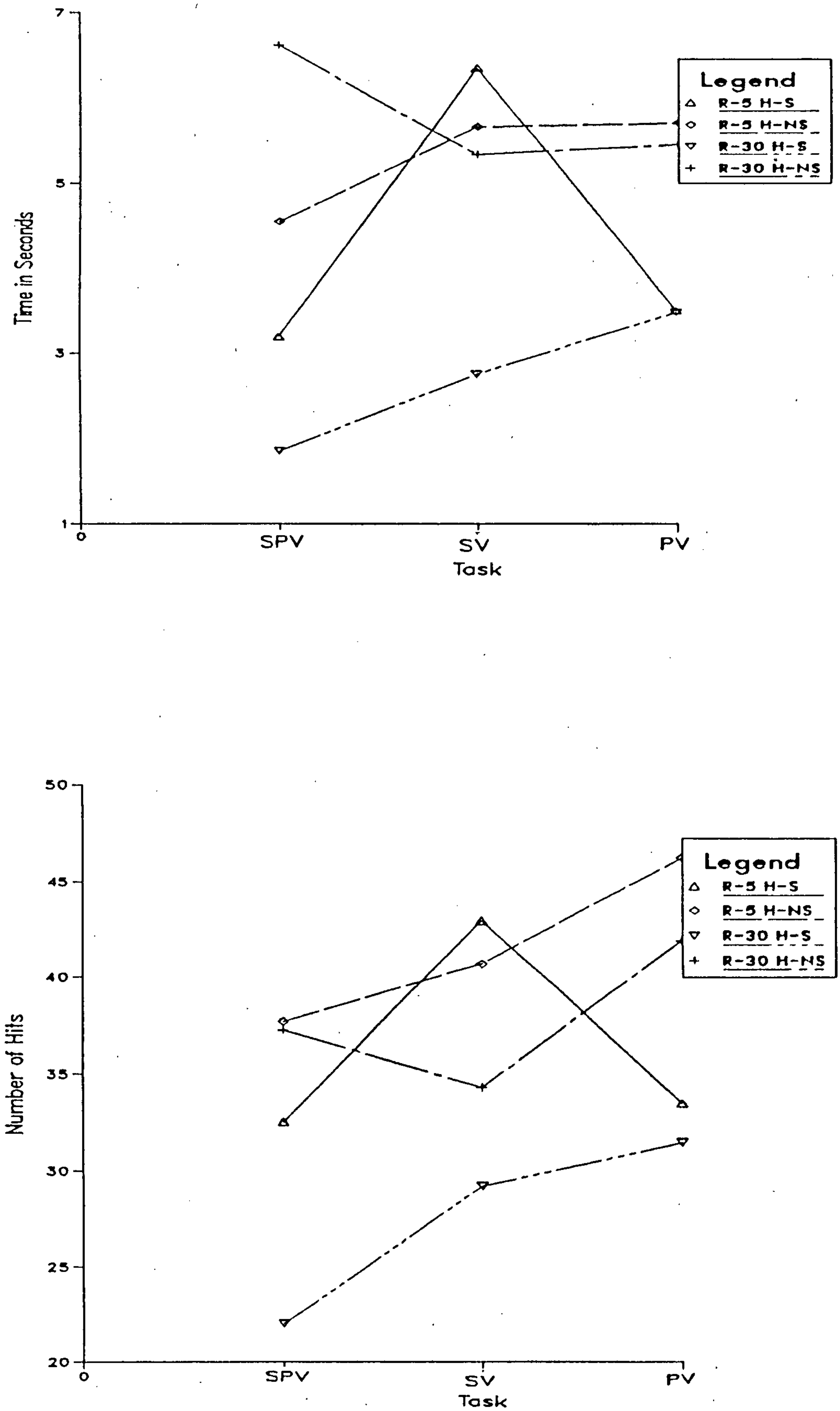
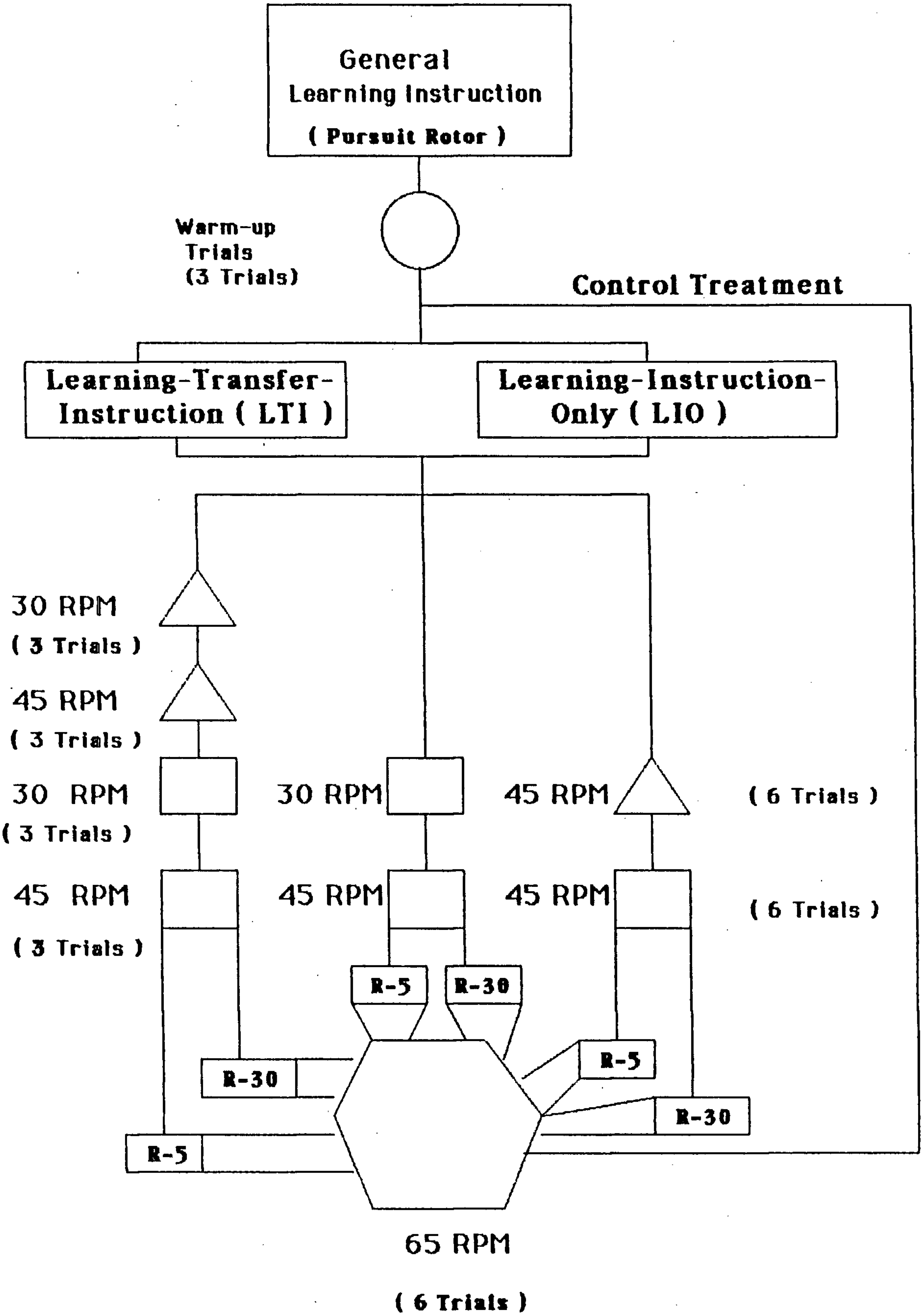


Figure 2b: The Mean Time on Target sec. and the Number of Hits for treatment combination by Task Variability, Shift of Hands, and Rest Intervals for Transfer Task. N=72

Appendex A


General
Learning Instruction
(Pursuit Rotor)
Warm-up
Trials
(3 Trials)
Control Treatment
Learning-Transfer-
Instruction (LTI)
Learning-Instruction-
Only (LIO)
30 RPM
(3 Trials)
45 RPM
(3 Trials)
30 RPM
(3 Trials)
45 RPM
(3 Trials)
30 RPM
45 RPM
45 RPM
(6 Trials)
45 RPM
(6 Trials)
R-5
R-30
R-5
R-30
R-30
R-5
65 RPM
(6 Trials)

Appendix B

Learning Treatments		Transfer Treatments		
Instruction Conditions	Task Conditions	Rest Interval	Shift Conditions	Subjects (n=82)
Learning-Transfer-Instruction (LTI)	Speed and Path Varied (SPV)	Rest 5 Min.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
		Rest 30 Sec.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
	Speed Varied (SV)	Rest 5 Min.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
		Rest 30 Sec.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
	Path Varied (PV)	Rest 5 Min.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
		Rest 30 Sec.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
Learning-Instruction-Only (LIO)	Speed and Path Varied (SPV)	Rest 5 Min.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
		Rest 30 Sec.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
	Speed Varied (SV)	Rest 5 Min.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
		Rest 30 Sec.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
	Path Varied (PV)	Rest 5 Min.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
		Rest 30 Sec.	Hand Shifted	n=3
			Hand Not-Sifted	n=3
Control Treatments			Hand Shifted	n=5
			Hand Not-Shifted	n=5

The Experimental design for the Learning and Transfer Task