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Intertask Transfer of Skill Acquisition & Work Decrement as a Function of Degree of Task Similarity between Mental Practice Trials & Physical Performance

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INTERTASK TRANSFER OF SKILL ACQUISITION AND WORK DECREMENT AS A FUNCTION OF DEGREE OF TASK SIMILARITY BETWEEN MENTAL PRACTICE TRIALS AND PHYSICAL PERFORMANCE

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INTERTASK TRANSFER OF SKILL ACQUISITION AND WORK DECREMENT AS A FUNCTION OF DEGREE OF TASK SIMILARITY BETWEEN MENTAL PRACTICE TRIALS AND PHYSICAL PERFORMANCE

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"As of today I have found no final answers....The miracle is that the universe created part of itself to study the rest of it, and that this part, in studying itself, finds the rest of the universe in its own natural inner realities."

--- John C. Lily

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Intertask Transfer of Skill Acquisition and Work Decrement as a Function of Degree of Task Similarity Between Mental Practice Trials and Physical Performance

William Lambert White June 25, 1981 48 Pages

Directed by: Daniel Roenker, John O'Connor, and Sebastiano Fisicaro

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The focus of this study was on motor learning, or the human learning of movement. It is well documented that physical or mental practice of a motor skill followed by an adequate rest period can enhance subsequent performance of that skill. The literature shows that transfer of skill acquisition occurs as a function of the similarity of physical practice trials and the criterion task. In this study mental practice trials were substituted for physical practice trials. It was hypothesized that the transfer of skill acquisition would also occur as a function of the similarity of mental practice trials and the criterion task. A crucial element in the transfer of skill acquisition is the existence of an adequate rest period. Without that rest period, work decrement will not dissipate and subsequent performance will be depressed. It was the author's contention that task similarity not only affects the transfer of skill acquisition, but also the transfer of work decrement. Thus, a second hypothesis was that the intertask transfer of work decrement would occur as a function of the similarity of the mental practice trials and the criterion task. These hypotheses were examined via the use of a rotory pursuit task. College

students practiced this rotory pursuit task at either 30, 45, or 60 revolutions per minute (rpm). Then all subjects performed the criterion task at 45 rpm. Half of the subjects practicing at each speed received a rest period between practice and criterion trials, and half of the subjects did not. On the average, these experimental groups performed the criterion task much more successfully than control groups, who received no practice at all. This finding reaffirmed the utility of mental practice in the enhancement of physical performance. Of the groups that received rest periods, the greatest degree of skill acquisition was demonstrated when the subjects practiced and performed at 45 rpm. Less transfer of skill was demonstrated in the other two rest groups. This supports the first hypothesis of intertask transfer of skill acquisition as a function of task similarity between the mental practice trials and physical performance trials. Of the groups that received no rest periods, the maximum amount of work decrement was obtained when subjects practiced at 30 rpm. The other two no-rest groups demonstrated equal levels of performance. Thus, the second hypothesis of intertask transfer of work decrement as a function of task similarity between mental practice trials and physical performance trials was not supported. This unexpected finding was discussed as a joint function of (a) a miscalculation of the relative amounts of skill acquisition transfer and work decrement transfer and (b) varying degrees of task difficulty.

CHAPTER I

Literature Review

The study of learning has been the domain of psychologists for nearly a century. Verbal learning, operant conditioning, and classical conditioning have been the foci of a multitude of studies. However, the human learning of movement, or motor learning, has received comparatively less attention. Recently some psychologists have sought to rectify the relative neglect of the study of motor learning by investigating some of the factors which influence the human learning of movement. One of these factors is practice. Motor learning tends to be facilitated by actual physical practice of the target skill followed by a rest period (e.g., Singer and Milne, 1974). An example of physical practice would be rehearsing a motor skill on a pursuit rotor, which is a device commonly used in the experimental study of motor behavior, prior to the measurement of that motor skill. Not only is motor learning facilitated by physical practice, but it is also facilitated by mental practice of the target skill followed by a rest period (e.g., Richardson, 1967a). Unlike physical practice, the meaning of mental practice is not intuitively clear. Mental rehearsal involves a person mentally imaging himself engaged in a physical activity with

no concomitant gross muscular movements. For example, a person engages in mental practice when he sits quietly and in his imagination goes through the motions of a tracking task on the pursuit rotor.

Physical practice preceding the performance of a motor skill is not always beneficial. If there is little or no rest between the practice trials or between practice and actual performance, the quality of the motor performance will suffer (e.g., Bell, 1942). This decrease in quality of performance which follows practice with insufficient intertrial rest or which results from insufficient rest between practice and performance assessment is called work decrement. Work decrement can also be produced when the physical practice is replaced by mental practice. For example, when Rawlings and Rawlings (1974) followed mental practice immediately with performance appraisal (i.e., without the utilization of a rest period), they found evidence of work decrement. Additional similarities between mental and physical practice exist. Recent research by Kohl and Roenker (1980) suggests that skill acquisition and work decrement can occur even when mental practice trials are conducted using one hand and performance trials are done with the other hand. This phenomenon is called bilateral transfer. The findings of Kohl and Roenker (1980) regarding bilateral transfer as a function of mental practice complement earlier research done by Ammons (1958) which demonstrated bilateral transfer as a function of physical practice. Thus, the effects of mental

practice parallel those of physical practice in skill acquisition, work decrement, and bilateral transfer.

It was noted above that physical practice trials can enhance subsequent motor performance. The behavior which one performs during these practice trials need not exactly mirror the performance task; however, the greater the degree to which the physical practice trial resembles the performance task, the greater the effect of the practice on the performance (e.g., Baker, Wylie, and Gagne, 1950). This principle of intertask transfer applies equally to skill acquisition and work decrement. For example, physical practice of a pursuit rotor tracking task at 30 rpm followed by a rest period and a performance assessment at 45 rpm would produce some intertask transfer of skill acquisition. Likewise, physical practice at 30 rpm followed by a performance assessment at 45 rpm with no intervening rest period would produce some intertask transfer of work decrement. However, the greatest intertask transfer of skill acquisition or work decrement would occur when the physical practice task and performance appraisal both used the same pursuit rotor tracking speed.

Whether intertask transfer occurs when mental practice precedes performance appraisal is a matter of debate and is the major concern of this thesis. It is hypothesized that the parallel between the effects of mental rehearsal and physical rehearsal on subsequent performance appraisal can be extended to the domain of intertask transfer. Thus, it

is posited that intertask transfer of skill acquisition and work decrement will occur when mental rehearsal precedes the assessment of a motor skill.

Despite the relative neglect of motor learning in the literature, there are still a number of studies which are related to this thesis. The first topic which deserves examination is the facilitation of the performance of a motor skill by physical and mental rehearsal. The literature is replete with studies providing empirical support for the intuitive notion that physically practicing an act can result in increased proficiency at that act (e.g., Williams, 1969; Singer and Milne, 1974). It is less intuitive that motor skill can be enhanced by mental rehearsal. However, in a rather comprehensive review of the literature, Richardson (1967a; 1967b) found eleven studies that supported that contention. Unfortunately, many of these studies were marred by flaws in methodology and design. There has been considerable investigation of mental practice since the Richardson review.

Oxendine (1968) studied the effects of different schedules of mental and physical practice on the learning of a pursuit rotor task, a soccer kick task, and a jump shot task. For each task he used four groups of subjects. Though all four groups had the same total number of trials, each group had a different proportion of physical and mental rehearsal trials. He found that the combination of physical rehearsal and mental rehearsal could be just as effective in

skill acquisition as physical rehearsal alone. More specifically, he found no difference between the performance of groups which used 50% physical and 50% mental practice. Also, he found no relationship between intelligence and the ability to utilize mental practice. The implication of the study is that, to some extent, mental practice can yield the same skill-enhancing effects as physical practice.

Further support is offered by the work of Williams (1969). He compared the performance on a polar pursuit tracking task of groups using only mental practice, groups using only physical practice, and control groups. Also, he assessed the role of arousal on performance in the different groups. He found that the performance of the mental practice groups and physical practice groups was better than that of the control groups but that they were not different from each other. Also, he discovered no difference in arousal between the groups using mental practice and the groups using physical practice. The results imply that exclusive mental practice is as effective as exclusive physical practice in the learning of a motor skill. However, Corbin (1972), who performed a massive review of the mental practice literature, believes that contention to be somewhat of an overstatement. As a result of his work, Corbin concluded that mental practice definitely can enhance skilled motor performance, but he cautioned that it is not necessarily as effective as physical practice in all situations.

The case for the use of mental rehearsal as an aid to skill acquisition is strengthened by the work of Rawlings, Rawlings, Chen, and Yilk (1972). They used a mental rehearsal group, physical rehearsal group, and control group. When they evaluated each group's performance on a pursuit rotor task, they found the mental rehearsal and physical rehearsal groups to be significantly and equally better than the control group. Finally, Kohl and Roenker (1980) performed a study in which subjects received massed physical practice, massed mental practice, or no practice, followed by a rest period and the performance assessment. They used a pursuit rotor task. The results corroborate the findings of Rawlings, et al. in that they found both mental and physical rehearsal to be equally good at facilitiating motor performance. Thus, the forementioned eight references agree that mental rehearsal and physical rehearsal definitely can increase the proficiency with which one performs a motor skill. In addition, several of the references suggest that the magnitude of the proficiency increase does not differ as a function of the type of rehearsal when a pursuit rotor tracking task is used. This may be due to the fact that the relative novelty of that particular task to subjects eliminates the role of any previous experience with the specific motor task.

Another subset of the motor learning research which is particularly relevant to this thesis concerns the existence of work decrement. To reiterate, work decrement is the decrease in the quality of motor performance which occurs

when there is insufficient rest between practice and performance assessment, or when there is insufficient intertrial rest during practice. Most of the work decrement research deals with physical practice. For example, Bell (1942) had his experimental groups take rest periods of either 10 minutes, one hour, 6 hours, 24 hours, or 30 hours after the fifth of 20 training trials on a pursuit rotor. The control group received no rest period. When the performance of the control group was compared to the performance of the experimental groups, Bell found that all groups receiving rest periods did better than the controls regardless of the exact duration of the rest periods. Thus, this study suggests that work decrement accumulates during practice sessions and dissipates during rest.

In many studies of work decrement the length of the intertrial rest period has been manipulated. In an investigation by Dore and Hilgard (1937), subjects were given various amounts of practice and rest on a rotory task. One group had 1-minute practice trials with intertrial rest periods of 11 minutes. Other groups had 1-minute practice trials with 3-minute rest, 1-minute practice trials with 1-minute rest, and 3-minute practice trials with 1-minute rest. They found that the group with the longest intertrial rest period performed significantly better than the other groups. This was interpreted to demonstrate that, unlike the longer rest periods, the shorter intertrial rest periods did not allow

much dissipation of work decrement and consequently decreased the quality of performance.

Kimbel and Shatel (1949) used an inverted-alphabet printing task instead of a pursuit rotor to examine work decrement as a function of intertrial rest. They used intertrial rest periods of 0, 5, 10, 15, and 30 seconds between the practice trials. They found that only the group with 0 seconds rest differed from the other groups. This suggests that work decrement significantly inhibited performance only when intertrial rest was completely absent.

Further research of work decrement as a function of intertrial rest is supplied by Bourne and Archer (1956). They gave subjects 30-second practice trials accompanied by either 0, 15, 30, 45, or 60 seconds of intertrial rest. Then all subjects had a 5-minute rest period followed by a performance appraisal. They found that performance increased as the length of the intertrial rest period increased. These results were interpreted to mean that work decrement builds up more quickly in groups with shorter intertrial rest periods. This decrement leads to interference with skill acquisition and is reflected in the poorer performance of those groups. Despite the difference in the studies by Dore and Hilgard, Kimble and Shatel, and Bourne and Archer, they do agree that very short or nonexistent intertrial rest periods lead to comparatively poorer performance due to work decrement.

Other research on work decrement has concentrated not on intertrial rest periods, but rather on the rest periods between the cessation of practice and onset of performance appraisal. Ammons (1947) gave subjects 20 seconds, 1 minute, 3 minutes, 8 minutes, or 17 minutes of continuous practice on pursuit rotors, followed by 20 seconds, 2 minutes, 5 minutes, 10 minutes, 20 minutes, or 6 hours of rest. This was followed by 8 minutes of performance. He was especially interested in an index of work decrement called reminiscence, which was defined as the gain on the first post-rest trial over the predicted level on this trial if no rest period had been introduced. When examining reminiscence as a function of pre-rest practice, he found performance to increase as the amount of pre-rest practice increased---except for the 17-minute pre-rest practice group, which did somewhat worse than the 8-minute pre-rest practice group. The implication of this finding is that with the rest periods constant, performance is a function of the amount of time spent in physical practice; however, when the amount of time of physical practice becomes excessive, as in the 17-minute group, the associated work decrement is extensive enough to inhibit performance on the post-rest trials. When he examined reminiscence as a function of length of rest period, he found performance to increase as the rest period increased with a levelling off of performance after the 5-minute rest period. The implication of this finding is that with pre-rest practice constant, the work decrement dissipates as the rest

period approaches 5 minutes. It also indicates that a rest period in excess of 5 minutes does not allow any significant additional decrease of work decrement. Thus, in Ammons' search for optimum combinations of practice and rest, he reinforced the research suggesting that work decrement occurs when physical practice is very long or when rest periods following practice trials are quite short or absent altogether.

Kimble and Horenstein (1948) also used a rotory pursuit task to investigate work decrement. They gave subjects 10 practice trials followed by rest periods of either 10, 30, 150, 300, 600, or 1200 seconds. Then subjects were given performance trials. They found that the performance improved as rest periods increased up to 600 seconds and levelled off after 600 seconds. This demonstrates that less work decrement is present as the rest period increases, and that after the rest period exceeds 600 seconds, little further decrease of work decrement occurs.

Ammons (1950) used the same paradigm as Kimble and Horenstein (1948), except that the rest periods for his groups of subjects were 0 seconds, 20 seconds, 50 seconds, 2 minutes, 5 minutes, 12 minutes, and 24 hours. Results indicated that performance peaked when rest periods lasted 50 seconds or 2 minutes, and it levelled off when rest periods were longer. This suggests that rest periods of 0 seconds and 20 seconds are not sufficient for the necessary dissipation of work decrement, and rest periods of 5 minutes or more do not allow any additional significant reduction of work decrement.

In a similar study Koonce, Chambliss, and Irion (1964) had subjects practice a pursuit rotor task continuously for 5 minutes. This was followed by a rest period of either 0 minutes, 10 minutes, 1 day, 7 days, 35 days, 70 days, 175 days, 365 days, or 730 days. Then each subject's performance was assessed in a 5-minute trial. The researchers discovered that the group who received no rest between practice and performance was significantly worse than each of the other groups. Also, there was a nonsignificant tendency for reminiscence to decrease as the rest period exceeded one day. The results suggest that work decrement in the no-rest group inhibited performance while a rest period of at least 10 minutes was sufficient to dissipate a good deal of work decrement. Also, it appears that rest periods in excess of 1 day did not further appreciably decrease work decrement. Though the results of the studies by Ammons, Kimble and Horenstein, and Koonce et. al. suggest a different optimum rest period, all four illustrate the deficit in performance which can result from work decrement associated with little or no rest between practice and performance trials.

Work decrement can result from massed practice which is a combination of no intertrial rest periods and little or no rest between practice and performance trials (e.g., Kimble and Horenstein, 1948). Also, work decrement can result from certain instances of distributed practice where the intertrial rest period is very short (e.g., Bourne and Archer, 1956). There have been several studies in which the impact of these two

practice schedules on the work decrement phenomenon have been simultaneously studied. Bradley and Adams (1953) divided their subjects into 14 experimental and 2 control groups. One control group performed exclusively massed practice while the other control group used exclusively distributed practice with intertrial rest periods of 30 seconds. Seven of the experimental groups started with massed practice and switched to distributed practice after either 4, 6, 8, 11, 16, 21, or 26 trials. Seven of the experimental groups started with distributed practice and switched to massed practice after either 4, 6, 8, 11, 16, 21, or 26 trials. The researchers found that the control group using distributed practice did much better than the control group using massed practice. Also, they found that switching from distributed practice to massed practice hurt performance considerably and drove it down almost to the level of exclusive massed practice. In addition, they discovered that switching from massed practice to distributed practice improved performance, though not quite to the level of exclusive distributed practice. The implication of the study is that work decrement and poor performance can be maximized by massed practice.

Jensen (1966) utilized a more complex procedure in his investigation of massed and distributed practice. Instead of using a pursuit rotor he instructed subjects to tap three telegraph keys in random order to the beat of a metronome. The subjects were not informed that one of the three keys needed 14 times more force to depress. In condition A, the

subjects tapped the keys for 5 minutes at 208 taps per minute. In condition B, the subjects tapped the keys for 10 minutes at 104 taps per minute. In condition C, the subjects tapped the keys for a total of 10 minutes at 208 taps per minute. However, in this latter condition, each 10 seconds of tapping was followed by 10 seconds of rest. Jensen discovered that the heavy key, which he assumed to be an instrument for assessing work decrement, was tapped considerably less in the case of highly-massed practice (condition A) than in the cases of less massed practice (condition B) and distributed practice (condition C). Thus, the response requiring more work was more inhibited than responses requiring less work. This suggests that the inhibition is greater and the work decrement is maximized under conditions of highly-massed practice. Singer and Milne (1975) support these conclusions in their discussion of massed and distributed practice. Also, they note that the best length for the intertrial rest periods depends on the intensity and duration of the specific tasks.

The specific results of all the forementioned studies dealing with work decrement vary due to the presence or absence of intertrial rest, length of practice trials, nature of the task, and length of rest between practice trials and performance trials. However, all the studies agree that the phenomenon of work decrement is real and can result from the lack of a sufficient rest period during the practice schedule.

Not only do the phenomena of skill acquisition and work decrement exist when one practices and performs a task with

with the same limb, they also exist when the task is practiced with one limb and performance is appraised using the other limb. Thus, practice with one limb followed by a rest period and opposite-limb performance evaluation with no intervening rest period can demonstrate bilateral intertask transfer of work decrement (Irion and Gustafson, 1952; Grice and Reynolds, 1952; Walker, DeSoto and Shelly, 1957; Ammons, 1958; Albright, Borrensen and Marx, 1957; Ammons and Ammons, 1970; Singer and Milne, 1975). Also, this bilateral transfer of skill acquisition and work decrement has been shown to occur when mental practice replaces physical practice (Corbin, 1972; Rawlings and Rawlings, 1974; Kohl and Roenker, 1980), which further illustrates the parallel between the effects of physical and mental practice.

The intertask transfer of skill acquisition and work decrement is largely dependent on task similarity. The greater the degree to which a practice trial resembles a performance task, the greater the effect of the practice on the performance. Thus, both work decrement and skill acquisition are said to be maximized when the practice task and the performance task are the same. Lincoln and Smith (1951) constructed their own visual tracking instrument to assess if physical training at certain target speeds affected performance at certain target speeds. They trained subjects for a total of 20 minutes at either 23, 30, or 37 rpm. After a rest period, each group was tested at their own speed and the other two speeds. They found that the best performance at

30 rpm was exhibited by the group trained at 30 rpm, and the best performance at 37 rpm was exhibited by the group trained at 37 rpm; however, the best performance at 23 rpm was obtained by the group who practiced at 30 rpm. The researchers could not explain the latter result except to attribute it to some specific factor involved in training at 23 rpm. Thus, this study offers only partial support for the expected effect of task similarity on intertask transfer.

More compelling support is offered by the work of Ammons, Ammons, and Morgan (1954). They had subjects practice a pursuit rotor task at speeds of 40, 50, 60, or 70 rpm. This was followed by a rest period and an appraisal in which some groups performed at unfamilar speeds. The results indicated that the groups who practiced and performed at the same speed did much better than groups who switched speeds from faster to slower or from slower to faster. A related study was performed by Lordahl and Archer (1958). They instructed three groups to perform a pursuit rotor task at either 40, 60, or 80 rpm. After a rest period, all the groups were tested on the task at 60 rpm. They found that the 60-60 group not only hit the target more frequently, but also made significantly more hits of longer duration than the 40-60 or 80-60 groups. The latter two groups were only slightly different from each other. They interpreted this as evidence of differential transfer as measured by level of performance as a function of target speed on practice trials. Thus, the superior performance of the 60-60 group and only the slight

difference between the 40-60 and 80-60 groups tend to support the expected effect of task similarity on the intertask transfer of skill acquisition.

Further support is offered by Baker, Wylie, and Gagne (1950). They used a crank-powered target pursuit task which could be driven at four rates of speed. Five groups practiced at one rate and were then assessed at a different rate. Three groups received no practice and then performed at various rates. With rate of target speed during performance held constant, they found that the groups who received training at any rate did better than those groups who received no training at all. Also, they found that the relative amount of skill transfer which was obtained depended on the degree of resemblance between the rates. Thus, the crucial factor was the degree of similarity between practice and criterion trials.

A study conducted by Leonard, Karnes, Oxendine, and Hesson (1970) yielded similar findings. They had groups practice a pursuit rotor tracking task at either 30, 40, 45, 50, or 60 rpm. Subsequent performance assessment was conducted at 45 rpm for all groups. Analysis revealed that the groups which practiced at 30 rpm and 60 rpm were on target much less during the performance appraisal than were the groups which practiced at the other speeds. Day (1956) believes that results such as these suggest an inverted-U-hypothesis for task similarity in an intertask transfer situation. In essence this hypothesis states that the closer the speed of the practice trial to the speed of the criterion trial, in the presence of adequate rest, the more easily the

skill acquired during the practice trial will transfer. It also posits that transfer decreases as the practice trial and criterion task become more dissimilar. This formulation of the effect of task similarity on the intertask transfer of skill acquisition is supported by Singer and Milne (1975) in their review of the motor learning research.

The author contends that the hypothesis of Day (1956) can be expanded to include the effect of task similarity on the intertask transfer of work decrement. According to the contention, work decrement should increase as the criterion task becomes more similar to the practice trial and as the rest period between the two becomes smaller. This expansion of Day's hypothesis is consonant with what is already known about the nature of work decrement. It is known that work decrement accumulates during physical practice and dissipates during a rest period (e.g., Ammons, 1947), and it is known that bilateral intertask transfer of work decrement is possible (e.g., Kohl and Roenker, 1980). As mentioned earlier, the more that similarity exists between the two tasks, the more transfer of skill will occur. This will result in an increase in performance. The author contends that similarity is also important in the case of work decrement. The greater the similarity between practice and performance trials, the more work decrement will transfer. This work decrement is a negative factor which depresses performance. Thus, the author posits a U-shaped curve of work decrement where maximum transfer, and hence most depressed performance, will occur where practice and criterion tasks are identical.

In sum, it is well documented that the physical practice of a motor skill followed by an adequate rest period can enhance subsequent performance of that skill. Likewise, mental practice followed by an adequate rest period can enhance subsequent performance. However, if the rest period following the physical practice or mental practice is not sufficient, work decrement will not dissipate; and consequently, performance will be depressed. Furthermore, the transfer of skill acquisition occurs as a function of the similarity of the practice trials and criterion tasks. The author suggests that transfer of work decrement also occurs as a function of the similarity of practice and criterion tasks. Thus, both skill acquisition and work decrement are more likely to occur as the practice situation more closely approximates the performance situation. However, the U-hypothesis of the effect of task similarity on intertask transfer has thus far been applied only to studies involving physical practice. This investigation seeks to extend the parallel between physical and mental practice by extending the U-hypothesis to mental practice and by combining this extension with what is already known about the transfer of skill acquisition and work decrement. It is the contention of the author that this study will demonstrate the intertask transfer of skill acquisition and work decrement as a function of the similarity between practice and criterion trials. Further, it is posited that the results, which will be obtained by the use of mental practice, will resemble the results which would have been obtained by the use of physical practice.

CHAPTER II

Method

Subjects

A sample of 160 right-handed students drawn from psychology and physical education classes at Western Kentucky University were randomly assigned to one of eight groups. During recruitment, right hand dominance and naivete to the pursuit rotor were established. The criterion for right hand dominance was the subject's own assessment. All subjects were tested individually or in pairs.

Design

The experiment represents a 4 (practice conditions) by 2 (rest/no-rest) by 3 (trial blocks) mixed factorial design with repeated measures on the last variable. However, the experiment was not analyzed as a 4x2x3. Such an analysis would include a rest/no-rest main effect, which would compare pooled rest groups with pooled no-rest groups, including the two control groups. This comparison would not be useful, and the degree of freedom associated with it was required for a more meaningful comparison. Thus, the experiment was analyzed as an 8 (treatment conditions) by 3 (trial blocks) factorial, with a breakdown of the seven treatment degrees of freedom into seven orthogonal contrasts.

Apparatus

The principal apparati were two Lafayette photoelectric pursuit rotors (model number 30014). The circle template was used with speeds of target revolution set at 30, 45, or 60 rpm, depending upon the experimental condition. The rotory pursuits were connected to Tenor timers (model number 6010-BF), which programmed the rotory pursuits for alternating 30-second practice and 8-second rest periods. Two Lafayette universal timers (model number 58007) recorded the subjects' total time on target for each trial. Tape recordings of a standard electronic metronome, which was set at either 30, 45, or 60 beats per minute, were utilized during the practice period. Both rotory pursuits were checked for accuracy between subjects. The cassette tape recorder was checked periodically to insure its accuracy.

Procedure

Upon entering the room, each subject was randomly assigned to one of eight groups: (1) 30 rest, (2) 45 rest, (3) 60 rest, (4) 30 no-rest, (5) 45 no-rest, (6) 60 no-rest, (7) control rest or, (8) control no-rest. These eight groups represented various combinations of mental practice speeds and rest period presence/absence. A more detailed explanation of the groups will follow. Practice conditions for each group consisted of 10 30-second mental rehearsal trials alternating with 10 8-second rest intervals. The practice conditions were preceded by an introduction of the pursuit rotor and by a cueing procedure which was designed to enhance

mental imagery (see Appendix). A metronome was set so that it clicked either 30, 45, or 60 times per minute depending on the target speed associated with that particular practice condition. Each subject was instructed to note that one click on the metronome would correspond to one revolution of the target. Performance appraisal for each group consisted of 9 30-second trials alternating with 10 8-second rest periods. The target speed for these performance appraisal trials was 45 rpm. All rest groups received a 9-minute rest period between the practice and performance conditions, during which time subjects read magazines or chatted with the experimenter. All no-rest groups received only the regular 8-second rest period following the tenth practice trial and preceding the performance appraisal.

30 rest: Each subject observed the experimenter perform two left-handed 30-second trials on the rotory pursuit at a target speed of 30 rpm. During this time, the experimenter explained how the task was performed and the importance of the tape-recorded clicks. The subjects then filled out some demographic information. Then each subject entered the practice condition. A rehearsal trial consisted of the subject creating a left-handed mental imagery performance of himself on the pursuit rotor. During the imagery session, the subject held the stylus with his left hand. Also, the subject was instructed to close his eyes and avoid making overt movements during mental imagery. This was followed by an 8-second intertrial rest period. The practice-rest

sequence was repeated eight times (see Appendix). Then the subject received a 9-minute rest period in which to read magazines. This was followed by the performance appraisal.

45 rest: This condition was the same as 30 rest except that the experimenter demonstrated the rotory pursuit at a target speed of 45 rpm, and subjects mentally imaged at 45 rpm.

60 rest: This condition was the same as 30 rest except that the experimenter demonstrated the rotory pursuit at a target speed of 60 rpm, and subjects mentally imaged at 60 rpm.

30 no-rest: This condition was the same as 30 rest except that the 9-minute rest period was eliminated. Only the regular 8-second rest period following the tenth practice trial preceded the performance appraisal.

45 no-rest: This condition was the same as 45 rest except that the 9-minute rest period was eliminated.

60 no-rest: This condition was the same as 60 rest, except that the 9-minute rest period was eliminated.

Control rest: Each subject read a magazine or chatted with the experimenter for the time equivalent to the practice trials. They continued reading during the 9-minute rest period. The rotory pursuit was disconnected during this time. Their performance was assessed in the same way as the performance of the other groups.

Control no-rest: Each subject read a magazine or chatted with the experimenter for the time equivalent to the practice trials. The pursuit rotor was not connected during this time. Then they received the same performance appraisal as the control rest group.

CHAPTER III

Results

Performance was assessed by measuring the time that each subject kept the stylus on the rotating target. These measures were converted into percentages. For each subject the nine performance trials were condensed into three trial blocks. The first three trials formed the first trial block, the second three trials formed the second trial block, and the remaining three trials formed the third trial block. This was done in order to stabilize the dependent variable. This process yielded three scores for each subject in each of the eight treatment groups. This resulted in a 8 x 3 mixed factorial design. An analysis of variance was used to evaluate the main effect of treatments, main effect of trials, and possible interaction between the two. The summary table for this overall analysis can be found in Table 1.

The mean percentage time-on-target and standard deviations as a function of treatment conditions and trial blocks is presented in Table 2. In order to assess the main effect of treatments, the data was collapsed across trial blocks and is represented by the row means in Table 2. The analysis revealed an overall effect of treatment conditions, $\underline{F}(7,152) = 10.19$; $p < .001$. Since this was the primary focus of the

TABLE 1

Orthogonal Comparisons and ANOVA Summary Table

Comparison 1: CR vs CNR
Comparison 2: CR, CNR vs 30R, 30NR, 45R, 45NR, 60R, 60NR
Comparison 3: 30R, 45R, 60R vs 30NR, 45NR, 60NR
Comparison 4: 30R vs 60R
Comparison 5: 30R, 60R, vs 45R
Comparison 6: 30NR vs 60NR
Comparison 7: 30NR, 60NR vs 45NR

Source	SS	df	MS	F	p
Total	4915.00	479			
Between Subjects	1452.76	159			
Treatments	463.99	7	66.29	10.19	.0001
Comparison 1	.44	1	.44	1	N/S
Comparison 2	215.77	1	215.77	33.17	.0001
Comparison 3	84.83	1	84.83	13.04	.001
Comparison 4	1.24	1	1.24	1	N/S
Comparison 5	87.50	1	87.50	13.45	.001
Comparison 6	56.72	1	56.72	8.72	.01
Comparison 7	17.49	1	17.49	2.69	N/S
Error (b)	988.77	152	6.51		
Within subjects	3462.24	320			
Trials	224.21	2	112.11	10.55	.001
Treatment x trials	6.78	14	.48	1	
Error (w)	3231.25	304	10.63		

TABLE 2

Mean Percentage Time-on-Target and Standard Deviations as a Function of Treatment Conditions and Trial Blocks

Treatments	Trial Block 1	Trial Block 2	Trial Block 3	$\overline{X}$s
30 rpm Rest (30R)	6.48 (2.64)[a]	7.85 (2.85)	7.90 (2.87)	7.41 (2.79)
30 rpm No-rest (30NR)	4.23 (2.03)	5.66 (2.06)	5.66 (1.91)	5.18 (2.00)
45 rpm Rest (45R)	9.10 (3.47)	10.83 (3.20)	10.36 (2.72)	10.10 (3.13)
45 rpm No-rest (45NR)	6.37 (2.81)	8.10 (3.34)	8.10 (3.17)	7.52 (3.11)
60 rpm Rest (60R)	7.00 (2.82)	8.13 (3.43)	8.15 (3.29)	7.76 (3.18)
60 rpm No-rest (60NR)	6.54 (3.32)	8.12 (3.51)	8.03 (3.49)	7.56 (3.44)
Control Rest (CR)	3.84 (2.44)	5.23 (2.60)	5.37 (2.45)	4.81 (2.50)
Control No-rest (NR)	4.14 (2.16)	5.53 (2.24)	5.39 (2.43)	5.02 (2.28)
$\overline{X}$s	5.96 (2.71)	7.43 (2.90)	7.37 (2.79)	

Note: [a]standard deviation

study, a further investigation of these results will be presented later. In order to assess the main effect of trials, the data were collapsed across treatment groups and is represented by the column means in Table 2. The analysis revealed an overall effect of trials, $F(2,304)=14.795$; $p<.001$. The average performance of the subjects increased significantly from Trial Block 1 to Trial Block 2. This was followed by little change in performance from Trial Block 2 to Trial Block 3.

The final part of the initial analysis involved the assessment of a treatment-by-trials interaction. This interaction was not found to be significant, $F(14,304)< 1$. Thus, the effect of treatment conditions is not dependent on whether one is examining the first, second, or third trial block.

Of more major concern is the overall effect of treatment conditions. After this overall effect was found to be significant, a more in-depth analysis of the data was performed. The understanding of the results of this detailed analysis may be facilitated by referral to Figure 1, which presents the performance of subjects pooled across trial blocks as a function of treatment conditions. The figure helps one to recognize the relative performances of the subjects in various treatment conditions. A series of orthogonal comparisons, which are presented in Table 1, were used to assess the effects of mental practice, rest periods, and various target speeds on the subjects' rotory pursuit performance.

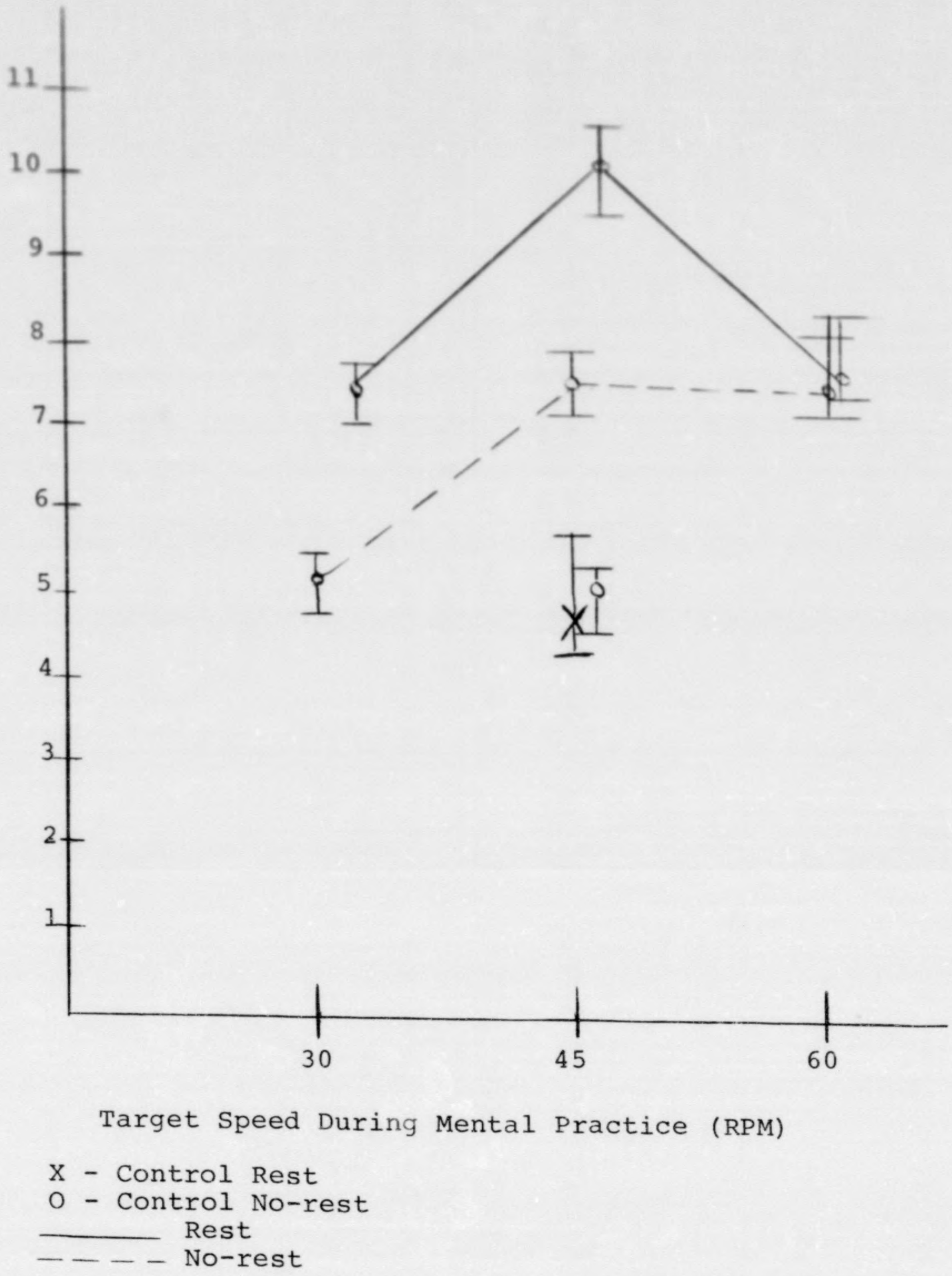

Figure 1. Mean Percentage Time-on-Target Pooled Across Trial Blocks as a Function of Treatment Conditions

The first orthogonal comparison revealed that there was no difference between the performances of the two control groups, $F(1,152) < 1$. This result was in agreement with the hypothesis, in that no performance differences would be expected if neither group engaged in practice.

The second comparison showed that the average of all the groups that engaged in mental practice exceeded the average of the control groups, $F(1,152)=33.17$; $p < .0001$. This finding reaffirms the utility of mental rehearsal in the enhancement of physical performance. Also, this suggests that mental practice aids performance more than no mental practice, regardless of whether the imaged target speed exactly matches the target speed used on the criterion task.

The third comparison found that the average of the groups which were allowed to rest between practice and criterion trials significantly exceeded the average of the groups which were allowed no such rest period, $F(1,152)= 13.04$; $p < .001$. This supports the contention that work decrement, which is the decrease in quality of performance following practice with no subsequent rest period, did occur. Further, it suggests that this work decrement dissipated during the rest period, thus increasing the scores of those groups.

The groups which received rest periods were examined more closely. The fourth comparison revealed that the groups practicing mentally at 30 rpm and 60 rpm and then receiving a rest period performed equally well, $F(1,152) < 1$, when

tested at 45 rpm. The fifth comparison showed that the group which practiced at 45 rpm and then rested stayed on target more than the pooled rest group which practiced at 30 rpm and 60 rpm, $\underline{F}(1,152)=13.45$; $p < .001$. Thus, the highest level of performance was obtained by the group in which the practice and criterion target speeds were identical and in which there was a rest period between mental and physical trials. These two comparisons provide evidence for the hypothesized intertask transfer of skill acquisition as a function of the degree of similarity between practice and criterion tasks.

The sixth and seventh comparisons concentrated on the groups which did not receive a rest period between mental practice and physical performance. The sixth comparison revealed that the group which practiced at 30 rpm and received no rest period was on target significantly less than the group which practiced at 60 rpm and received no rest period, $\underline{F}(1,152)=8.72$; $\underline{p} < .01$. This finding ran counter to the hypothesized similarity between the 30 rpm and 60 rpm groups. The seventh comparison revealed that the pooled performance of these two groups was not significantly different from the performance of the group which practiced at 45 rpm and received no rest period, $\underline{F}(1,152)=2.69$; $\underline{p} > .05$. However, the interpretation of this latter finding should be made only in conjunction with a referral to Figure 1. The figure illustrates that the performance of the no-rest groups practicing at 45 rpm and 60 rpm were quite similar while the average time-on-target of the no-rest group which practiced

at 30 rpm was considerably less. The relative inferiority of the performance of the 30 rpm group was not expected; rather, it was hypothesized that the 45 rpm group would have the least time-on-target of all the no-rest groups. Thus, the hypothesis of intertask transfer of work decrement, which posited the 30 rpm and 60 rpm groups to be equal to each other and superior to the 45 rpm group, was not supported by the data.

In sum, several key points should be noted. There was a main effect of treatment conditions. Subsequent orthogonal comparisons revealed that the pooled mental practice conditions were superior to no mental practice at all. Also, it was found that mental practice followed by a rest period, which allowed the dissipation of work decrement, had a more positive effect on performance than mental practice followed by no rest period. In addition, the hypothesis of intertask transfer of skill acquisition as a function of task similarity was supported. This hypothesis suggests that the maximum amount of skill acquisition would be obtained by the groups that practiced at 45 rpm, rested, and performed at 45 rpm. However, the hypothesis of intertask transfer of work decrement as a function of task similarity was not supported. The relatively high score of the no-rest group that practiced at 45 rpm and the comparatively low score for the no-rest group which practiced at 30 rpm did not support the hypothesized U-function.

Finally, there was a main effect of trial blocks, in that scores increased dramatically from Trial Block 1 to Trial Block 2 and changed little from Trial Block 2 to Trial Block 3.

CHAPTER IV

Discussion

Most of the results of this study are consistent with the majority of mental practice research. The results clearly demonstrate that mentally practicing a motor skill will aid in one's learning of that motor skill. In this regard, the presence of a rest period following the mental rehearsal is not important. Groups which were allowed the rest period and groups which were denied the rest period both outperformed the control groups on the criterion task. The role of rest periods becomes more crucial when one considers the degree to which mental rehearsal enhances performance. The fact that the groups which received rest periods performed better than the groups who did not have rest periods suggests that the inclusion of rest periods can accentuate the beneficial effects of mental practice. This accentuation is related to the phenomenon of work decrement. Schedules of massed practice, which according to Kimble and Horenstein (1948) are capable of manufacturing work decrement, were used with all six experimental groups. The rest period for half of these experimental groups was designed to allow the dissipation of work decrement. Thus, the performance of the rest groups was superior to the other groups because the accumulated work decrement had been reduced during the rest period.

This suggests that the effect of mental practice can be maximized by inserting rest periods after the practice and prior to the assessment of the designated motor skill. In that regard, it appears that the results of this study parallel the results of explorations of work decrement as a function of physical practice. Thus, it appears that the findings of this study concerning the presence and dissipation of work decrement and the role of mental practice in skill acquisition serve to further the case of the parallel between physical and mental practice.

The other hypotheses of intertask transfer of skill acquisition and work decrement as a function of task similarity were less well grounded in the literature. Some studies have shown that in the case of physical practice, the more the physical practice trial approaches the performance trial, the greater the amount of transfer of skill acquisition. In the current study of mental practice, this phenomenon of intertask transfer of skill acquisition as a function of task similarity was found. When the work decrement was allowed to dissipate, the maximum transfer of skill occurred when the practice trials and criterion task were identical. Lesser degrees of transfer were found in the groups which practiced at speeds either faster or slower than the speed used for the criterion task. Though there were no studies in the physical practice literature suggesting an intertask transfer of work decrement as a function of task similarity, this study hypothesized that the processes would be similar

and posited a U-function of intertask transfer of work decrement. It was thought that the maximum amount of transfer of work decrement would occur when the speed of the practice trials and the criterion task were identical. Also, it was expected that less work decrement would accrue in the two groups which practiced at speeds either faster or slower than the criterion speed. However, this was not the case. As can be seen in Figure 1, the group which practiced at 45 rpm and received no rest period performed much better than anticipated and in fact performed as well as the group which practiced at 60 rpm. A second unexpected finding was the dismal performance of the group which mentally practiced at 30 rpm and received no rest period. Thus, the unexpected results could be reduced to three key questions: (a) Why was the performance of the 45 no-rest group so high? (b) Why was the performance of the 30 no-rest group different from the 60 no-rest group? (c) Why was the performance of the 30 no-rest group so low?

First, one must consider the unexpected magnitude of the scores of the 45 no-rest group. It is possible that the discrepancy between hypothesized and actual performance in this case comes from a miscalculation of the relative importance of the phenomena of intertask transfer of work decrement and intertask transfer of skill acquisition. As noted earlier, skill acquisition is a positive factor which would enhance performance, and work decrement is a negative factor which would depress performance. It was hypothesized that

both factors would maximally transfer when practice and performance trials were conducted at the same speed. Also, it was posited that the absence of a rest period would cause the negative factor to dominate the positive factor. It is entirely possible that the significance of the similarity of practice trial and performance task, particularly the effect of this similarity on skill acquisition, was underestimated. It appears that there was much transfer of learning in the 45 no-rest group, which was primarily a function of task similarity. Further, it appears that even the effects of work decrement were not strong enough to counteract the strong effects of intertask transfer of skill acquisition. Thus, this miscalculation of the relative amounts of skill transfer and work decrement transfer could account for the unexpectedly high scores of the 45 no-rest group.

The problem of the relative performance of the 30 no-rest and 60 no-rest groups is less easily handled. An investigation of these results necessitates the introduction of the idea of task difficulty. It can be reasonably assumed that practicing at a slow speed and then immediately performing at a faster speed is more difficult than practicing at a fast speed and then performing at a slower speed. In the former case, the change would require the person to take in and process more information (i.e., more completed revolutions of the target) in the alloted time. In the latter case, the change would require the person to take in and process less information (i.e., less completed revolutions of the

target) in the allotted time. An assumption is that it is more difficult to quickly increase the amount of information one takes in and processes than it is to decrease it -- perhaps because the increase requires greater amounts of effort and energy expenditure. If one accepts the premise of differential task difficulty, then the group practicing at 30 rpm would have a higher amount of task difficulty, and the group practicing at 60 rpm would have a lower amount of task difficulty. Support for this assumption includes the comments of members of the 30 rpm and 60 rpm groups. The members of the 30 rpm groups often mentioned the increased criterion speed, and the members of the 60 rpm groups made very few remarks about the criterion speed.

It is possible that this difference in task difficulty was potentiated in the presence of work decrement and produced the results. It is possible that work decrement produces a certain state in the individual which makes him more susceptible to variations in task difficulty. This state of increased susceptibility in the groups in which work decrement accrued and did not dissipate (i.e., groups with no rest periods) may be a function of time. The work decrement groups received no 9-minute rest, and consequently, the practice and criterion trials occurred quite close together in time. This temporal pairing may have made the differences in speed between practice and criterion trials more readily apparent. However, with a 9-minute break between the practice and criterion trials, the differences in speed were less

apparent to the subjects in the rest groups due to a loss of information. This loss of information is assumed to be uniform across the rest groups. However, the information loss was not complete; this is reflected in the higher performance of the rest groups as compared to the no-rest groups. This information loss factor could explain why there was no effect of task difficulty in the groups which received rest periods designed to dissipate work decrement. Thus, it appears that in the presence of work decrement, the effect of task difficulty is maximized. This would cause the difference between the scores of the 30 rpm and 60 rpm groups. Furthermore, it would cause the difference to be in the direction obtained, i.e., the 30 no-rest group would score lower due to the greater difficulty of that task and the 60 no-rest group would score higher due to the lesser difficulty of that task. So it appears that task difficulty may account for the discrepancies between the hypothesized and obtained results of the 30 no-rest and 60 no-rest groups. Also, it appears that the results of the 45 no-rest group could be due to the miscalculation of the relative importance of the phenomena of transfer of work decrement and transfer of skill acquisition.

There is an alternative explanation of the relative performances of the no-rest groups. It is possible that the sizeable contrast between practice at 60 rpm and performance at 45 rpm produced a psychological release from work decrement, i.e., the change in information load was of sufficient magnitude to offset whatever inhibiting factors were in

operation. Thus, the performance of the 60 no-rest group was elevated due to this release from work decrement. The 30 no-rest and 45 no-rest groups did not experience this release. Consequently, their performance reflects only the combined effects of skill acquisition and work decrement. Such an explanation is consonant with the assumption that work decrement and skill acquisition are additive factors which work in opposition to each other to determine the actual level of performance.

Most of the results of this study are consistent with the literature and support the hypotheses; however, in retrospect, the failure to find the intertask transfer of work decrement is not surprising. The assumption of work decrement as a "simple" phenomena akin to skill acquisition has no widespread support. Thus, the argument that work decrement should show the same intertask transfer properties as skill acquisition is somewhat flawed. One should note that the literature has many studies of intertask transfer of skill acquisition which utilize physical practice, but no such studies of intertask transfer of work decrement exist. It would be beneficial to the area of motor learning if this situation was remedied. A carefully controlled study of the intertask transfer of work decrement, using physical practice instead of mental practice, would be desirable. If the results of that experiment mirror the results of the current endeavor, it would provide some support for the idea of work decrement accentuating the effects of task difficulty. A

further investigation into the nature of work decrement and factors which affect it would be integral to a better understanding of motor learning.

The study of motor learning is still a young and largely untapped area. Especially in view of this, it is imperative that the findings of this experiment be replicated. If replicable, this study suggests future areas of investigation. To what degree does mental practice parallel physical practice? Are the parallels only similar effects, or are there similar mechanisms underlying physical and mental practice? What is the nature of these mechanisms? Are they central or peripheral? What are the roles of these mechanisms in intertask transfer? Future endeavors which attempt to answer questions such as these will shed more light on the factors affecting the human learning of movement.

APPENDIX

APPENDIX

<u>Introduction to experiment and cueing procedure</u>

Please pay close attention; it is essential that you have a clear understanding of what is about to be said. In order to insure accurate and valid testing, it is requested that you not discuss the proceedings with other students.

This is a rotory pursuit apparatus. It is used to measure hand-eye coordination. (Experimenter picks up stylus with left hand). One needs to grasp the stylus with the left hand, then assume a comfortable standing position with shoulders facing the apparatus. (Experimenter demonstrates described position). Place the tip of the stylus on the target. (Experimenter places stylus tip on target and starts apparatus with opposite hand). To be successful at this task, one must always keep the tip of the stylus on the rotating target. Make one distinct and continuous movement while following the rotating target with the stylus. (Experimenter pursues target). Do not make a discrete or jerky movement. (Experimenter demonstrates). If I were to hand you the stylus right now, would you know what to do with it?

Listen to the ticks on this tape. (Experimenter turns on tape). Note that the light is approximately at this part of the circle when you hear the tick. (Experimenter pursues

target and tape remains on for 2 30-second trials). Do you have any questions about the relationship between the speed of the target and the ticks on the tape? (Experimenter answers questions only with restatements of above).

Please fill in your name, age, and birthdate on this form. (Experimenter resets the rotory pursuit to 45 rpm, if necessary, while S fills in the form).

Instructions for practice trials

You will have 9 30-second practice trials. Between practice trials you will have 8 seconds in which to rest. Grasp the stylus with your left hand.

Sit on the stool which has been provided for you. You are to mentally rehearse the rotory pursuit task. Mental rehearsal refers to imagining the task is one of pursuing the target with the stylus. Conceptualize and create a mental image of yourself performing this task. You may wish to close your eyes. For the duration of each practice trial, imagine yourself making a distinct and fluid movement with the stylus. Try to get "the feel" of executing this task by imagining yourself performing this task as precisely as possible. Do you have any questions? While you are imagining, you will hear a series of ticks. These ticks will help you imagine the speed at which the target is rotating. As you remember from my demonstration, each tick corresponds to one revolution of the target. Can you explain to me what I want you to do in your own words? (Experimenter asks this randomly of one of the subjects). Do you have any questions?

(Experimenter asks this of the other subject). It is very important for the validity of this test to carry out the instructions to the best of your ability.

When you hear the ticking start, begin mentally following the target with the stylus. When the ticking stops, rest. When the ticking resumes, immediately begin mentally following the target again. You will have 9 30-second practice trials which will alternate with brief rest periods. Do you have any questions regarding the procedure? (Experimenter answers all questions with restatements of the above).

This project is the result of many man-hours of research and considerable expense. Please follow the instructions exactly. Assume a ready position with the stylus in your left hand. Remember that you are conceptualizing the task without any overt movement. <u>Do not move the stylus</u>. Create an image for the entire trial that corresponds with the ticks. (Experimenter turns on tape. When Experimenter hears the warning click, he asks) Ready? When the ticking starts, begin imagining. (When ticking stops after first trial, Experimenter says) Stop imagining. (At end of rest period number one, Experimenter says) It is important to image for the full 30 seconds at the speed indicated by the ticks. (During rest period number three, Experimenter says) Stop imagining. (At end of rest period number three, he says) Get ready to start again. (During the rest period number four, Experimenter says) You're doing just fine so far. (During rest period six, Experimenter says) Remember to image

for the full 30 seconds. (During rest period number eight, Experimenter says) It is important to image for the full 30 seconds at the speed indicated by the ticks.

Instructions for interim rest period

Now you will have some time to read through these magazines. I will let you know when we will proceed. It is important that you respond quickly to the instructions that I will give you at that time.

Instructions for performance trials

Stand up. Put the stylus on the center of the glass -- not on the target. When the target starts moving, perform the task just like I demonstrated and just like you imagined (These latter five words are used only where applicable). (Experimenter starts performance trials from control board. As soon as the target stops, Experimenter says) Keep the stylus away from the light whenever the target is not rotating. Get ready to being again.

(Experimenter gives positive reinforcement, such as "Good job", "You're doing fine", etc. after the first, second, fifth, seventh, and eighth trials).

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