Work Decrement and Facilitation of Performance as a Function of the Accuracy of Mental Imagery

Maxwell Turner

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WORK DECREMENT AND FACILITATION OF
PERFORMANCE AS A FUNCTION OF
THE ACCURACY OF MENTAL IMAGERY

A Thesis
Presented to the Faculty
Department of Psychology
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
of the Requirement for the
Master of Arts Degree

Maxwell Kevin Turner
September, 1982
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WORK DECREMENT AND FACILITATION OF PERFORMANCE AS A FUNCTION OF THE ACCURACY OF MENTAL IMAGERY

Recommended September 16, 1982

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Approved October 19, 1982

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The purpose of this study was twofold: to determine the relationship between accuracy of the image and work decrement and to investigate the relationship between accuracy of the image and facilitation of performance. A total of 36 right-handed undergraduates were tested on the rotor pursuit operating at 45 rpm and asked to imagine themselves actually tracking the target with the stylus. During the imagery trials the subjects verbalized the word "top" each time their image made one complete revolution. Each subject engaged in 9 30-sec imagery trials which were followed by either an 8-sec rest and then 9 30-sec performance trials (no-rest condition) or a 5-min rest and then 9 30-sec performance trials (rest condition). Each subject attended two sessions seven days apart. During the first session the subjects received either the rest or no-rest condition, and during the second session the subject received the other condition. The order in which the rest and no-rest conditions were administered was counterbalanced across subjects so that half received the rest condition first while the other half received the no-rest condition first. Accuracy of the image was measured by the number of "tops" the subject verbalized during each 30-sec imagery trial. Performance was measured by the total time the subjects kept the stylus over the rotating target during each 30-sec performance trial.

A regression analysis showed that accuracy of the image predicted overall performance. This finding supports previous research which
indicates that performance increases as the similarity of practice and criterion tasks increases. A second regression revealed that accuracy of the image, for under imagers and accurate imagers, did not predict work decrement. This outcome supports White's (1981) results that under and accurate imagers accumulate equivalent amounts of work decrement. Finally, the author discusses a possible mechanism involved in producing the apparently equal levels of work decrement for both under and accurate imagers. It is speculated that perhaps the apparent level of work decrement for those who under image is exaggerated by an abrupt change in information density.
CHAPTER I

Literature Review

The human learning of motor tasks (i.e., motor learning) has long been an area of research in psychology and physiology. Much of the early research in motor learning dealt with enhancing performance. It was discovered that physically practicing a task increases subsequent performance on that task (Ammons, 1947). However, it was also discovered that subjects who practice continuously, without appropriate rest periods between trials, perform worse than subjects who have appropriate rest periods between trials (Bell, 1942). This inhibition of performance due to a lack of appropriate rest periods between practice trials is called work decrement. In addition, it has been found that physically practicing with one limb not only facilitates performance with that limb but also facilitates performance with the contralateral limb. Ammons (1958) called this phenomenon bilateral transfer. Finally, the degree to which physical practice facilitates performance either unilaterally or bilaterally is dependent upon the similarity between practice and performance tasks (Lordahl & Archer, 1958).

Physically practicing a motor task is not the only way to enhance performance. Research has shown that imagining oneself performing a task without any muscular movement also facilitates performance (Richardson, 1967a, 1967b). This "symbolic rehearsal of physical activity in the absence of any gross movements" (Richardson, 1967a, p. 95) is called mental practice. Work decrement can also result from lack of appropriate rest periods when mental practice is being used (Rawlings & Rawlings, 1974).
Furthermore, bilateral transfer has been found to occur under conditions of mental practice, as well as physical practice (Kohl & Roenker, 1980). Lastly, in the case of mental practice, as well as physical practice, evidence suggests that the degree of transfer is dependent on the similarity of the tasks (White, 1981).

The mental-practice research has developed along the same lines as the physical-practice research and, to a lesser degree, many of the same phenomena that have been established for physical practice have also been established for mental practice. Therefore, a short review of the physical-practice research will be presented. The mental-practice research will then be reviewed in somewhat more detail with particular attention devoted to studies investigating work decrement and facilitation of performance as a function of task similarity. These studies will be discussed to build a case for the contention that degree of work decrement and facilitation of accuracy of the image used in mental practice.

Physical Practice

**Conditions Which Facilitate Performance.** The fact that physical practice of a motor skill facilitates performance does not come as a great surprise. That is why basketball players practice basketball, runners practice running, and pitchers practice pitching. Everyone has improved performance on some task by physically practicing that task. This phenomenon has also been empirically established. Ammons (1947) conducted a study using a rotor pursuit to examine aspects of motor learning. The rotor-pursuit task required the subject to follow with a pointer a target that rotated in a circular pattern at
60 rpm. One of Ammons' (1947) findings was that over the course of 8 6-min trials the subject's percent time-on-target increased significantly. Other studies which demonstrate that physical practice facilitates performance are too numerous to mention.

In addition, the degree to which performance is facilitated within a single limb appears to be influenced by the similarity between practice and performance tasks. Lordahl and Archer (1958), using a rotor pursuit, studied the unilateral transfer effects of different target speeds. In a unilateral design, the subjects received 30 30-sec trials alternated with 60-sec rest intervals using a target speed on either 40, 60, or 80 rpm on the first day. On the second day all subjects performed at 50 rpm. The group that trained at 60 rpm performed better than either of the other two groups, while the 40-rpm group performed slightly better than the 80-rpm group. Noble (1968) in his review also concluded that the degree of transfer between tasks is a function of the similarity between practice and performance tasks.

Physical practice not only affects the limb used to practice, but also leads to bilateral transfer. That is, performance gains are transferred from the limb used to practice to the contralateral limb. Ammons (1958) used a rotor pursuit set at 60 rpm to demonstrate the bilateral transfer of skill. The subjects practiced with either the right or the left hand for 8 30-sec trials, rested 20 minutes, then performed with the contralateral hand for 8 30-sec trials. Half of the subjects practiced with their right hand and performed with their left hand, while the other half practiced with their left hand and performed with their right hand. Bilateral transfer of skill was found for both the left-to-right and right-to-left conditions as compared to a control group, which had no
practice trials. Other studies including Kohl and Roenker's (1980) investigation, which will be discussed at length later in this paper, also demonstrate that skill acquisition can be transferred bilaterally under conditions of physical practice.

**Conditions Which Inhibit Performance.** Although physical practice generally increases performance, under massed-practice conditions performance can be inhibited. Massed practice is practice without a rest period either between practice trials or between practice and performance trials. This inhibition of performance due to lack of appropriate rest periods is called work decrement. The recovery from work decrement with appropriate rest is called reminiscence. Numerous studies have documented the phenomenon of work decrement.

Bourne and Archer (1956) used a pursuit rotor set at a speed of 54 rpm. All subjects received 21 30-sec trials. One group had no rest between trials while the other groups had either 15, 30, 45, or 60 seconds of rest followed by a test session consisting of 4.5 minutes of massed practice (i.e., 9 consecutive 30-sec trials). The performance curves of the groups with longer intertrial rest periods rose faster during the first 21 trials. These results were interpreted as evidence that work decrement had built up faster in the groups with shorter intertrial rest periods, thereby inhibiting performance. Furthermore, in order to estimate the amount of work decrement generated in the first 21 trials for all groups, the difference between the first postrest test trial and the last prerest trial (i.e., 21st) was computed. The analysis indicated a significant difference among the groups with the maximum amount of reminiscence (i.e., dissipation of work decrement) occurring in the 15-sec and 0-sec
groups followed consecutively by the 30-, 45-, and 60-sec groups. Thus, the groups with the relatively short intertrial rest periods (0 and 15 seconds) accumulated work decrement which did not dissipate until the 5-min rest period following the 21st trial. The results support the theory that work decrement accumulates when appropriate intertrial rest periods are not used.

Similarly, Ammons (1947) conducted a study using a rotor pursuit set at 60 rpm. Using a work-rest-work paradigm, 35 groups which combined various amounts of initial work and rest were employed. The 35 conditions were 5 prerest continuous work periods (1/3, 1, 3, 8, 17 min) crossed with 7 rest periods (1/3, 2, 5, 10, 20, 60, 360 min). All subjects practiced continuously for 8 minutes following the rest period. Ammons found that, as the length of the rest interval increased, the total time-on-target increased for the performance trials. This outcome was interpreted as meaning that the rest allowed work decrement to dissipate (i.e., reminiscence to occur) and thereby increased performance. Ammons also found that amount of reminiscence varied as a function of length of the prerest practice. More specifically, reminiscence rises to a maximum after 8 minutes of prerest practice and then falls off gradually. Several other studies including Bell (1942) and Albright, Borrensen and Marx (1956) also support the contention that work decrement accumulates as a result of massed physical practice.

It was noted earlier that the positive effects of mental practice transfer bilaterally. A similar bilateral transfer phenomenon also holds for work decrement. Bilateral transfer of work decrement under conditions of physical practice is well documented in the literature. Grice and Reynolds (1952) used a rotor pursuit to conduct two parallel experiments
using 432 right-handed airmen. In one experiment subjects used their left hand before and after a rest period (unilateral design) while in the second experiment subjects used the left hand before the rest period and the right hand following the rest period (bilateral design). Subjects were given 15 30-sec practice trials alternated with 10-sec rest periods, after which they were given a rest period of either 10 seconds, 30 seconds, 1, 3, 5, or 10 minutes. Each subject was then given 15 30-sec performance trials. Results showed that, as the length of the rest periods increased, the scores on the postrest trials increased. Presumably, the accumulation of work decrement depressed the scores of the groups with shorter rest periods. This result is to be expected for the group which used the same hand (i.e., unilateral) for prerest and postrest conditions (Ammons, 1947; Bourne & Archer, 1956). Additionally, the presence of this same relationship between amount of rest and postrest performance for the bilateral group indicated that work decrement can be transferred from one limb to another under conditions of physical practice.

Furthermore, Irion and Gustafson (1952), using a rotor pursuit, had two groups of subjects practice 20 30-sec trials with the right hand followed by 10 trials with the left hand. The intertrial interval was 5 seconds. For one group (no-rest) this 5-sec intertrial interval was also the amount of time allocated between shifting to the left hand. The other group (rest) received a 5-min rest before shifting to the left hand. The postrest performance with the left hand was significantly better for the 5-min rest group. Here again it was assumed that work decrement transferred bilaterally and depressed the performance of the no-rest group. Numerous additional studies support the contention that work decrement resulting from physical practice can be transferred bilaterally
(e.g., Albright, Borrenson, & Marx, 1956; Ammons & Ammons, 1951; Kimble, 1952; Kohl & Roenker, 1980).

In summary, the previously cited research using physical practice has established several relatively stable phenomena. First, physical practice can enhance performance. Second, this facilitation can transfer from one limb to another. Third, the degree of transfer seems to be dependent on the similarity of practice and performance tasks. Fourth, if appropriate rest periods are not given between trials, work decrement can accumulate and depress performance. Finally, work decrement can also be transferred bilaterally.

**Mental Practice**

**Conditions Which Facilitate Performance.** In many ways mental practice research has followed the same approach established by the physical practice research. To a lesser degree, many of the same phenomena have been noted for mental practice that were previously obtained with physical practice.

Most studies indicate that mental practice procedures are associated with improved performance on the task. Richardson (1969) conducted a comprehensive review of the literature and noted that statistically significant positive findings were obtained in eleven studies, while seven further studies showed positive trends. Only two studies that were reviewed failed to indicate any improvement in performance as a result of mental practice.

Rawlings, Rawlings, Chen, and Yilk (1972) found that mental practice facilitates performance of a rotor pursuit task set at 60 rpm. During the first day all groups (physical practice, mental practice, and control) physically practiced tracking with their preferred hand for 25
30-sec trials with 30-sec rest intervals between trials. On days 2 through 9 the physical-practice group practiced tracking for 25 trials each day. The mental-practice group was told to visualize themselves performing the task for the 25 30-sec trials on each day. The control group practiced a color-naming task for 25 30-sec trials on each day. On day 10 all groups were tested again using 25 30-sec trials with 30-sec intertrial intervals. An analysis of the mean total time-on-target scores of the three groups on both days 1 and 10 showed that the mental-practice and physical-practice groups performed significantly better than the control group, thus indicating that both mental and physical practice facilitate performance. Furthermore, there was no significant difference in the performance scores of the mental-practice and physical-practice groups, suggesting that mental practice is equally as effective as physical practice in facilitating performance.

William (1969) used a polar pursuit tracker (basically similar to the rotor pursuit except that a wide target variability is provided by a removable glass plate) set at 60 rpm. The subjects were divided into four groups: physical practice, mental practice, placebo control (which met regularly in order to rule out the motivational problem that is often present with strict controls who are only exposed to posttests), and strict control (which met for posttest only). The mental-practice and physical-practice groups practiced for 3 3-min trials alternated with a 1-min rest for 16 consecutive days. Each subject was posttested on the criterion task using the same work-rest ratio on either the 17th or 18th day. The posttest total time-on-target scores of the mental-practice and physical-practice groups were significantly better than either of the control groups. Additionally, there was no significant difference between mental-practice and physical-practice groups. Here again this result was interpreted to mean that mental
and physical practice equally facilitate performance.

Powell (1973) also demonstrated the benefits of mental practice in a study involving a comparison between positive and negative mental practice. The positive-mental-practice group was to imagine throwing darts and hitting around the center of the board. The negative-mental-practice group was to imagine just hitting the edge of the board. The procedure consisted of 5 blocks of 24 dart throws with blocks 1, 3, and 5 being actual physical practice and blocks 2 and 4 being mental practice. When the scores on blocks 1 and 5 were compared, the subjects in the positive-mental-practice group performed significantly better (i.e., closer to the center) than those in the negative-mental-practice group. Numerous other studies have established that mental practice can facilitate performance (e.g., Clark & Verdelle, 1969; Jones, 1965; Twining, 1949; Vandell, Davis & Clugston, 1943; Williams, 1969).

Mental practice not only increases performance with the limb used in imagery but also enhances performance with the contralateral limb. At least two studies have been conducted in which there is evidence of bilateral transfer of skill due to mental practice. Arnold (1946) discusses an unpublished study conducted by Beattie in which subjects improved their dart throwing with both hands after mentally practicing the task with only one hand.

Kohl and Roenker (1980) conducted a series of experiments in which the role of mental practice in bilateral transfer was investigated. A rotor pursuit set at 60 rpm was used in all three experiments. In Experiment 1 subjects were randomly divided into physical-practice, mental-practice, and control groups. Each subject received 25 30-sec rehearsal trials with 30-sec intertrial rest periods. The rest periods consisted of reading and verbalizing one color per second. The physical-practice
group actually performed the task with their right hand, while the
mental-practice group only held the stylus and mentally imagined themselves
performing the task with their right hand. The control group practiced
verbalizing multiplication tables. All subjects were given a 60-sec rest
between the end of the right-hand practice trials and the beginning of
left-hand performance, which consisted of 3 30-sec physical trials alternated
with 3 30-sec color-naming intervals. The results of the left-hand
performance trials indicated that there was no significant difference
between the mental-practice and physical-practice groups in terms of
percent time-on-target. However, both groups were significantly better
than the control group. These results support Beattie's (Arnold, 1946)
contention that mental practice facilitates bilateral transfer of a skill.

_Conditions Which Inhibit Performance._ Although mental practice
generally increases performance, under massed practice conditions performance
can be inhibited. Massed mental practice is practice without appropriate
rest periods.

In Experiment 2 Kohl and Roenker (1980) sought to investigate the
relative effectiveness of mental and physical practice in facilitating
bilateral transfer of a skill. One possible interpretation of the results
of Experiment 1 was that the physical-practice group accumulated and
transferred work decrement, thereby suppressing left-hand performance.

In order to minimize the effect of work decrement in the physical
practice condition, the duration of the rest interval between limbs was
increased from 60 seconds to 5 minutes (to allow work decrement to dissipate);
and the number of right-handed prerest practice trials was reduced from
25 to 18. It was anticipated that the physical-practice group, once
given a chance to recover from bilaterally transferred work decrement,
would show a higher level of left-hand performance than would the mental-practice group. However, the results again showed no significant difference between the mental-practice and physical-practice groups on left-hand performance, while both groups performed significantly better than the control group. This outcome could be interpreted as indicating that under both mental-practice and physical-practice conditions work decrement can be transferred bilaterally or that there is no transfer of work decrement for either.

In Experiment 3 subjects were divided into six groups: mental-imagery rest, mental-imagery no-rest, physical-practice rest, physical-practice no-rest, control rest, and control no-rest. The intertrial rest period was decreased from 30 to 8 seconds, which produces a faster build-up of work decrement. The mental-imagery rest group engaged in 9 30-sec right-handed imagery trials, rested for 9 minutes, then resumed 9 30-sec performance trials alternated with 8-sec intervals with the left hand. The mental-imagery no-rest group was the same as the mental-imagery rest group except that the rest period between switching limbs lasted for 8 seconds rather than 9 minutes. The physical-practice groups followed the same schedule as the mental-practice groups except that during the practice trials the subjects actually physically performed the task. The control groups verbalized multiplication tables during practice trials.

The results of left-hand performance showed that the two mental-practice groups and the two physical-practice groups performed significantly better than the two control groups. In addition, there was no significant difference between mental and physical practice in facilitating bilateral transfer of skill. The superiority of the rest over the no-rest groups demonstrated that work decrement was present. More importantly, the
difference between the rest and no-rest conditions (i.e., work decrement) was the same for the physical-practice and mental-practice conditions. Knowing that conditions of physical practice can lead to bilateral transfer of work decrement (Grice & Reynolds, 1952), the most feasible interpretation of these data is that there exists some analogous phenomenon that results from mental practice. In other words, the data indicate that work decrement can be transferred bilaterally under conditions of mental or physical practice.

Rawlings and Rawlings (1974) also indicate that work decrement can occur under conditions of mental practice. The Revised Gordon Test of Visual Imagery Control (Richardson, 1969) was used to designate those subjects who had controllable mental imagery (i.e., scored above the median) and those subjects who had autonomous visual imagery (i.e., scored below the median). The basic work-rest-work paradigm was used with the rotor pursuit set at 60 rpm. The prerest practice lasted 5 minutes (i.e., 5 trials each consisting of 50 seconds of work alternated with 10 seconds of rest) followed by 10 minutes of rest and 5 minutes of postrest practice. Half of the subjects rested and half of the subjects mentally practiced the task during the 10-min rest period. Further, half of the subjects in each condition were autonomous imagers and half were controllable imagers. With respect to subjects who imaged during the rest period, they found that controllable imagers had significantly lower reminiscence (i.e., recovery from work decrement) than autonomous imagers. These data could be interpreted as indicating that controllable mental imagers maintained work decrement through the rest periods while autonomous imagers did not.

In summary, the previously cited research using mental practice has established several relatively stable phenomena. First, mental practice
can enhance performance. Second, this facilitation can transfer from one limb to another. Third, if appropriate rest periods are not given, work decrement can accumulate and depress performance. Finally, work decrement can also be transferred bilaterally under conditions of mental practice.

In light of these results, White (1981) extended the parallel between mental practice and physical practice phenomena. As pointed out earlier, Noble (1968) concluded that the degree of skill transfer was a function of the commonality of the tasks when physical practice was used. Therefore, White (1981) studied the intertask transfer of skill acquisition as a function of the degree of similarity between mental practice trials and physical performance trials. He also investigated the transfer of work decrement as a function of task similarity.

Subjects mentally practiced left-hand performance of the rotor pursuit task at either 30, 45, or 60 rpm. Then all subjects performed the criterion task at 45 rpm. While imaging, each subject was instructed to note that one click of a metronome, set at either 30, 45 or 60 clicks per minute, was to correspond to one revolution of their image (i.e., cued imagery). The subjects practiced imaging for 10 30-sec trials alternated with 8-sec rest intervals. Performance appraisal for each subject consisted of 9 30-sec trials alternated with 8-sec rest intervals. Half of the subjects in each group received a 9-min rest period between practice and performance trials (i.e., rest group) while the other half received an 8-sec rest (i.e., no-rest group). A comparison of the rest groups showed that subjects who imaged and then performed at 45 rpm performed significantly better than the other two rest groups. This result confirmed White's (1981) supposition that the degree of intertask transfer would vary as a function of task similarity. For the no-rest groups performance was
equivalent at 45 and 60 rpm and both were superior to the 30 rpm group. In the no-rest groups it was hypothesized that the group that practiced and performed at 45 rpm would accumulate significantly more work decrement than the other groups. However, the results showed that the 45 rpm no-rest and 30 rpm no-rest groups showed evidence of work decrement while the 60 rpm no-rest group did not. More specifically, the difference between rest and no-rest (i.e., work decrement) was present at 30 and 45 rpm but was not present at 60 rpm. Thus it appears that subjects who image at or below criterion speed build work decrement, but those who image above criterion speed do not.

Similarly, Kohl, Turner, and Koenker (unpublished) conducted research on cued versus uncued imaging. Pilot data indicated that most people under image in an uncued condition. That is, they image at a speed slower than the actual speed of the target. Therefore, if one is willing to accept the assumption that uncued imagers are under imaging, then the Kohl et al. comparison of cued versus uncued is basically a comparison of accurate (cued) versus under imaging (uncued). This study is in essence a replication of part of White's (1981) study (i.e., imaging and performing at 45 rpm versus imaging at 30 rpm and performing at 45 rpm).

Specifically, Kohl et al. investigated the effects of cued versus uncued imagery practice on performance under rest and no-rest conditions. They used a rotor pursuit set at 45 rpm. Each subject was given 9 30-sec practice trials followed by 9 30-sec performance trials. The intertrial rest period was 8 seconds for both practice and performance trials. The rest group was given 5 minutes of rest between practice and performance trials while the no-rest group was given 8 seconds of rest. Kohl et al. found that work decrement (i.e., the difference between rest and no-rest)
was essentially equivalent for the cued and uncued imagery groups. These data also revealed that cued imagers performed at a higher level overall than uncued imagers. If it can be assumed, based on the pilot data, that the subjects in the uncued condition were under imaging, then these results would support White's (1981) finding that under imaging and accurate imaging lead to approximately equivalent amounts of work decrement and that facilitation of performance varies as a function of the similarity between the practice and performance tasks.

Summary

Research has shown that physical practice enhances performance when appropriate rest periods are used between trials. In addition, the degree of enhancement varies as a function of the similarity of the practice and performance tasks. However, under conditions of massed physical practice, work decrement accumulates and performance is depressed. Furthermore, under physical practice conditions both facilitation of performance and work decrement can be transferred bilaterally.

Research has also indicated that mental, as well as physical, practice can enhance performance. The studies of Rawlings and Rawlings (1974) and Corbin (1972) suggest that work decrement can accumulate as a result of massed mental practice. Subsequently, Kohl and Roenker (1980), using mental practice, provide evidence that both facilitation of performance and work decrement can be transferred bilaterally. White's (1981) findings then indicate that under imaging and accurate imaging lead to work decrement while over imaging does not. White (1981) also found that accurate imaging leads to greater facilitation of performance. In addition, Kohl, Turner, and Roenker's (unpublished) data on cued versus uncued imagery, when interpreted in light of data which indicate that
uncued imagers under image, support the contention that under imaging and accurate imaging produce approximately equal amounts of work decrement and that facilitation of performance occurs as a function of task similarity.

Statement of Problem

Having reviewed the literature, the logic for the present study becomes evident. First, White (1981) showed that forced under imagers (i.e., cued under imagers) have lower performance levels than forced accurate imagers. Second, White (1981) also found that forced under imagers as well as forced accurate imagers produce work decrement. Third, Kohl et al. demonstrated these same two phenomena for uncued and cued imagers. That is, uncued imagers have lower levels of performance and produced the same amounts of work decrement as cued imagers. This similarity of results suggests that uncued imagers are under imaging and cued imagers are imaging accurately. However, the accuracy of the image for uncued imagers was not directly measured in the Kohl et al. study. Therefore, the present study tests uncued imagers for accuracy of image and then assesses the effects of image accuracy on performance level and work decrement. Thus, it is expected that accuracy of the image will affect performance but not work decrement.
CHAPTER II

Method

Subjects

The subjects were 40 right-handed students drawn from psychology classes at Western Kentucky University. Naive, with respect to the rotor pursuit task, and right-hand dominance were established during recruitment. Self report from the subjects was the criterion for dominance as well as naivete with respect to the rotor pursuit task. All subjects were tested individually.

Apparatus

The principle apparatus were two Lafayette Photoelectric Pursuit Rotors (Model Number 30014). The rotor pursuits were connected to Lafayette Universal Timers (Model Number 6010-BF), which programmed the rotor pursuits for 30-sec trials alternated with 8-sec rest periods. Lafayette Timers (Model Number 58007) also recorded the subject's total time-on-target for each trial. A cassette tape recorder was used to record the subject's verbalization of "top" each time the image made one revolution. The rotor pursuit was checked for accuracy periodically between subjects.

Procedure

Upon entering the room subjects were randomly divided into two groups. All subjects used their left hand for both mental practice and performance trials. One group engaged in 9 imagery trials, rested 5 minutes, then undertook 9 performance trials (i.e., rest condition).
Seven days later this group returned and engaged in 9 imagery trials and 9 performance trials with only an 8-sec interval between practice and performance trials (i.e., no-rest condition). The second group experienced the no-rest condition seven days prior to the rest condition.

Practice conditions were preceded by an introduction to the rotor pursuit (see Appendix A), as well as a demonstration of the rotor operating at 45 rpm. The imagery trials consisted of 9 30-sec rehearsal trials alternated with 9 8-sec rest intervals. During the imagery practice the subject held the stylus with the left hand and verbalized the word "top" each time the image made one revolution. Also, the subject was instructed to keep his/her eyes closed and avoid making any overt movements during mental imagery. During the 5-min rest period the subjects read magazines or chatted with the experimenter. Performance appraisal for each group consisted of 9 30-sec left-handed trials alternated with 9 8-sec rest periods. During performance trials the rotor pursuit was set at 45 rpm.

Data Collection

Using this design two types of data were collected and analyzed: accuracy-of-image and time-on-target. The imagery data were gathered by asking subjects to verbalize the word "top" each time the image made one revolution. The number of "tops" the subject verbalized during each 30-sec trial was recorded. The number of "tops" recorded during each 30-sec trial was compared to the number of revolutions the rotor would have made at 45 rpm in a 30-sec interval. In this way the experimenter could identify the accuracy with which a given subject was imaging. The time-on-target data were gathered during the actual performance trials and represented the total time the subject kept the stylus over the rotating target during each 30-sec trial.
CHAPTER III

Results

A preliminary analysis of the accuracy-of-imagery data showed that less than 5% of the subjects imaged at speeds faster than the test speed. Given this outcome and the results of Kohl, Turner, and Roenker's (unpublished) and White's (1981) study it was expected that image accuracy would predict overall levels of performance, but not the amount of work decrement.

To determine if work decrement was present, the time-on-target data for each subject were converted to percent time-on-target. These data were analyzed in a 2 (Order) by 2 (Rest/No-rest) by 9 (Trials) factorial design with repeated measures on the last 2 variables (see Appendix B). This analysis revealed that the main effect of Rest/No-rest was marginally significant, $F(1,34)=3.97, P<.06$. Additionally, the Trials by Rest/No-rest interaction was significant, $F(8,272)=2.70, P<.05$. This interaction is presented in Figure 1. One can see that the rest/no-rest differences are greatest for Trials 1 through 3. A Newman-Keuls was performed on this interaction (see Appendix C), and only on the first three trials were the rest/no-rest differences significant. There was also a main effect of Order, $F(1,34)=4.76, P<.05$. Subjects who received the no-rest condition first performed at a higher level than subjects who received the rest condition first. The author is unable to explain why this effect was obtained. However, there was no interaction between Order and Rest/No-rest, $F(1,34)=1.80, P>.05$. Therefore, order did not effect work decrement measures. The Order by trials by Rest/No-rest interaction was not
FIGURE 1. REST/NO-REST BY TRIALS INTERACTION
significant, $F(8, 272) = 1.75$, $P > .05$. Finally, the main effect of Trials was significant, $F(8, 272) = 5.97$, $P < .05$. This effect reflects the fact that performance generally increased across trials. Thus, this analysis showed that work decrement was present on the first three trials but dissipated across the remaining six trials.

To determine the stability of the accuracy of the image measure, the imagery data were also analyzed with a 2 (Order) by 2 (Rest/No-rest) by 9 (Trials) factorial design with repeated measures on the last 2 variables (see Appendix D). This analysis revealed that imagery accuracy was not affected by Order of the conditions, $F(1, 34) < 1$, nor by Rest/No-rest, $F(1, 34) = 2.08$, $P > .05$, nor by Trials, $F(8, 272) = 1.56$, $P > .05$, nor by any two way combination of these variables, $F's < 1.27$, $P's > .05$. The only significant effect in this analysis was the Order by Trials by Rest/No-rest interaction, $F(8, 272) = 11.88$, $P < .01$. However, this effect shows no readily discernable pattern and is probably due to the overwhelming power of the test. Furthermore, this interaction accounted for less than 6% of the variance. Thus, the analysis shows that the accuracy of the image remained relatively unchanged throughout the course of the experiment.

To summarize, the analyses have shown that (1) work decrement was present although the magnitude decreased after the third trial and (2) accuracy of the image did not vary as a function of the rest/no-rest conditions. Once it had been established that work decrement was present and that image accuracy was relatively stable the two major hypotheses could be tested. That is, does image accuracy predict work decrement or total performance?

Before these hypotheses could be tested some modification of the data were required. A measure of overall performance was obtained by
summing the percent time-on-target data across all trials of both the rest and no-rest conditions. Thus, a measure of performance independent of rest and no-rest conditions was obtained. In addition, the difference between the rest and no-rest performance for each subject was used to index work decrement. Further, since the accuracy of the image was unaffected by experimental manipulation, a single measure of image accuracy was obtained for each subject by summing the number of reported "tops" across all trials of both the rest and no-rest conditions.

Simple regressions were used to determine if the accuracy of the image would predict total performance scores and/or work decrement. The first regression used accuracy of the image to predict total performance. This regression analysis revealed that accuracy (A) was a significant predictor of performance (P), $F(1,34)=7.31, P<.05$. The regression equation ($P=37.842 + 7.602A$) indicates that there was a positive relationship between these two variables. More specifically, as accuracy of the image increased, total performance increased. However, accuracy of the image accounted for only 18% of the variance in performance.

A second regression, using accuracy of the image to predict amount of work decrement, was not significant, $F(1,34)<1$. This result demonstrates that, as hypothesized, accuracy of the image was not a reliable predictor of work decrement.

It should be recalled that the magnitude of work decrement declined after Trial 3. Thus, a second pair of regressions were run using only the time-on-target data from the first three trials to ensure that the same relationship that had previously been found would hold true for the trials where the magnitude of work decrement was greatest. Here again the accuracy of the image predicted overall performance, $F(1,34)=6.15, P<.05$, and
failed to predict work decrement, $F(1,34) > 1$. The total performance regression equation was $\bar{y} = 4.195 + .787A$. This regression accounted for approximately 15% of the variance.

If, as has been hypothesized, accuracy of the image affects overall performance but not the amount of work decrement, the implication is that the overall level of performance should not predict the amount of work decrement. That is, work decrement should be constant regardless of the level of performance of the subject. A regression, using overall performance to predict the amount of work decrement, was not significant, $F(1,34) < 1$. These two variables shared approximately 2% variance. Thus, this analysis is consistent with the previous regression analyses in that the amount of work decrement is independent of the overall level of performance.

To summarize, the analyses have shown that (1) work decrement was present, although the magnitude decreased after the third trial, (2) accuracy of the image did not vary as a function of rest/no-rest conditions, (3) image accuracy predicts performance, (4) image accuracy does not predict work decrement, and (5) performance does not predict work decrement.
CHAPTER IV

Discussion

The results of this study revealed two major findings: (1) accuracy of the image, to a limited extent, can predict overall levels of performance for under and accurate imagers, and (2) accuracy of the image does not predict work decrement for under and accurate imagers.

The first finding that accuracy of the image can predict performance replicates White's (1981) data, as well as the Kohl et al. data. The research on task similarity may provide some insight as to why this relationship was obtained. This research seems to demonstrate that as the similarity between the practice and performance trials increases, the degree of performance facilitation also increases (Lordall & Archer, 1958; Noble, 1968; and Powell, 1973). It appears that as task similarity increases more relevant information from the practice task is transferred to the performance task, thus improving performance. Correspondingly, when a person inaccurately images, then irrelevant information is processed, resulting in poorer performance. However, the fact that accuracy of the image only accounted for 18% of the variance in total performance scores needs to be addressed.

There are at least two possible reasons that image accuracy only accounted for 18% of the variance. First, it could be that the measure of image accuracy used was inadequate. Perhaps having the subjects verbalize the work "top" does not accurately represent the quality of the subject's image. Second, perhaps the 18% of the variance accounted for accurately represents the strength of the relationship.
The second major finding in the present study was that accuracy of the image does not predict work decrement for under and accurate imagers. This finding is in agreement with the results of the experiments of White (1981) and Kohl et al. (unpublished) concerning under and accurate imagers. These results suggest that the level of work decrement is consistent across levels of imagery accuracy. The implication then is that work decrement is some sort of constant that affects all imagery levels equally. However, this relationship does not fit with White's (1981) finding that over imagers did not accumulate significant amounts of work decrement. This incongruency leads to the formulation of a more complex relationship.

One should keep in mind that work decrement is an inhibition of performance which is measured by obtaining the difference between the rest and no-rest performance. In that light it could be that under imagers actually do accumulate less work decrement but the difference between rest and no-rest performance could be exaggerated if some factor other than work decrement caused the no-rest performance of the under imagers to be abnormally low. This abnormally low no-rest performance could be due to shock brought about by an abrupt change in information density that the under imaging no-rest subjects would experience. The under imaging rest subjects would not experience the same degree of shock that the no-rest subjects would because there was a longer time interval (i.e., 5 min rather than 8 sec) between practice and performance. It should also be noted that this contrast decreases as the accuracy of the image increases. Therefore, there is no contrast in information density for accurate imagers.

In summary, accuracy of the image does predict performance but
only accounts for a small amount of the variance. This result is probably because as accuracy increases the similarity between the practice and performance tasks increases. In addition, the accuracy of the image does not predict work decrement for accurate and under imagers, possibly due to the change in information density experienced by under imagers but not by accurate imagers. Thus, the actual amount of work decrement for under imagers may have been overestimated.

A clearer understanding of work decrement is an important component of the understanding of the field of motor learning. However, there is little existing research on the relationship between the amount of work decrement and levels of performance. Thus, it is imperative that these results be replicated. Furthermore, the work decrement levels of those who over image need to be investigated.
REFERENCES


Bell, H. M. Rest pauses in motor learning as related to Snoddy's hypothesis of mental growth. Psychological Monograph, 1942, 54, (1, No.243).


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White, W. L. Intertask transfer of skill acquisition and work decrement as a function of degree of task similarity between mental practice trials and physical performance. Unpublished master of arts thesis, Western Kentucky University, 1981.

APPENDIX A

Introduction to experiment

First of all, let me explain how this apparatus works. 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 important that you not discuss the proceedings with other students.

This is a rotary 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 over the target. (Experimenter places stylus tip over 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?

Instructions for practice trials

No, let me tell you what we are going to be doing today. To begin with, you will have 9 30-sec practice trials; you will have 8 seconds in which to rest. Grasp the stylus with your left hand. I will tell you when to begin and end each trial. When I tell you to start, I want you to
mentally practice the rotor pursuit task. When I say mentally practice, I mean that I want you to imagine yourself following the target with the stylus. Conceptualize and create a mental image of yourself performing this task. During your imagery trials, I would like for you 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. Remember that you are conceptualizing the task without any overt movement. Do not move the stylus.

Each time your image goes around once, I would like for you to say the word top out loud. Look, pretend that this (experimenter points to rotor pursuit rotating at 45 rpm) is your image. You would pick a point, say here (experimenter places finger at six o'clock position on rotor pursuit while it is rotating). Now each time your image passes this point you would say the word top like this (experimenter demonstrates by verbalizing the word "top" each time the light passes under his finger). Notice the speed at which the light rotates. (Experimenter allows subject to observe the speed at which the light rotates.) Do you have any questions about the imagery practice?

**Instructions for performance trials**

After you have completed your practice trials, you will have an 8-sec (for no-rest group) /5-min (for rest group) rest before the performance trials begin. When you start the performance trials, I want you to hold the stylus over the center of the glass, not on the target, until the target starts moving. When the target begins to rotate, start tracking it just as I demonstrated and as you imagined. When the
target stops rotating, hold the stylus over the center of the glass until the target begins to rotate again. Do you understand what to do during the performance trials? (Experimenter gives positive reinforcement, such as "you're doing fine" after second trial.)
APPENDIX B

Analysis of Variance:
Time on Target

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APPENDIX C

Newman-Keuls Analysis of Rest/No-rest by Trials Interaction

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Note: Values in parentheses are mean percent time-on-target.
APPENDIX D

Analysis of Variance:
Imagery Accuracy

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