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**Factors Influencing the Effects of
Instructed Human Imagining Behaviour on
Subsequent Performance**

Submitted to the School of Psychology, University of
Ottawa, in partial fulfilment of the requirements for
the Ph.D. Degree.

Guy A. Bourgon



Guy A. Bourgon, Ottawa, Canada, 1994



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In loving memory of my Mom

Abstract

Numerous anecdotal reports from athletes and coaches suggest that performance of a physical skill can be improved by imaginal practising of that skill. Practising a skill in one's imagination has been called symbolic rehearsal, mental practice, mental rehearsal, conceptualizing practice, imaginal practice, covert rehearsal, and instructed human imagining behaviour (IHIB). For at least 50 years, researchers have attempted to empirically demonstrate the effects of instructed human imagining behaviour on subsequent performance. A review of the IHIB and related literature suggests (a) that although IHIB can influence skill performance, it may not always do so; (b) that the conceptual schemes involved in IHIB need careful development; and (c) that before IHIB can be used to effectively and systematically improve performance, we need to identify critical variables involved in IHIB. An alternative explanation of IHIB and its effects on subsequent performance based on radical behaviourism is described and examined. This conceptual scheme proposes that IHIB is similar to the overt behaviour and thus, shares similar controlling variables. Three experiments, investigated the effects

of presenting task-specific auditory stimuli during IHIB procedures. The results suggest that task-specific auditory stimuli increase the similarity between IHIB and the target behaviour, and that it is this similarity that mediates the effects of IHIB on subsequent performance.

Introduction

There have been many anecdotal reports from athletes and coaches suggesting that performance of a physical skill can be improved by imaginal practising of that skill. Practising a skill in one's imagination has been called symbolic rehearsal (Sackett, 1935), mental practice (Feltz & Landers, 1983; Richardson, 1967a), mental rehearsal (Ryan & Simmons, 1981; Wrisberg & Ragsdale, 1979), conceptualizing practice (Egstrom, 1964), imaginal practice (Perry, 1939), covert rehearsal (Corbin, 1972) and instructed human imagining behaviour (IHIB) (Watters & Bourgon, 1988). Throughout this paper, the term instructed human imagining behaviour (IHIB) will be used to refer to the imaginal practising of a physical skill. For at least 50 years, researchers have attempted to empirically demonstrate this phenomena with varied success (e.g., Corbin, 1972; Feltz & Landers, 1983; Richardson, 1967a; Sackett, 1935; Watters & Bourgon, 1988). In the first section, the five major reviews of the literature (Corbin, 1972; Murphy, 1990; Richardson, 1967a, 1967b; Suinn, 1983; Weinberg, 1983) and two meta-analyses (Feltz & Landers, 1983; Hinshaw, 1991) are examined.

Reviews of the Literature

The first major review of IHIB research by Richardson (1967a,b), concluded that "despite a variety of methodological inadequacies, the trend of most studies indicates that mental practice [IHIB] procedures are associated with improved performance" (1967a, p. 102). Richardson noted the following trends: (a) the degree of familiarity with the physical performance of a task is related to the efficiency of IHIB relative to physical practice; (b) alternating imagining with physical practice during acquisition of a skill results in improvement of performance which is as good as or better than physical practice alone; (c) IHIB sessions should not exceed 5 minutes in duration - - otherwise the beneficial effects may be decreased; and (d) it appears that there are individual factors such as games ability, imagining ability, and the capacity for selective attention that show a significant relationship with performance gains following IHIB.

Richardson (1967b) outlines three plausible explanations presented in the literature for the effects of IHIB on subsequent overt performance. The first speculates that any improvement in performance

following IHIB may result from increases in motivation to perform in comparison to control conditions. A second explanation proposes that improvement in performance following IHIB may be derived from increases in the complexity of association between stimulus and required behaviour. Referred to as the symbolic learning explanation, this hypothesis holds that tasks which require higher levels of "intervening associative processes between reception of stimulation and the making of overt responses" are tasks that will benefit more from periods of IHIB (Richardson, 1967b, p. 265). However, Richardson suggested that this explanation fails to account for studies which found significant improvement of performance in low symbolic tasks that require little memorization and/or decision making. The third explanation, the psychoneuromuscular view, speculates that improvement in performance following IHIB may be the result of the subject using internal kinaesthetic feedback produced by IHIB to make appropriate corrections in performance. Richardson (1967b) noted that these hypotheses require further research before a more precise statement can be made concerning the necessary and sufficient conditions for effective IHIB.

Richardson (1967a,b) also noted that methodological problems permeate the IHIB literature. These problems include (a) the lack of attention to frequency, duration, and detailed reporting of the IHIB treatment procedures; (b) uncontrolled physical practice or imaginal practice; (c) variable subject and task characteristics; (d) uncontrolled motivation between groups; and (e) inadequate comparison groups. In conclusion, Richardson (1967b) stated that "it is clear that better, controlled investigations are needed" (p. 270) in order to establish optimal IHIB conditions.

Corbin (1972) in a subsequent review of the IHIB literature is more tenuous in his conclusions, stating "a careful perusal of the literature raises more questions than it answers (but) there is little doubt that mental practice can positively affect skilled motor performance" (p. 115). Corbin cautioned that, although IHIB can affect performance, no other generalizations are warranted until more controlled, rigorous experimentation is done. Corbin noted the following trends: (a) previous experience with the target behaviour is related to the effects of IHIB; (b) alternating periods of actual task performance with

IHIB enhances task performance; (c) there is likely an optimal, relatively short, length of time that a subject should spend engaged in IHIB; and (d) individual differences, such as conceptualizing or imagining ability, likely play a role in the effective use of IHIB.

Corbin (1972) reviewed six explanations presented in the literature for the effects of IHIB. Like Richardson (1967b), he described the motivation theory as a possible explanation of IHIB effects. However, he suggested that the effects of IHIB cannot be fully attributed to differences in motivation between comparison groups. Another explanation suggests that IHIB serves to reinforce important details of the desired behaviour or of critical task stimuli needed to perform the task behaviour. Thus, IHIB helps prevent forgetting of these details. Corbin's discussion of this "selective attention" explanation suggests it is an incomplete explanation. A third explanation, the Feedback Theory, is identical to the psychoneuromuscular explanation described by Richardson (1967b): IHIB improves subsequent performance via kinaesthetic feedback that occurs during IHIB. Corbin, like Richardson (1967b), noted that this explanation is

tentative. A fourth possible explanation, the gross framework theory, holds that IHIB helps the subject to conceptualize the entire task, to get the 'gestalt'. Corbin suggested that this explanation cannot account for any improvement in performance after the gross concept of the skill has been learned. A fifth possible explanation is that IHIB provides the subject with an opportunity for learning through insight. The insight explanation suggests that IHIB would not insure improved performance but could lead to new perceptual organization which may or may not lead to improve performance. The final explanation described by Corbin (1972) is the connectivist theory. This explanation holds that small magnitude muscular responses during IHIB form a connection with the imagined stimulus. This connection is strengthened during repeated pairings during IHIB. However, it is unclear how this hypothetical connection between imagined stimulus and minute muscular activity is related to the actual stimulus and the actual task behaviour.

Corbin also noted many of the same methodological problems as Richardson (1967b). These problems include (a) variable length and duration of IHIB sessions; (b) varying degrees of previous experience with the

experimental task; (c) varying imagining (conceptualizing) ability; (d) varying skill level; (e) lack of details of IHIB procedures and instructions; and (f) task variability.

The third review, by Weinberg (1983) concludes that IHIB is generally effective in enhancing performance but "methodological problems limit the generalizability of the research" (p. 203). Weinberg noted the following trends: (a) IHIB is most effective when combined and alternated with physical practice; (b) an individual needs some minimum prior experience with the task for IHIB to be of any benefit; (c) IHIB is associated with responses in the muscles that would be used in actual performance of the skill; (d) 5 minutes appears to be the optimum length of time for IHIB practice; and (e) the greater the ability of the individual to imagine, the more likely that IHIB will effect subsequent performance. Weinberg suggested that the use of clear internal visual imagining during IHIB enhances the effects of IHIB.

Weinberg (1983) criticized the literature on IHIB for its failure to provide a conceptual framework that allows a consistent understanding, prediction, and control of the factors which determine the outcome of

IHIB. In particular, Weinberg, like Richardson (1967b) and Corbin (1972), suggested that the effects of IHIB may be simply due to differences in motivation between a group of subjects who engage in IHIB and a control group.

Like his predecessors, Weinberg also noted methodological problems associated with IHIB research, such as varying subject characteristics (e.g. skill level, imagining ability), varying task characteristics (simple versus complex), minimal checking of the IHIB in terms of frequency and duration of IHIB, as well as the lack of specific IHIB procedural details. He also commented on the need to strengthen dependent measures, particularly in terms of reliability, and suggested that greater attention be given to the control and systematic manipulation of variables in order to provide practitioners with specific procedures and concrete information they may use to increase their client's performance.

A fourth review of the IHIB literature by Suinn (1983) reached a conclusion similar to Richardson (1967b), Corbin (1972) and Weinberg (1983): IHIB can have "a positive influence in the acquisition or the performance of a skill but research designs have been

such that conclusive or consistent results have not always been possible" (p. 510). Suinn noted these trends regarding IHIB: (a) IHIB usually results in below threshold muscular movements; (b) IHIB is best used in combination with physical practice to obtain maximum effects; and (c) there are individual differences among subjects such as previous experience with the target behaviour that influence IHIB's effectiveness.

Suinn (1983) observed that no theory offers a comprehensive framework of IHIB and its effects on behaviour. He suggested that researchers should develop a better framework for discovering and understanding the principles regarding IHIB. Suinn (1983) distinguished between typical IHIB procedures, defined by Corbin (1972) as repetition of a task without observable movement with the specific intent of learning, and his own IHIB procedure, termed Visuo-Motor Behavioral Rehearsal (VMBR) and defined as covert practice where imagining is the dominant experience to achieve rehearsal. Suinn (1983) limited his review to studies investigating VMBR, thereby implying that VMBR is more effective than typical IHIB procedures in increasing the effects on performance. Suinn (1983)

suggested that IHIB is on a continuum, with thinking about a behaviour on one end and vivid realistic dreaming on the other end. Suinn implied that typical IHIB procedures fall at the 'thinking about' end because little or no muscle activity is observed and VMBR falls at the realistic end because muscle activity is observed which closely resembles muscle activity while performing the behaviour. However, Suinn (1983) failed to explain how 'vivid realistic dreaming' or VMBR could result in improved performance.

Suinn (1983) also noted common methodological problems such as (a) the variability in experience level; (b) differences in task characteristics; (c) variability in imaginal practice instructions and procedures; (d) variability of the duration of time spent in IHIB; and (e) frequency of IHIB trials. Suinn (1983) recommended that future research should develop more controlled and replicable studies to isolate important variables.

Finally, a recent review of the IHIB literature by Murphy (1990) distinguishes between 'mental practice' (IHIB) and 'mental preparation strategies'. 'Mental practice' interventions require subjects to mentally rehearse a skill in order to improve performance of

that skill. 'Mental preparation strategies' are a variety of cognitive-behavioural techniques which include some imagery techniques. These strategies are viewed as coping strategies which help manage performance, such as 'psyching up' techniques, relaxation imagery, and attentional focus. Murphy, like others before him, cautiously suggested that mental practice (IHIB) does appear to improve performance although the effects are far from systematic.

Murphy's major criticism of the literature involves the conceptualization of IHIB and the limitations it creates for research. He identified six problems deriving from the 'mental practice' model: (a) there are only a few theoretical explanations of IHIB effects on performance, which has resulted in very few research projects that aim to explore the conceptual scheme of IHIB and its effects; (b) he identified a problem in the lack of detailed descriptions of IHIB scripts: he noted that the procedures used to instruct subjects to 'mentally practice' are inadequate, rarely given adequate attention in published articles and result in a wide range of IHIB procedures used across different studies; (c) he criticizes the research for

its failure to consistently check IHIB, the independent variable; (d) he noted that only two self-report instruments have been used to assess IHIB to evaluate its quality; (e) he criticized researchers for their neglect of individual differences of IHIB; and (f) he also criticized researchers for their overemphasis on the effects of IHIB on performance rather than on other potentially significant effects such as arousal levels and confidence which also has an effect on performance. Murphy concluded that researchers conceptualizing imagery as 'mental practice' have hindered both theoretical and applied explorations in this area. He suggested that more comprehensive and heuristic research models are needed for the area to develop better applied techniques and interventions.

The meta-analysis of Feltz and Landers (1983) concluded, as did the earlier reviews (Corbin, 1972; Richardson, 1967a,b; Suinn, 1983; Weinberg, 1983), that on the whole IHIB improves performance in comparison with no practice. Again, the need to "redirect the research efforts away from simple empirical demonstrations of mental practice [IHIB] effects on performance to the examination of variables that impact and/or mediate the relationship between mental practice

[IHIB] and task performance" (p. 51) was noted. Feltz and Landers (1983) conclude that published studies have shown significantly larger IHIB effects than unpublished studies and that cognitive tasks showed significantly larger effects than motor or strength tasks.

Feltz and Landers (1983) also comment on the disarray of the theoretical framework. They discuss a number of hypothetical explanations that appeared in the literature. One explanation is the cognitive-symbolic, previously described in the reviews of Richardson (1967b) and Corbin (1972). Feltz and Landers (1983) suggest that IHIB allows the individual time to engage in problem solving and/or rehearse rules which govern task performance. However, they state that it is still not clear why IHIB can affect 'motor' tasks (those tasks which have fewer symbolic elements).

Feltz and Landers (1983) also describe what they term the 'stage specific proposition'. They suggest that IHIB affects the processes of learning differently at different stages of learning. In the early stages, IHIB gives the subject a rough schema of the cognitive elements of the task, whereas in the latter stages feedback from muscles and senses allow the schema to be

developed more fully. However, they caution that this proposition is tenuous until more research is done.

The third explanation Feltz and Landers describe is the psychoneuromuscular proposition. This explanation holds that low-gain neuromuscular efference activity during IHIB is identical, but reduced in magnitude, to activity during the same overt movement. This activity is transferred to the actual performance testing session. Feltz and Landers recognized that their meta-analysis lacked a direct test of this proposition. Nonetheless, they did review some of the pertinent literature and concluded that the literature fails to support the psychoneuromuscular proposition.

The final proposition reviewed by Feltz and Landers is the 'motivation explanation' as described by previous reviews. Feltz and Landers (1983) suggest that IHIB prepares the subject to perform his/her best by altering arousal to optimal levels, however this proposition cannot account for all the effects of IHIB.

Feltz and Landers (1983) also note the common methodological problems associated with IHIB research, such as (a) variability of the tasks employed; (b) variability of subject characteristics; (c) variability in IHIB procedures; and (d) the use of performance

scores which may be insensitive to the small effects typically produced by IHIB.

Hinshaw's (1991) meta-analysis was more optimistic about the effects of IHIB. She concludes that there is reasonably solid evidence for significant benefits to performance in using IHIB compared to no practice. However, her optimism about IHIB effects may be a result of the studies she used in the meta-analysis. Hinshaw assessed only published studies whereas Feltz and Landers (1983) assessed both published and unpublished studies with published studies showing a significantly larger effect size. Nevertheless, Hinshaw also noted the problem that IHIB research primarily focuses on outcome effects, and tends to neglect the identification or examination of the underlying processes mediating between IHIB and performance.

In summary, the major reviews of the literature to date have indicated that while IHIB can benefit subsequent performance, the effects on subsequent performance are unsystematic and unreliable. Two general problem areas have been identified:

1. Methodological problems permeate the IHIB research. Many of Richardson's early methodological

criticisms are still valid today. There are still problems with (a) the variability of the tasks used to examine the effects of IHIB; (b) the variability and lack of details of IHIB treatment procedures; and (c) the general lack of controlled rigorous experimental research (Corbin, 1972; Feltz & Landers, 1983; Hinshaw, 1991; Murphy, 1990; Richardson, 1967b; Suinn, 1982; Weinberg, 1982).

2. The proposed theoretical explanations for IHIB have not proved useful: (a) they have failed to synthesize research findings; (b) they have failed to indicate new directions for research; and (c) they have not led to an understanding of the principles underlying IHIB. The same hypothetical explanations presented by Richardson (1967b) are still discussed today, with little, if any, additional evidence (Murphy, 1990; Suinn, 1983; Weinberg, 1982). In fact, Feltz and Landers' (1983) 'new' stage specific learning model may be viewed as little more than an elaboration and combination of the symbolic learning and neuromuscular feedback hypotheses described by Richardson (1967b). Weinberg (1982) also noted the theoretical vacuum in IHIB research and observed that theory has not stimulated any new fruitful research.

Consequently, there has been very little progress made in the identification of the necessary and sufficient conditions for producing reliable IHIB enhancement of subsequent performance. Since Richardson (1967a), the list of important variables influencing IHIB effectiveness has been lengthened by a only one --internal vivid imagining (Corbin, 1972; Feltz & Landers, 1983; Hinshaw, 1991; Murphy, 1990; Richardson, 1967a; 1967b; Suinn, 1983; Weinberg, 1982). There seems to be some justification for Weinberg's (1982) and Murphy's (1990) criticism that IHIB research does not provide the practitioner with specific rules, guidelines, or procedures to put into use to enhance performance.

Recent Developments

Research since 1980 can be described as four general categories: (1) studies which include additional treatment groups as a methodological strategy; (2) studies employing multiple measures to assess IHIB effects; (3) studies investigating physiological activity during IHIB; and (4) studies employing decision-making tasks to investigate the similarity between overt and imagining behaviour.

Additional Treatment Comparison Groups

Traditionally, researchers have investigated IHIB effects by comparing the IHIB group with a no practice control group and a physical practice control group on a single measure of performance (Corbin, 1972; Hinshaw, 1991; Murphy, 1990; Richardson, 1967a; Suinn, 1982; Weinberg, 1982). Recently researchers have begun to employ other methodological strategies in an attempt to address some of the criticism of the IHIB research. One recent addition is the inclusion of more treatment comparison groups.

One of the first studies to employ a more complex methodological strategy in the examination of IHIB was by Weinberg, Seabourne, and Jackson (1981). They used four groups with multiple measures of performance to investigate the IHIB technique Suinn (1982) called Visuo-Motor Behaviourial Rehearsal (VMBR). VMBR is a structured training technique that includes relaxation training, visual imagining training, and the use of both training techniques during structured visual imagining of the target behaviour. Thirty-two subjects, matched on karate performance ability, were divided into four groups: a relaxation group, an imagining group, a VMBR group, and an attention-placebo

group. Subjects were rated on three aspects of performance: a single skill, a combination skill, and sparring performance. To evaluate the effectiveness of each treatment procedure on a subject's degree of relaxation, heart rate was recorded and a state-trait anxiety test was administered prior to performance. Results indicated that the subjects who received relaxation or VMBR reported significantly less state anxiety than the subjects who only imagined performing the target behaviours or the subjects in the attention-placebo group. No differences were found on heart rate. Of the three performance measures, significant differences among the groups were observed only for sparring, with subjects who received VMBR scoring significantly higher than those in the other three groups. Weinberg et al. (1981) concluded that, due to lack of consistent results across measures, the effectiveness of VMBR in enhancing karate performance was only partially supported.

This study is important for three reasons. First, it initiated the use of additional treatment groups. Second, multiple measures were employed, thus allowing for a more comprehensive assessment of the effects of IHIB. Of six different measures, only sparring and

state anxiety differentiated between experimental groups, indicating that IHIB may effect different aspects of performance in different ways. Third, two IHIB treatment groups that differed on a single factor were used in the design, thus allowing for an evaluation of a single variable. Although no definitive conclusions were reached in this study, the inclusion of more comparison groups allowed for a systematic examination of variables thought to influence IHIB effects on performance.

Ryan and Simmons (1982) also used multiple IHIB groups to study the role of imagining on the effectiveness of a 'mental practice' technique. They compared 80 male traffic officers divided into six groups on a stabilometer task. This task involves standing on something like a pivoting balance beam with the goal of keeping one's balance and remaining parallel to the ground. Subjects were divided into 'imagers', 'nonimagers', and 'occasional imagers' based on self-reported use of imagining behaviour in their everyday life. 'Occasional imagers' were randomly assigned to the traditional no-practice (n=16) and physical practice (n=16) groups. In addition, four IHIB groups were used. Two of these groups contained

16 'imagers' each: one group was instructed to imagine doing the task, whereas the other group was instructed to use any cognitive means they wished, such as describing the task in words, without actually imagining the behaviour. The other two groups contained 'nonimagers': one group had eight 'nonimagers' instructed to imagine doing the task, and the other group had eight 'nonimagers' instructed to use any cognitive means they wished but not imagining. The results indicated that regardless of the type of subject (i.e., an 'imager' versus a 'nonimager'), imagining performing the task was significantly more effective in enhancing performance on the stabilometer than using other cognitive methods. In addition, there was a trend indicating that imagining by an 'imager' subject resulted in a larger performance improvement than imagining by a 'nonimager' subject.

Ryan and Simmons (1982) concluded that imagining plays a key role in the effectiveness of 'mental practice'. The results support earlier reviews (e.g., Corbin, 1972; Richardson (1967a) which suggested that it is the imagining behaviour (or the subject's imagining behaviour ability) and not self-talk or other cognitive strategies which plays the critical role in

'mental practice'.

Hall and Erffmeyer (1983) compared 10 highly skilled female basketball players randomly divided into two IHIB groups based on basketball foul shooting percentages. The members of one group were exposed to a videotaped model to assist them in their imagining of proper basketball foul shooting. The other group did not have this videotaped model but still was instructed to imagine proper basketball foul shooting. Although there were no significant between group differences, IHIB with videotaped modelling led to significant pre-post improvement in foul shooting percentages whereas IHIB without videotaped modelling did not result in significant pre-post changes in foul shooting percentages. Conclusions drawn from this study are limited for two reasons: first, each group contained only five subjects, and second, the experiment lacked adequate control groups. Nonetheless, these results suggest that videotaped modelling may help increase the effectiveness of IHIB procedures. It should be cautioned that, due to omission of control conditions, the significant improvement may be simply due to the videotaped modelling.

Andre and Means (1986) also employed multiple

treatment groups to examine a single variable thought to be important to IHIB. They examined the effects of slow motion imagined practice during IHIB. Sixty-six university undergraduates were randomly assigned to an attention placebo group, an IHIB group, or a slow motion IHIB group. The performance measure was Frisbee disc golf "putting". The task required subjects to throw a Frisbee to specific targets. The slow motion IHIB group differed from the IHIB group in that they were instructed to imagine the task behaviour in slow motion. No between group differences were found. The authors concluded that slow motion IHIB may not be critical for IHIB to improve subsequent performance. They suggested that the failure of IHIB to produce any effects may be due to procedural problems such as boredom with IHIB instructions, too short a period performing IHIB, low motivation among subjects, or the all-or-none nature of the performance measure.

Van Gyn, Wenger, and Gaul (1990), in conjunction with other training procedures, used multiple IHIB groups to study the benefits of IHIB to facilitate transfer of training to performance. They compared 40 university physical education students randomly assigned to one of four groups on a test of peak power

and on 40 metre sprints. The test of peak power required subjects to complete the Wingate cycle ergometer for a period of thirty seconds. Peak power was determined from pedal frequency and resistance. One group of subjects received 'Imagery Training' which consisted of imagining sprinting the 40 metres, another group received 'Power Training' which consisted of practice on the peak power test, a third group received 'Imagery and Power Training' (these subjects engaged in IHIB of 40 metre sprints during peak power training), and a fourth group received no additional training. After pre-treatment performance on the two tasks was evaluated, subjects received treatment three times per week for 6 weeks. Following treatment, subjects were again evaluated on the peak power test and the 40 metre sprint. The results showed that subjects who received 'Imagery Training' alone performed at the same level as the no-treatment control subjects. However, subjects who received 'Imagery and Power Training' performed significantly better than all other groups on the 40 metre sprint. Although the 'Imagery and Power Training' group did not differ from the 'Power Training' subjects on the peak power measure, both these groups were significantly better than the

'Imagery Training' alone group and the no-treatment control group. These researchers suggested that IHIB can facilitate the transfer of skills in training procedures (e.g., peak power practice) to the skills required under performance conditions (e.g., 40 metre sprint).

These studies have added little to the understanding of IHIB and the variables that are critical in the mediation of subsequent performance effects, and they do not provide a practitioner with specific procedures to maximize performance through IHIB. Nonetheless, the assessment of IHIB effects through the use of multiple treatment groups represents a significant attempt to address some of the previous criticisms of IHIB research.

Two recent studies have employed this methodological strategy and they appear to have identified a variable that may play a critical role in the effectiveness of IHIB. Woolfolk, Parrish, and Murphy (1985) classified 30 subjects into three skill levels on putting a golf ball. They randomly assigned an equal number of subjects to one of three different groups. Ten subjects were assigned to the no-practice control group; ten subjects were assigned to the IHIB

group and instructed to imagine negative consequences (putting the ball and missing the cup) prior to each putt; and ten subjects were assigned to the IHIB group and instructed to imagine positive consequences (putting the ball into the cup) prior to each putt. In subsequent tests, IHIB with positive consequences was superior to the no-practice control group which in turn was superior to IHIB with negative consequences. The authors suggested that IHIB can be divided into two components, the task performance or behaviour itself and the outcome or consequence of that imagined performance. They suggested that effective imagining behaviour instructions should also include the imagining of outcome, a factor which has been neglected in most of the earlier IHIB studies.

In a follow up study, Woolfolk, Murphy, Gottesfeld, and Aitken (1985) attempted to evaluate the imagined behaviour and imagined outcome components of the IHIB instructions. They classified 60 subjects into three skill levels on putting a golf ball. They randomly assigned an equal number of subjects from each level to one of six different groups. Initially each group had 10 subjects, but a manipulation check indicated that some subjects failed to comply with the

IHIB instructions: they were, therefore eliminated from the analysis. Group 1 (n=7) was instructed to imagine the behaviour of putting the ball without imagining the outcome. Group 2 (n=9) was instructed to imagine just the positive outcome (the ball rolling into the cup). Group 3 (n=7) was instructed to imagine just the negative outcome (the ball rolling and missing the cup). Group 4 (n=8) was instructed to imagine the behaviour (holding the putter and striking the ball) and a positive outcome. Group 5 (n=9) was instructed to imagine the putting behaviour and a negative outcome. Group 6 (n=8) was a no-practice control group. The results indicated that there was a main effect for negative outcome only: that is, imagining a negative outcome resulted in a significant decrease in putting performance. No other differences were found. The authors suggested that a change in the procedure from the Woolfolk et al. (1985) study may have accounted for the lack of differences in the performance of the imagined positive outcome group compared to the no practice control.

These two studies used multiple treatment conditions to isolate two of the components of IHIB -- imagining the task behaviour and imagining the outcome

of that behaviour. They have helped identify what appears to be one variable deserving of attention in future research: imagining the outcome.

Multiple Measurement

Recently, researchers have employed a broader range of measures than previously used in order to assess the effects of IHIB on subsequent performance. There are two aspects to the use of multiple measures in IHIB research. First, multiple performance measures have been used to assess those aspects of performance which are influenced by IHIB. Second, information about the imagining behaviour obtained through self report measures has been used to identify variables which may be of importance for IHIB effectiveness.

Measures of Performance. Few studies to date have gathered multiple performance measures even though this can help clarify the effects of IHIB (Watters & Bourgon, 1988). The study by Weinberg et al. (1981) described earlier measured three aspects of performance: single skill, combination skill, and sparring. They found that the Visuo-Motor Behavioural Rehearsal group performed significantly better on sparring than the relaxation group, the imagining

group, or the control group. No conclusions were offered because of only partial support for their hypotheses. However, it is worth noting that if only one performance measure had been used (e.g., single skill) then the study would have been just one more study showing IHIB to have no effect on subsequent performance.

Watters and Bourgon (1988) also measured three aspects of performance to assess the effects of IHIB. Thirty university students were randomly assigned to one of three groups, a no practice control group, a physical practice control group and an IHIB group. Subjects performed, as fast as possible, a simple sequence of eight motor responses on a telegraph key and joystick. Measures consisted of speed, variability in the speed, and errors. They found that the IHIB group performed significantly better on two of the three measures (variability and errors) than the no practice and the physical practice groups. Again, it should be noted that if only speed had been chosen as the measure of performance, then this study would have been another study showing IHIB to have no effect on subsequent performance. The results of the Weinberg et al. (1981) study and the Watters and Bourgon (1988)

study support the use of multiple performance measures to assess and further the understanding of the effect of IHIB on subsequent performance.

Self Reports of Imagining Behaviour. The information obtained by self-report measures of the imagining behaviour is another methodological strategy that has been recently added to the study of IHIB. Wollman (1986) suggested that a thorough monitoring of the imagining behaviour can lead to the identification of factors that may be worthy of future experimental study. One such example is visual perspective (internal versus external imagining perspective), which Mahoney and Avener (1977) identified by surveying elite athletes. They found that athletes whose imagining behaviour had an internal perspective performed better than those athletes whose imagining behaviour had an external perspective (as if watching oneself on TV). Further experimental research provided additional support for their anecdotal reports (Suinn, 1983; Weinberg, 1982).

Subjective reports have suggested that the greater the vividness of the imagining behaviour the more likely that IHIB will result in performance improvement (Corbin, 1972; Richardson, 1967a; Suinn, 1983;

Weinberg, 1982). Ryan and Simmons (1982) had subjects rate their IHIB in terms of quality of the kinetic and visual imagining behaviour. They ranked subjects in terms of the self-reported quality of IHIB and found those who ranked higher in terms of IHIB quality had greater performance change scores than those with lower quality rankings. They concluded that vivid IHIB was related to increased effectiveness of IHIB.

Recently, two studies by Ryan and Simmons (1981; 1983) used subjective reports to examine the effects of frequency of IHIB trials on IHIB effectiveness. Ryan and Simmons (1981) asked subjects to indicate the number of trials during which they engaged in IHIB (range = 4 to 37 trials; $M = 20.46$). Subjects were divided into a high ($M = 28.86$ trials) and low frequency ($M = 10.67$ trials) groups based on a median split. No differences were found in terms of performance improvement on either the Dial-a-Maze or Stabilometer task following IHIB. They did, however, note a nonsignificant trend in the opposite direction with the low frequency group performing better than the high frequency group.

Ryan and Simmons (1983) subsequently re-examined the relationship between the quantity of IHIB trials

and IHIB effectiveness. Using a median split to divide subjects into high and low frequency of IHIB trials, no differences were found on Dial-a-Maze performance following IHIB. They concluded that the quality of IHIB is likely to be more important than quantity.

Subjects have also been asked to rate how effective they thought IHIB would be in improving their subsequent performance. One study (Ryan and Simmons, 1982) examined the relationship between perceived effectiveness and IHIB effectiveness. Following post-test performance, subjects rated how helpful they felt IHIB had been. Subjects were then ranked in terms of perceived effectiveness of visual and kinetic imagining behaviour. The study found that those subjects who reported that kinetic imagining was helpful performed better than those who reported little or no help from kinetic imagining. Those subjects who reported that visual imagining was helpful performed no differently than those subjects who reported little or no help from visual imagining.

In summary, monitoring the IHIB experience is another method to help identify factors that may influence the effectiveness of IHIB in improving subsequent performance. Imagining behaviour

perspective (internal, external), vividness, and perceived effectiveness appear to influence IHIB's effectiveness whereas the number of IHIB trials alone does not affect subsequent performance. Continued monitoring and subjective reports of IHIB may lead to the identification of additional variables that warrant attention.

Physiological Activity

In the behavioural medicine and biofeedback literature, it has been widely accepted that imagining can affect physiological activity. Shiekh and Kunzendorf's (1984) extensive review of this literature demonstrates that physiological activity during imagining is clearly similar to the physiological activity observed during overt behaviour. They cited studies which showed physiological responses such as heart-rate, electrodermal activity, voluntary muscle activity, blood flow, and skin temperature are affected during imagining in a manner that is similar to the effect observed during overt behaviour.

Although the measurement of physiological activity during imagining is not new, it is only recently that this method has been used in IHIB research (Hale, 1982;

Harris & Robinson, 1986; Suinn, 1983; Weinberg, 1982). According to the Psychoneuromuscular-Feedback hypothesis of IHIB effects as described by Richardson (1967b) and others (Corbin, 1972; Feltz & Landers, 1983; Suinn, 1983; Weinberg, 1982), IHIB results in minute muscle innervations which provide feedback on the imagined performance to the individual so that necessary corrections may be made. Without such muscle activity, no feedback is available and thus no learning should occur. It has also been proposed that the greater the amount of physiological activity, the greater the probability of gains in performance following IHIB (Hale, 1982; Harris & Robinson, 1986; Suinn, 1983).

Physiological responses during IHIB have been measured for two reasons. First, physiological measures may provide evidence that IHIB is eliciting the minute responses from the specific muscles that would be used during overt performance (Hale, 1982; Suinn, 1983). Second, consistent with the above rationale, the magnitude of the physiological response can provide a method of evaluating variables of importance to IHIB (Hale, 1982; Harris & Robinson, 1986; Suinn, 1983). It is assumed that the greater the

physiological activity, the greater the performance gain; therefore, variables that result in greater amounts of physiological activity are likely to be those that will produce the largest performance gains.

Hale (1982) reasoned that greater physiological activity (in the parts of the body that are required for the target behaviour) should be observed during IHIB in comparison to baseline rates. In addition, muscle activity should be larger under conditions that have been identified as more likely to result in performance improvement following IHIB than under contrary conditions. Hale (1982) hypothesized that greater amounts of electromyographic (EMG) activity would be recorded in the right biceps muscle for subjects during internal perspective ("from your own eyes") IHIB for biceps weight curl, as compared to external perspective ("seeing one self on TV") IHIB which would have greater amounts of electro-oculographic (EOG) activity. In addition, greater EMG and EOG activity should occur for individuals with more experience (i.e., high skill levels) than those individuals with less experience (i.e., low skill levels). Finally, it was hypothesized that imagery vividness, a factor believed to mediate IHIB's effect

on subsequent performance, would be positively correlated with EMG activity.

Hale (1982) tested these hypotheses with 48 subjects who were divided into experienced and inexperienced weight lifters. He measured EMG activity in the right biceps muscle during internal perspective and external perspective imagined biceps curls. It was found that EMG activity was significantly higher during IHIB than during baseline conditions. Internal perspective IHIB had significantly larger EMG activity than external perspective IHIB but no differences were found for EOG activity. No differences were found on EMG and EOG activity between the two different weight lifting experience levels. In a post-hoc analysis, there were no significant differences in EMG or EOG activity between individuals with high imagery vividness and those individuals with low imagery vividness, as measured by the Imagery Exercise Questionnaire (Epstein, 1980) and the vividness subscale of the Betts Questionnaire of Mental Imagery (QMI; Sheehan, 1967).

Harris and Robinson (1986) tested the same hypotheses. Thirty-six karate students, half beginners and half advanced, were randomly assigned to

counterbalanced conditions of internal/external perspective IHIB and right/left side arm lifts. EMG activity was recorded from both the right and left deltoid muscles. Consistent with Hale's (1982) result, they found that localized EMG activity was significantly greater during IHIB as compared to baseline conditions. However, contrary to Hale (1982), they found that internal and external perspective IHIB did not differ in EMG magnitude. Also contrary to Hale (1982), they found that advanced karate students had significantly greater amounts of EMG activity than the beginner karate students.

These results illustrate two points. First, localized EMG activity in the muscles that are used during actual performance is significantly increased from baseline rates during IHIB. The evidence indicates that similar muscle activity occurs during IHIB and during the parallel overt behaviour. Second, results illustrate the difference between prediction based on present theory and the empirical results of IHIB research. Many theories have suggested that the greater the muscle activity during IHIB, the greater the effect in performance improvement. The psychoneuromuscular theory (Feltz & Landers, 1983;

Richardson, 1967b), the feedback theory (Corbin, 1972), the connectivist theory (Corbin, 1972), the stage-specific proposition (Feltz & Landers, 1983) and VMBR - a technique rather than theory - (Suinn, 1983) all hold this view. However, empirical evidence fails to support this position.

On the other hand, there is one experiment that provides some evidence for the necessity of physiological activity for IHIB to be effective in behaviour change. Lang (1979) divided phobic subjects into two groups based on EMG and heart rate activity during IHIB of fear producing situations. One group of subjects demonstrated physiological responses during IHIB that were similar to the physiological responses during actual fear producing situations. The other group of subjects did not demonstrate such physiological responses during IHIB. Following a systematic desensitization intervention (an imagery-based procedure that uses IHIB to change overt behaviour), those subjects who showed overt-like physiological responses during IHIB showed significant fear-reduction to phobic stimuli compared to those subjects who showed physiological responses during IHIB that were not overt-like. Lang (1979) suggested that

overt-like physiological responding during IHIB is necessary for IHIB to be effective.

Lang's (1979) study suggests that overt-like physiological responding is a critical aspect of IHIB's effectiveness in changing subsequent behaviour. However, the results by Hale (1982), Harris and Robinson (1986) and the meta-analysis of Feltz and Landers (1983) do not support the psychoneuromuscular nor the feedback theory.

Similarity of Imagining Behaviour and Overt Behaviour

There have been a few studies which examined some of the characteristics of imagining behaviour. In these studies, imagining behaviour has been shown to possess similar temporal properties to its parallel overt behaviour. In an early study, Shepard and Metzler (1971) presented pairs of three dimensional figures, each drawn with a different orientation. Subjects reported whether or not the figures were identical and the latency of their responses were measured. In this experiment, imagery was reasoned to be the mental manipulation of the objects. It was found that it took the subject longer to make a decision as the degrees of rotation required to give

the figures the same spatial orientation increased, and that the length of time was a linear function of approximately 60 degrees rotation per second. These results suggest that imagery ('mental rotation of the objects') shares similar temporal properties with its overt behaviour counterpart (physical rotation of the objects).

In a follow up study, Shepard and Feng (1972) tested this suggestion that imagining behaviour is an analog to overt behaviour. The task involved using patterns of six connected squares such as those that would result when the faces of a cube are unfolded onto a flat surface. Time for the subject to determine whether the two arrows marked on a pattern would or would not meet if the squares were folded back into a cube was measured. In two similar experiments, 10 subjects for each experiment were tested on this 'mental paper folding' task. Analysis of latencies revealed a linear function based on number of operations (folds) performed and difficulty associated (number of squares that needed to be carried with that fold) with each operation. Shepard and Feng suggest that the physiological events taking place during the imagining of an external behaviour have a great deal in

common with the physiological events that take place when one is actually doing the external behaviour.

In another study, Pinker and Kosslyn (1978) also found the temporal properties of imagining to be similar to those of overt behaviour. They presented a number of objects suspended in a box to 16 university students. Once the subjects had memorized and demonstrated accurate imagining of these objects and their location, the testing session began. The tape-recorded instructions asked the subject to imagine the box and one object in its location in the box. When the second object was named, the subject was to imagine a small black dot moving at a constant rate as fast as possible from the first to the second object. The latency of responses was measured. The results showed that the time to scan between objects was highly correlated with the three dimensional distances between the objects. In fact, the time to scan different distances between objects increased linearly with actual distances, as would be expected if the subject was actually performing this task rather than just imagining doing it.

Summary

In summary, the effects of IHIB on subsequent performance are unreliable and far from systematic even though it is generally accepted that IHIB can enhance performance. A variety of reasons have been identified to explain the difficulty in this area.

First, there are a number of methodological problems associated with the IHIB literature such as variability of tasks, IHIB procedures, subject characteristics, and variability of performance measures. Recently, there has been a trend towards employing different methodological strategies such as additional treatment groups, multiple measures of performance, and self-reports of IHIB to address some of these concerns. These methodological strategies illustrate the evolution of IHIB research yet they have resulted in little new knowledge of factors which influence the effects of IHIB on subsequent performance.

A second reason for the difficulty in finding reliable effects of IHIB pertain to the definition of IHIB. It has been suggested that IHIB is similar to the target behaviour without the overt movement. Similarity of a variety of physiological activities and temporal properties has been demonstrated between IHIB

and the overt target behaviour. In addition to difficulty of objective observation of IHIB, the variability of tasks, procedures, and subject characteristics means that there is little consistency within subjects, between subjects, or across studies. Consequently, finding consistent and reliable effects of IHIB is rendered more difficult.

A third reason is that the theoretical frameworks suggested have not provided an adequate understanding of the phenomena nor have they stimulated much fruitful research. Consequently, there has been relatively little progress made in identifying critical variables that influence the effect of IHIB on subsequent performance. The variables which appear to be related to increased, albeit unreliable, effects of IHIB are increased levels of experience or skill with the target behaviour, alternating IHIB with physical practice, vividness of imagining behaviour, use of an internal perspective during IHIB, and imagining the outcome of the target behaviour.

Proposed Conceptual Scheme

Present conceptual schemes regarding IHIB have not proved useful. They have failed to synthesize research

findings, have not provided new directions for research, and have not led to an understanding of the principles underlying IHIB nor provided methods to ensure reliable and systematic effects of IHIB on subsequent performance.

Within the IHIB paradigm, the intent of research is to isolate variables involved in the learning of an overt behaviour during IHIB. A group of subjects are exposed to a specific set of environmental variables. A collection of behaviours are emitted and some of these behaviours are measured. These behaviours are referred to as baseline or pre-test performance. Following this baseline observation, the group of subjects are exposed to a second set of environmental variables. One important variable in this set is the IHIB instructions (e.g., 'imagine doing the same behaviour you have just emitted'). At this point, a collection of behaviours are emitted, all of which are referred to as imagining behaviour. With the present technology, this collection of behaviours may or may not be measurable and the researcher may or may not choose to monitor some of the measurable behaviours. The group of subjects are then exposed to the initial set of environmental variables again, behaviours are

emitted, and some of these are measured. The final set of behaviours are referred to as subsequent performance. IHIB research evaluates the effects of the imagining behaviour and its environmental variables on subsequent performance.

An alternative explanation regarding IHIB, which has not yet been evaluated, is provided by Skinner (1974). Skinner suggested that covert behaviour [IHIB] is simply overt behaviour that is emitted on a very small scale and therefore, not directly observable by most persons. If this is so, the occurrence of physiological activity (which is just a subset of all the behaviours occurring) similar to that observed during overt activity is an indication that IHIB is taking place. The magnitude of this physiological activity may signify little, beyond its presence or absence. However, what may be of critical importance is the pattern of this activity. If IHIB resembles the overt behaviour reduced in magnitude, then the pattern of physiological activity should be also be similar. Therefore, the critical characteristic would be the degree of similarity of the patterns of activity during the overt behaviour and the IHIB. However, the degree of similarity in this pattern will vary due to such

factors as different learning histories, and different imagining behaviour instructions. It would be predicted, therefore, that the higher the degree of similarity between the pattern of imagining behaviour activity and the pattern of the overt behaviour activity, the greater the effects of IHIB on overt behaviour. Therefore, the goal of an IHIB procedure should be to increase the similarity between the imagining behaviour and the overt behaviour. In turn, the goal of IHIB research should then be to identify variables that affect this degree of similarity.

One way of influencing any behaviour is manipulation of its environmental variables. Identifying variables that exert control over overt behaviour, such as antecedent stimuli and behavioural consequences, is easier than identifying variables that exert control over IHIB due to the difficulty of observing IHIB. However, it is postulated that overt behaviour and IHIB are sufficiently similar that variables that exert control over overt behaviour should also exert some control over IHIB, or vice versa. Thus, using variables identified as controlling variables for the overt behaviour during IHIB procedures should result in greater control of IHIB,

which should result in IHIB being more similar to the overt behaviour, and consequently in greater gains in performance.

One such set of variables is antecedent stimuli. Antecedent stimuli exert some control on the overt behaviour and can often be easily identified. These antecedent stimuli should also exert some control over IHIB because the overt behaviour and IHIB share similar behaviours. Therefore, presenting these antecedent stimuli during IHIB procedures should result in IHIB that is more similar to the overt behaviour than if these antecedent stimuli are not presented during IHIB procedures.

Introduction to Experiments

The following series of parametric studies was designed to examine this behavioural interpretation of IHIB. This was accomplished by presenting auditory stimuli associated with task performance during IHIB treatment procedures. The stimuli were auditory stimuli that were utilized during actual task performance, that is, task-specific auditory stimuli. It was reasoned that an IHIB procedure that included the presentation of task-specific auditory stimuli

should result in IHIB that is more similar to the target overt behaviour. To evaluate this, a measure of similarity was required.

The literature has used two general methods of assessing IHIB; self-report evaluations of the quality of IHIB and physiological measures such as EMG. Self-report measures were not chosen because individual variation and the meaning associated with these measures are far from clear, they do not provide a very objective measure of the similarity of between IHIB and target behaviour, and are also potentially intrusive. Some of the problems associated with the evaluation of physiological measures of IHIB have been already noted. In addition, in order to evaluate similarity of the patterns between IHIB and target behaviour would require a large number of measures even for the simplest of tasks. For example for a simple hand-eye coordinated task, physiological measurements of eye movement, muscles in the shoulder, arm, hand and each finger would likely be required. Measuring physiological responses can be very intrusive and often reflect more the magnitude rather than pattern of IHIB. An appropriate objective measure of the similarity of IHIB to target behaviour would depend on the task and

the behaviour required to perform that task. Any component measure of target behaviour that could also measure some component of IHIB would allow an assessment of the similarity of the two behaviours. In the following experiments, the elapsed time to complete a trial was used to evaluate actual performance, therefore, the elapsed time to complete the IHIB was also obtained, with a comparison of the two latencies providing an index of similarity.

Experiment 1

The main purpose of Experiment 1 was to examine the effects of task-specific auditory stimuli on IHIB. It has been proposed that presenting such stimuli during IHIB treatment procedures should result in an increase in the similarity of IHIB to target performance. Conversely, the similarity of IHIB to target performance should be reduced when such stimuli are not presented during IHIB treatment procedures. Secondly, an initial examination was made of the effect of the similarity of IHIB to target performance on subsequent performance. It has been proposed that

increases in similarity should also increase the effectiveness of IHIB to enhance subsequent performance. Finally, an evaluation was made of the overall effectiveness of IHIB in enhancing subsequent performance.

Subjects

Seventy-five university students, 18 males and 57 females, served as subjects. The average age was 22.6 years ($SD=7.0$) with a range of 18 to 71. Subjects were randomly assigned to one of five groups.

Apparatus

The subject's chair faced a 12-inch (30.4 cm) diagonal black and white television monitor. A 10 cm high joystick was clamped to the right corner of a 60 cm wide table. A telegraph key was clamped to the left hand corner. The television monitor was connected to a Commodore VIC-20 computer and printer. The computer controlled the presentation of all stimuli and measured times to complete the task within each trial.

Two sets of visual stimuli were used. One set was presented throughout each trial, from the beginning of the trial until the subject completed the task. This

set consisted of a list of words in the following order, presented vertically from top to bottom on the television monitor: RIGHT, KEY, DOWN, KEY, LEFT, KEY, UP, KEY. The word KEY referred to pushing the telegraph key. The words RIGHT, LEFT, UP, and DOWN referred to the direction the joystick was to be moved. The second set of visual stimuli was presented on the screen at the end of a trial after the subject completed the task. This set consisted of feedback to the subject. A detailed description of the feedback is found in the procedure section and in Appendix 1.2. In addition to these visual stimuli, two auditory stimuli were presented as described below. Stimulus 1 (ST-1) was a constant tone of 1760 Hz at 60 db. Stimulus 2 (ST-2) was a constant tone of 880 Hz at 60 db. These stimuli were produced by a speaker in the right front of the monitor. The intensity of the auditory stimuli were measured using a Bruel and Bjoer meter, type 1613 at a distance of approximately .5 metres from the speaker.

Procedure

The experiment was divided into six periods: (a) the preliminary period, (b) TEST-1, (c) TREATMENT-1,

(d) TEST-2, (e) TREATMENT-2, and (f) TEST-3. The experimental design is summarized in Appendix 1.1. Each subject was randomly assigned to one of five treatment groups and run individually. One treatment group was the no-practice (NP) group, in which subjects engaged in conversation with the experimenter during TREATMENT-1 and TREATMENT-2 for approximately the same amount of time that subjects in the other groups were occupied during these periods. The second treatment group was the IHIB+ group, which engaged in instructed human imagining behaviour with auditory stimuli presented during both TREATMENT-1 and TREATMENT-2 trials. The third treatment group was the IHIB- group, which engaged in instructed human imagining behaviour with no auditory stimuli presented during TREATMENT-1 and TREATMENT-2 trials. It was expected that the IHIB + group would demonstrate IHIB responses that would be significantly more similar to target performance than the IHIB - group due to the presence of auditory stimuli during IHIB. In addition, pilot work suggested that there may be some interaction when a subject is exposed to both of these types of IHIB treatment. Therefore, two additional treatment groups were included. One, the fourth treatment group in this

experiment was the IHIB -/+ group, which engaged in instructed human imagining behaviour with no auditory stimuli presented during TREATMENT-1 trials but with auditory stimuli presented during TREATMENT-2 trials. Two, the fifth treatment group in this experiment was the IHIB +/- group, which engaged in instructed human imagining behaviour with auditory stimuli presented during TREATMENT-1 trials but with no auditory stimuli presented during TREATMENT-2 trials.

The subject entered the experimental room and was seated in the chair facing the apparatus. The preliminary period began with the subject being given typed introductory instructions to read (see Appendix 1.3) which described what the subject was required to do.

Following the introductory instructions, the subject was asked if he/she wished to continue (all did). If so, the subject was asked to sign a consent form (see Appendix 1.5) and told that at any time he/she could discontinue the experiment (none did). A complete description of what the experimenter said to the subject can be found in Appendix 1.4.

The preliminary period also contained two practice trials. Each trial started with the presentation of a

constant tone (ST-1) and a list of words on the monitor indicating the sequence of behaviours required of the subject. The subject had been instructed to perform this sequence of behaviours using his/her right hand only. The tone continued until the first behaviour of the sequence was completed correctly at which time the tone changed to the next tone (ST-2). A change of tones indicated that the subject had correctly completed a behaviour and could continue to do the next behaviour in the sequence. After completing the first behaviour (RIGHT), ST-1 changed to ST-2. ST-2 continued until the second behaviour (KEY) was completed at which time ST-1 started again. This alternating of tones continued until the sequence of behaviours was completed. Before each joystick move, ST-1 was presented until that behaviour was completed and before each key press, ST-2 was presented until that behaviour was completed. When the sequence of behaviours was completed, the auditory stimulus stopped and the monitor cleared. The visual feedback to the subject then appeared on the monitor for 6 seconds. The presentation of the next trial was preceded by the monitor being cleared for a random interval of between 0 and 1 second. At the end of each practice trial, the

visual feedback presented on the monitor was "Good, get ready". After the two practice trials, the subject was asked if there were any questions. If so, the appropriate part of the introductory instructions were re-read by the subject.

The second period, TEST-1, began when the subject was given typed scoring instructions to read (see Appendix 1.3) which provided the following information. The objective was to score as many points as possible. The closer the response was to a perfect score, the higher the score with scores ranging from a minimum of 0 points to a maximum of 5 points. If the sequence was completed too slowly, the message "TOO SLOW" was presented on the monitor. If the sequence was completed too quickly, "TOO FAST" would appear on the monitor. The feedback with the score remained on the monitor for a short period (6 seconds). Then it cleared and another trial started. The subject was asked if there were any questions. If there were any, the relevant part of the instructions was re-read by the subject. The subject then completed the five trials of TEST-1. The details of the scoring system are found in Appendix 1.2.

After completion of TEST-1, the third period,

TREATMENT-1, started. If the subject was assigned to the NP group, that subject engaged in conversation with the experimenter for approximately the same time that was needed to complete the other treatment conditions. Subjects assigned to any of the four IHIB groups were asked to read the typed IHIB instructions (see Appendix 1.3) which described the IHIB procedure. This involved five steps: (1) the experimenter instructed the subject to imagine performing a response which would score a certain number of points; (2) the subject closed his/her eyes and said "ready" when the apparatus was clearly visualized; (3) on a designated cue (described later), the subject began imagining seeing and feeling himself/herself doing each of the behaviours of the sequence; (4) when the sequence of imagining behaviours was completed, the subject imagined seeing and reading the feedback of his/her performance on the computer screen; and (5) after completing these steps, the subject was to say "finished" to indicate to the experimenter that he/she was finished with that trial. The subject was asked if there were any questions. If there were any, the relevant part of the instructions was re-read by the experimenter to the subject. The experimenter then informed the subject that he/she was

required to push the "." button on the computer keyboard with the first finger of his/her right hand after imagining completing each behaviour of the sequence.

There were five IHIB treatment trials. The subject was instructed to imagine one trial in which he/she scored "0 - too fast", then one trial in which he/she scored "0 - too slow", followed by three "5 point" trials which were at the correct speed. A IHIB trial began with one of two cues. One cue was the experimenter saying "GO": this cue was used for the treatment condition when no auditory stimuli were presented during IHIB trials (IHIB-). The second cue was the tone ST-1 which was initiated by the experimenter: this cue was used for the treatment condition when auditory stimuli were presented during IHIB trials (IHIB+). The IHIB+ trials began with the presentation of the tone ST-1, which continued until the subject pressed the "." button, at which time the tone changed to the next tone (ST-2). ST-2 continued until the second "." button push at which time ST-1 started again. This alternating of tones continued until the final (the eighth) "." button push. Thus, before each imagined joystick behaviour and

corresponding "." button push, ST-1 was presented until the "." button was pushed. Then, before each imagined key behaviour and corresponding "." button push, ST-2 was presented until the "." button was pushed. All IHIB treatments trials were identical except for the presentation of auditory stimuli and the cue to begin. The IHIB- treatment condition did not include auditory stimuli during IHIB trials, and these trials began when the experimenter said "Go". The IHIB+ treatment condition included the same auditory stimuli that were used during the two practice trials and the TEST-1 trials, and these trials began when the auditory stimuli was presented.

After the five IHIB trials of TREATMENT-1, the IHIB subjects completed a 4-item questionnaire. The four items, rated on a 6 point scale, were: (1) how vivid was his/her visual imagery? (2) how much imagined movement of arm and hand was used? (3) how did the subject rate his/her ability to do IHIB? and (4) what did the subject predict the effect of IHIB on performance to be? (see Appendix 1.6.1).

The fourth period, TEST-2, which began after TREATMENT-1, consisted of five trials. Before beginning the TEST-2 trials, the subject was reminded

to score as many points as possible. TEST-2 trials were identical in every way to the TEST-1 trials.

The fifth period, TREATMENT-2, followed the five TEST-2 trials. Subjects assigned to the NP group once again engaged in conversation with the experimenter. The IHIB subjects repeated the IHIB treatment procedure appropriate to the group to which the subject was assigned. Following these 5 IHIB trials, the subject completed a questionnaire which was the same as the one used after TREATMENT-1 with an additional item asking the subject to rate, on a 6 point scale, which IHIB session, TREATMENT-1 or TREATMENT-2, he/she preferred (see Appendix 1.6.2).

After the questionnaire was completed, the subject did TEST-3, the final phase of the experiment. This required the subject to again complete five trials which were identical to TEST-1 and TEST-2 trials. Following TEST-3, the subject was debriefed, and thanked for participating.

Results

Separate statistical analyses evaluated (1) the effect of the presentation of auditory stimuli during IHIB on the similarity of IHIB to the target

performance; (2) how this similarity of IHIB to target performance was related to subsequent performance; (3) the effect of treatment groups on the self reported questionnaire data; and (4) the overall effect of IHIB treatment on subsequent performance compared to no practice (NP).

Effect of auditory stimuli presentation during IHIB

The behavioural interpretation of IHIB suggested that presenting the same auditory stimuli that are associated with physically performing a task during IHIB should increase the similarity of IHIB to the target performance. The degree to which IHIB was similar to target performance was measured by the time to complete an IHIB trial: the time elapsed from the cue to begin imagining performing the sequence until the 8th "." button push by the subject (presumably this "." push corresponded to the completion of the 8th and final response in the imagined performance of the task). These times were converted into an IHIB duration equivalency score, using the same criteria used to calculate the points scored for performance on an actual test trial. In other words, an IHIB trial or a test trial which took equal time was converted into a score of equal value (e.g., a trial, either test or

IHIB, that took 9 seconds was converted into a score of 5).

Subjects were instructed to imagine a 0 (too fast), a 0 (too slow) and three 5-point correct responses during the 5 IHIB treatment trials at each treatment period. If a subject's IHIB duration equivalency scores were exactly what he/she was instructed to imagine, the resulting distribution would have had 40% of responses with a 0 duration equivalency score and 60% of responses with a 5 duration equivalency score. Due to small cell frequencies, responses were collapsed into 3 categories of 0-1, 2-3, and 4-5 duration equivalency scores and across the different treatment groups (i.e., for the first TREATMENT PERIOD, the IHIB+ treatment condition included responses from the IHIB+ group and the IHIB +/- group and for the second TREATMENT PERIOD included responses from the IHIB+ group and the IHIB -/+ group; for the first TREATMENT PERIOD, the IHIB- treatment condition included responses from the IHIB- group and the IHIB -/+ group and for the second TREATMENT PERIOD included responses from the IHIB- group and the IHIB+/- group). Figure 1.1 shows the frequency distribution of these duration equivalency scores for each of the two

IHIB treatment conditions (IHIB- and IHIB+) at each of the two treatment periods. Chi-square analyses of the distribution of the duration equivalency scores at each treatment period between the type of treatment received (IHIB+ and IHIB-) at that treatment period showed them to be significantly different at TREATMENT-1, χ^2 (2,N=300) = 16.1, $p < .05$, and at TREATMENT-2, χ^2 (2,N=300) = 31.4, $p < .05$. The presentation of auditory stimuli during IHIB treatment was associated with fewer 0 or 1 duration equivalency score responses at TREATMENT-1 (64% compared to 85%), χ^2 (1,N=224) = 4.02, $p < .05$, and at TREATMENT-2 (56% compared to 85%), χ^2 (1,N=212) = 9.13, $p < .05$, more 2 or 3 equivalency score responses at TREATMENT-1 (17% compared to 9%), χ^2 (1,N=39) = 4.33, $p < .05$, and at TREATMENT-2 (27% compared to 9%), χ^2 (1,N=53) = 13.7, $p < .05$, and more 4 or 5 duration equivalency score responses at TREATMENT-1 (18% compared to 7%), χ^2 (1,N=37) = 7.81, $p < .05$, and at TREATMENT-2 (17% compared to 6%), χ^2 (1,N=35) = 8.26, $p < .05$. In addition, responses made during IHIB- treatment appeared relatively unchanged over the two treatment periods with approximately 80% of the responses being 0 or 1 point duration equivalency scores. Responses made

during IHIB+ treatment appeared to show some improvement over the two treatment periods (i.e., a closer approximation to the ideal 40% 0 point and 60% 5 point distribution).

Summary

As predicted, the manipulation of auditory stimuli during IHIB did affect the duration for completing an IHIB trial. Presenting auditory stimuli during IHIB treatment was associated with a lower percentage of 0 or 1 IHIB duration equivalency responses, a greater percentage of 2 or 3 IHIB duration equivalency responses, and a greater percentage of 4 or 5 IHIB duration equivalency responses compared to the absence of auditory stimuli. It appears that presenting the task specific auditory stimuli during IHIB treatment procedures increased the similarity of IHIB to target performance in terms of elapsed time.

The relationship between IHIB similarity to target performance and subsequent performance

It was hypothesized (see pp. 43-47) that the similarity of IHIB performance to actual task performance may be critical for IHIB enhancement of subsequent performance, with greater similarity leading

to greater gains in performance. To examine this hypothesis, for all IHIB groups the trial pairs 10 and 11 and the trial pairs 20 and 21 were examined. Any similarity in performance on test trials should be most evident at these trial pairings because in each case the first trial of the pair is an IHIB trial and the second trial is a test trial. Trials 10 and 20 were the final IHIB trials in a treatment period (subjects were instructed to imagine doing a 5-point response on these trials). Trials 11 and 21 were the first test trials following a period of IHIB.

The similarity of actual task performance to IHIB performance was evaluated by using the IHIB duration equivalency score. Frequency analysis of IHIB duration equivalencies by test trial score showed very small cell frequencies. Therefore, two strategies were used to increase cell frequencies. The first involved collapsing both the duration equivalencies of IHIB trials and the points scored on the test trials into three categories: those responses scoring 0 or 1 into one category, those responses scoring 2 or 3 into the second category, and those responses scoring 4 or 5 into the third category. The second strategy involved combining both trial pairs (10:11 and 20:21) into a

single sample for analysis.

Table 1.1 shows for each of the three IHIB duration equivalency categories the percentage of responses in the three scoring categories on the following test trial. A chi-square analysis on the distribution presented in Table 1.1 revealed significant differences, $\chi^2 (4, N=120) = 12.9, p < .05$. Follow up analysis on the IHIB duration equivalency responses revealed that following 0 or 1 point IHIB duration equivalency responses, test trial scores were equally distributed across the three scoring categories, $\chi^2 (2, N=87) = 0.61, p > .05$. Following 2 or 3 point IHIB duration equivalency responses, test trial scores were not equally distributed across the three scoring categories, $\chi^2 (2, N=21) = 5.80, p < .06$, with the most probable test score being a 2 or 3 point response. Finally, following 4 or 5 point IHIB duration equivalency responses, test trial scores were not equally distributed across the three scoring categories, $\chi^2 (2, N=12) = 6.45, p < .05$, with the most probable test score being a 4 or 5 point response.

Additional follow up analysis looking at test trial responses showed that the distribution of 0 or 1 test trial scores to be equally distributed across the

three IHIB duration equivalency categories, χ^2 (2,N=41) = 1.32, $p > .05$. The distribution of 2 or 3 test trial scores across the three IHIB duration equivalency categories were found to be significantly different, χ^2 (2,N=39) = 6.26, $p < .05$, with an over-representation of 2 or 3 point test trial scores found in the 2 or 3 point IHIB duration equivalency category. The distribution of 4 or 5 test trial scores across the three IHIB duration equivalency categories were found to be significantly different, χ^2 (2,N=40) = 5.28, $p < .07$, with an over-representation of 4 or 5 point test trial scores found in the 4 or 5 point IHIB duration equivalency category.

A similar frequency distribution was prepared based on NP subjects only to compare their distribution of responses to the pattern found for IHIB. Trial pair 5 and 11, and trial pair 15 and 21 were examined as above (i.e. collapsing into 0 or 1, 2 or 3, and 4 or 5 point scoring categories and combining both trial pairs into a single sample for analysis). Trial 5 and trial 15 were the last test trials prior to a period of no practice and trials 11 and 21 were the first test trials following a period of no practice. Although no chi-square was computed due to small cell frequencies,

this distribution (see Table 1.2) indicated that regardless of level of performance prior to a period of no practice, the subject was likely to perform at the same level or below on the test trial following the period of no practice.

Summary

It appears that the score on the test trial immediately following IHIB treatment is significantly influenced by the duration of the IHIB response immediately prior to that test trial. When the subject engages in an IHIB 0 or 1 point equivalency response, all point scoring responses on the following test trial are equally probable. In this case, for an IHIB 0 or 1 point equivalency category, the probability of scoring 0 or 1 (38%), 2 or 3 (30%) or 4 or 5 (32%) closely approximates the distribution of responses on those same test trials following a period of no practice (i.e., percentages of 43%, 37%, and 20% respectively). On the other hand, when the subject engages in an IHIB 2 or 3 point duration equivalency response, it is likely that the following test trial will be a response that scores 2 or 3 points. This trend was not seen in the NP frequency distribution.

When the subject engages in an IHIB 4 or 5 point

duration equivalency response, it is likely that the following test trial will be a response that scores 4 or 5 points. This trend was not evident in the NP group trial pairs which were separated by a no-practice treatment period (see Table 1.2).

Questionnaire data

The subjects' ratings on the four questions on the IMAGINING QUESTIONNAIRE were analyzed. Each subject had two sets of four ratings, one set of four following each of the two IHIB treatment periods. The mean ratings for each group are presented in Table 1.3. Each item was analyzed separately using a 4 X 2 (GROUP by TREATMENT PERIOD) repeated measures analysis of variance (see Table 1.3). The only significant effect for each item was TREATMENT PERIOD. The ratings on all four items increased significantly from the TREATMENT-1 period to the TREATMENT-2 period.

The comparison item which asked subjects to indicate which IHIB treatment period he/she had preferred was also analyzed. After TREATMENT-2, subjects rated which IHIB treatment condition they preferred on a scale from 1 which indicated a strong preference for TREATMENT-1 to 6 which indicated a

strong preference for TREATMENT-2. ANOVA showed no significant differences among the four IHIB treatment groups ($F(3,56) = 0.35$; n.s.). The overall mean rating (6 point scale) for this item was 4.7 (SD = 1.4) indicating a preference for the second IHIB treatment period over the first period of IHIB treatment.

Effects of IHIB compared to NP

Although the literature indicated that finding an overall effect of IHIB was unlikely, particularly in light of the behavioural interpretation of IHIB which suggested that stronger control of the similarity of the IHIB response would be required, the effects of IHIB compared to NP were evaluated. For each subject at each test period, a score was derived by summing the points scored on the five trials that made up that test period. To examine the effects of the different treatment procedures on subsequent performance, a repeated measures analysis of variance (ANOVA) compared the five treatment groups on points scored across the three test periods. Table 1.4 summarizes the ANOVA and presents the means and standard deviations of points scored for the different groups at each of the three test periods. The ANOVA revealed a significant effect

of TEST PERIOD, $F(2,140) = 62.3$, $p < .05$. The main effect of GROUP, $F(4,70) = 2.33$, n.s., and the interaction between GROUP and TEST PERIOD was not significant, $F(8,140) = 0.62$, n.s.. Follow up analysis of the main effect of TEST PERIOD revealed a significant increase, $t(74) = 8.30$, $p < .05$, from TEST-1 to TEST-2, and from TEST-2 to TEST-3, $t(74) = 2.54$; $p < .05$.

Summary

It is clear that all subjects improved their performance over time. However, no significant differences were found between any of the IHIB treatment groups and the NP group.

Discussion

As hypothesized, the presentation of auditory stimuli during IHIB had an effect on the time to complete an IHIB trial. IHIB equivalency scores in Experiment 1 demonstrated that IHIB treatment with auditory stimuli (IHIB+) resulted in significantly more IHIB responses in the 2 or 3 point and the 4 or 5 point duration equivalency categories and significantly fewer in the 0 or 1 point duration equivalency category, compared to IHIB treatment without auditory stimuli

(IHIB-), at both the first and second treatment periods. It is evident that presenting task-specific auditory stimuli during IHIB treatment results in IHIB responses that are more similar to target performance (on the measure of elapsed time). It should be noted that duration of the auditory stimuli during IHIB was not predetermined, rather the duration varied according to the subject's response rate.

The results of the self reported questionnaire data indicate no differences between treatment groups. Although their IHIB responses were different depending on the type of IHIB treatment received, subjects did not rate them differently. This evidence supports the criticism of using self reported IHIB data as a measure of similarity as indicated earlier; the objectivity of such measures is questionable and the meaning associated with such measures are far from clear.

Second, it was hypothesized that degree of similarity of IHIB to the target would influence the effects of IHIB on subsequent performance. Results indicated that similarity of IHIB to target performance as measured by the duration equivalency score was related to the performance score on the following test trial. Test trial scores following IHIB responses with

a 0 or 1 point duration equivalency score were found to be equally distributed across all scoring categories. These responses were distributed in a fashion similar to the distribution of responses on the test trial following a period of no practice. The results indicated that a 2 or 3 point IHIB duration equivalency score was most likely followed by a test trial score of 2 or 3 points. Results also indicated that a 4 or 5 point IHIB duration equivalency score was most likely followed by a test trial score of 4 or 5 points.

It is interesting to note that in spite of these effects due to IHIB, there were no global group differences on performance. IHIB with auditory stimulus presentation (IHIB+) did not show significantly superior task performance compared to IHIB without such auditory stimuli presentation (IHIB-) or to the no-practice control group (NP). Additionally, no supportive evidence was found for an interaction between these two type of IHIB as suggested by the pilot work. One reason for the lack of significant group differences may be that only a few 4 or 5 point IHIB duration equivalency responses were made on the trials immediately preceding testing. Nonetheless, all 12 of the 4 or 5 point IHIB duration equivalency

responses on IHIB trials 10 and 20 were made by subjects who were being exposed to IHIB+ treatment (with auditory stimuli presentation) on that particular IHIB trial.

In summary, IHIB with auditory stimuli presentation results in IHIB responses that are more similar to target performance than during IHIB treatment without such auditory stimuli presentation. Although no significant performance differences were found between the two IHIB treatment conditions, it does appear that the similarity of IHIB to target performance is related to subsequent performance. IHIB duration equivalency scores of 2 or more points are followed by performance scores of similar value. This pattern was not found for IHIB equivalency scores of 0 or 1. The performance scores on test trials following an 0 or 1 point IHIB duration equivalency score was distributed in a manner similar to those following a period of no-practice.

Experiment 2

The main purposes of Experiment 2 were: (1) to replicate the effect of presenting task-specific

auditory stimuli during IHIB on IHIB responses; and (2) to further examine the relationship found between IHIB and subsequent performance.

The results of Experiment 1 indicated that performance scores following IHIB were more likely to be similar to the duration equivalency score of the preceding IHIB response when the IHIB response had a duration equivalency score of 2 or more points. However, due to the small number of IHIB responses that met this criterion, Experiment 2 attempted to increase the observed frequency of these duration equivalency scores by four methods. First, IHIB subjects were instructed to imagine performing only 5-point responses on all IHIB trials, rather than the method used in Experiment 1. Data suggested that IHIB responses of this duration appear to facilitate performance on the following test trial. Second, a design change was made to increase the number of IHIB trial - test trial pairs. In Experiment 1, each subject had 2 IHIB - test trial pairs. In Experiment 2, the treatment period required IHIB subjects to repeatedly perform two trials of IHIB followed by two test trials. In this manner, each subject had 5 such IHIB trial - test trial pairs. Third, the scoring criterion was expanded slightly to

increase the chances of subjects engaging in higher duration equivalency scores. Fourth, the number of subjects in each treatment group was increased from 15 to 20.

These changes in procedure, imagining 5-point responses exclusively, a large number of IHIB trial - test trial pairs, expanded scoring criteria, and an increased number of subjects per group were intended to provide an adequate sample of the three different IHIB equivalency categories and perhaps even an adequate sample of all six IHIB duration equivalency scores (i.e., 0, 1, 2, 3, 4, and 5) to evaluate the impact of IHIB similarity on subsequent performance.

In addition, an evaluation was made of the overall effectiveness of IHIB in enhancing subsequent performance. In Experiment 2, additional comparison groups were added to the design in order to provide more complete comparisons. Again, as with Experiment 1, it was not thought very likely that there would be an overall effect due to IHIB.

Subjects

One hundred and twenty university students, 23 males and 97 females, served as subjects. The average

age was 23.9 years (SD=7.0) with a range of 18 to 56.

Procedure

The experiment was divided into four periods: (a) the preliminary period: (b) TEST-1, (c) the TREATMENT period, and (d) TEST-2. A chart depicting the experimental design is presented in Appendix 2.1.

Experiment 2 began the same way as Experiment 1. The introductory instructions were read by the subject (subject's instructions and experimenter script are found in Appendix 2.3 and 2.4 respectively) and the consent form was explained and signed (see Appendix 2.5). The subject then completed the two preliminary practice trials. The introduction to the task and the two practice trials (without scoring feedback) were the same as in Experiment 1. This was followed by five TEST-1 trials which were identical to the five TEST-1 trials of Experiment 1 with one exception. The scoring criterion was expanded slightly and is found in Appendix 2.2.

The TREATMENT period consisted of 18 trials of two different general types of trials. One type of trial was a test trial which was identical to the trials of TEST-1 and TEST-2 and required the subject to

physically perform the task and then receive feedback. Another type of trial was a treatment trial, which varied across different groups. Subjects were randomly assigned to one of six treatment groups. Each group contained 20 subjects.

1. IHIB with auditory stimuli presentation (IHIB+). This group of subjects performed a mixture of IHIB with auditory stimulus presentation trials (IHIB+) and test trials. First these subjects completed 2 IHIB+ trials followed by 2 test trials. This was followed by another 2 trials of IHIB+, 2 test trials, 2 more IHIB+ trials, 2 more test trials, 2 more IHIB+ trials, 2 more test trials, and finally 2 IHIB+ trials. The procedure used for IHIB+ trials was identical to the procedure used for IHIB+ trials in Experiment 1.

2. IHIB without auditory stimuli presentation (IHIB-). This group of subjects completed a mixture of IHIB without auditory stimulus presentation trials (IHIB-) and test trials. First these subjects did 2 IHIB- trials followed by 2 test trials. This was followed by another 2 trials of IHIB-, 2 test trials, 2 more IHIB- trials, 2 more test trials, 2 more IHIB- trials, 2 more test trials, and finally 2 IHIB- trials. The procedure used for IHIB- trials was also identical

to the procedure used for IHIB- trials in Experiment 1 with one minor modification. To obtain as accurate as possible, a measure of the elapsed time for a subject to complete an IHIB trial during IHIB-, the cue to begin imagining performing the task for the subject was a 'beep' presented by the computer instead of the verbal prompt by the experimenter used in Experiment 1.

3. No Treatment control group (NT). This group of subjects were required to read a book for a length of time that was equal to the time spent in treatment by subjects in the other groups.

4. No practice control group (NP). This group of subjects first paused and engaged in conversation with the experimenter for a brief period of time that was equal to the time spent by IHIB subjects in reading the IHIB instructions and performing 2 IHIB trials. These subjects then completed 2 test trials, and briefly paused for a period of time equal to the time spent by subjects being instructed on what they would be doing on the next pair of trials and in performing 2 IHIB trials. They then completed 2 test trials followed by another pause, then completed 2 more test trials followed by another identical pause, then completed 2 more test trials followed by another pause. Therefore,

the subject in the NP group was actually performing the task the same number of times as the IHIB subjects, with brief intervening periods of no practice to match the time spent imagining (IHIB) by the IHIB subjects.

5. Physical practice control group (PP). This group of subjects completed 18 test trials separated into 9 pairs of trials with very brief pauses between each set of two trials. This pause was equal to the time needed for IHIB subjects to be instructed on what they would be doing on the next pair of trials.

6. Physical practice without feedback control group (PP WITHOUT FEEDBACK). This group of subjects completed 18 trials separated into 9 pairs of trials in an identical fashion to the PP group. The difference between this group and the PP group was that for the trials during which IHIB subjects engaged in IHIB, the PP WITHOUT FEEDBACK group performed test trials with no scoring feedback. The feedback they received on these trials was identical to the feedback received on the two preliminary practice trials. Therefore, these subjects completed the same number of test trials which received actual feedback as the IHIB subjects and they completed the same number of treatment trials, test trials without actual scoring feedback, as the IHIB

subjects had imagined performing. This group was used because it is similar to IHIB groups in that the task was practised but no actual scoring feedback is received on 10 trials.

Following this TREATMENT period, the subject was instructed that he/she would actually perform the task and score points for the next five trials. The subject was reminded to score as many points as possible. The subject then perform the five TEST-2 trials which were identical to the five trial of TEST-1. Following this, the subject was debriefed and thanked.

Results

Separate statistical analyses evaluated (1) the effect of the presentation of auditory stimuli during IHIB on the similarity of IHIB to the target performance; (2) the relationship between similarity of IHIB to target performance and subsequent performance; and (3) the overall effect of IHIB compared to no-practice (NP), physical practice (PP), and physical practice without feedback (PP WITHOUT FEEDBACK).

The effect of auditory stimuli on IHIB

Experiment 1 demonstrated that presenting auditory stimuli during IHIB increased the similarity of IHIB to

the target performance as measured by the elapsed time of an IHIB response (i.e., duration equivalency scores). Experiment 2 looked for this same effect. For the IHIB+ group and the IHIB- group, duration equivalency scores were calculated as in Experiment 1. For the PP group and the PP WITHOUT FEEDBACK group, scores were based on actual responses for the corresponding trials. The two control groups (NT and NP) were not included as there were no corresponding trials. The NT subjects were reading a book and the NP subjects were talking to the experimenter (see Appendix 2.1).

A repeated measures ANOVA on the duration of the responses made during the treatment trials (see Table 2.1 for complete breakdown) revealed that IHIB with auditory stimuli presentation (IHIB+) resulted in significantly higher duration equivalency scores than IHIB without such auditory stimuli presentation (IHIB-). In addition, the IHIB+ group showed a significant increase in similarity over time whereas the IHIB- group showed no changes over time. In fact, 80% of all IHIB responses for the IHIB- group were 0-point duration equivalency scores, that is, they were not at all similar in duration to the target performance.

Responses for the PP group and the PP WITHOUT FEEDBACK group on these trials resembled the responses of the IHIB+ group, and were significantly different from the IHIB- group's responses. The only significant difference between the IHIB+ group and the PP group was on the fifth trial pair, where the PP group had significantly higher scores than IHIB+.

The relationship between IHIB similarity to target performance and subsequent performance

The results of Experiment 1 suggested that the score on a test trial immediately following IHIB treatment is influenced by the duration of the IHIB response. Specifically, when IHIB duration equivalency score was 2 points or greater, subsequent performance was more likely to be of equal value (same elapsed time) than to be of any other value. When IHIB duration equivalency scores were 0 or 1 points, subsequent performance scores were found to be equally distributed across all scoring categories. Comparisons to response pairs from the no-practice (NP) group found subsequent performance scores were distributed in a manner that was identical to subsequent performance following IHIB duration equivalency scores of 0 and 1.

Data were analyzed in the following manner: each

subject contributed five separate sets of three data points (see Table 2.2 for a complete breakdown of how subjects contributed to this data set). The three data points were prior performance (performance on the scoring trial that immediately preceded treatment trials), treatment response (the responses on the treatment trial immediately preceding a scoring trial), and subsequent performance (performance on the scoring trial immediately following a treatment trial). The first set was trial 6, a test trial was prior performance; trial 7, a treatment trial was omitted from the analysis; trial 8, a treatment trial was the treatment response; and trial 9, a test trial was subsequent performance. The second set was trial 10, a test trial was prior performance; trial 11, a treatment trial was omitted from the analysis; trial 12, a treatment trial was the treatment response; and trial 13, a test trial was subsequent performance. The third set was trial 14, a test trial was prior performance; trial 15, a treatment trial was omitted from the analysis; trial 16, a treatment trial was the treatment response; and trial 17, a test trial was subsequent performance. The fourth set was trial 18, a test trial was prior performance; trial 19, a treatment trial was

omitted from the analysis; trial 20, a treatment trial was the treatment response; and trial 21, a test trial was subsequent performance. The fifth set was trial 22, a test trial was prior performance; trial 23, a treatment trial was omitted from the analysis; trial 24, a treatment trial was the treatment response; and trial 25, a test trial was subsequent performance.

An analysis of covariance (ANCOVA) was chosen because such an analysis could control for prior performance levels when comparing subsequent performance across the different treatment responses with duration equivalency scores of 2, 3, 4, and 5 points (see Table 2.3 for means, standard deviations and ANCOVA table). Duration equivalency scores of 0 and 1 point were excluded from the analysis because the results of Experiment 1 found that these responses appeared to have no relationship to subsequent performance. The ANCOVA revealed a violation of the homogeneity of slopes assumption. This indicated that prior performance and IHIB treatment response interacted.

To analyze this interaction, the treatment responses were classified into one of three different classes (again only IHIB responses with duration

equivalency scores of 2 points or more were used in the following analyses). One class was defined as all those treatment responses for which the IHIB duration equivalency score was lower than the prior performance score (i.e., prior performance was a closer approximation to the target time than was the IHIB treatment response). The second class was defined as all those treatment responses for which the IHIB duration equivalency score was equal to the prior performance score (i.e., both prior performance and IHIB treatment response were equal approximations to the target time). The third class was defined as all those treatment responses for which the IHIB duration equivalency score was higher than the prior performance score (i.e., IHIB was a closer approximation to the target time than was prior performance).

These three classes of responses were compared with respect to change in performance, defined as subsequent performance minus prior performance (see Table 2.4 for means, standard deviations and ANOVA). The ANOVA and follow-up analyses revealed that the three classes of responses were significantly different from one another on performance change. When IHIB is a closer approximation to the target time than prior

performance, subsequent performance shows an increase from prior performance levels. When IHIB and prior performance are equal approximations to the target time, subsequent performance shows no change from prior performance. When IHIB is a poorer approximation to the target time than prior performance, subsequent performance shows a decrease from prior performance levels.

Effects of IHIB compared to NT, NP, PP and PP WITHOUT FEEDBACK

It was hypothesized that increased similarity of IHIB to target behaviour would enhance the effectiveness of IHIB in increasing subsequent performance. Therefore, IHIB+ should result in better performance compared to IHIB-, to NP and to NT.

A score for each subject at each of the two testing periods was calculated by summing the points scored for the five trials that made up that test period. An ANCOVA compared all six groups at TEST-2 using TEST-1 as a covariate. Table 2.5 presents the means, standard deviations for all six groups, the ANCOVA and follow up analyses. (see Table 2.5). The main effect of GROUP was significant ($F(5,113) = 4.13$; $p < .05$) indicating a significant difference between

groups. Follow up Tukey's HSD tests found that the NT group scored significantly lower than the NP group, IHIB+ group, the IHIB- group, and the PP group. No other significant differences were found. It should be noted that the ANCOVA revealed no significant differences on measures of performance at TEST-2 between the five treatment groups which physically performed the task during the TREATMENT period (e.g., NP, PP, PP WITHOUT FEEDBACK, IHIB-, and IHIB+).

In addition to performance at TEST-2, comparisons were made on the test trials during the TREATMENT period (trials during which all subjects did the task, scored points, and received feedback). The NT group was excluded from this analysis because they did not perform the task during the TREATMENT period. A repeated measures ANOVA (5 groups by 5 blocks by 2 trials per block) on these test trials (see Table 2.6 for means, standard deviations, ANOVA, and follow-up analyses) revealed a significant GROUP by TRIAL interaction.

Follow up analyses on this interaction revealed that on the first test trial (this trial was preceded by two treatment trials), the PP WITHOUT FEEDBACK group performed significantly lower than the NP (no-practice

control) group and the PP (physical practice) group. No between-group differences in performance were found on the second test trial (this trial was preceded by the first scoring trial which was preceded by two trials of treatment). Two groups were found to have within group differences: the PP WITHOUT FEEDBACK group and the IHIB+ group were found to perform significantly higher on the second test trial than on the first test trial.

It appears that IHIB+ effects performance in a manner that is similar to but slightly weaker than PP WITHOUT FEEDBACK as indicated by the significant increase from first to second test trial. Both of these groups received auditory stimuli presentation during treatment and did not receive any feedback about responding during treatment. PP WITHOUT FEEDBACK and IHIB+ differ only with respect to the behaviour emitted during treatment. Subjects in the PP WITHOUT FEEDBACK treatment emitted overt behaviour whereas subjects in the IHIB+ emitted instructed human imagining behaviour. It appears, therefore that the effect of emitting overt behaviour is slightly stronger than the effect of emitting imagining behaviour.

Discussion

The behavioral interpretation identified two characteristics of IHIB: (1) IHIB's behavioral activity is similar to, but smaller in magnitude than, the behavioral activity of performance (so small that is not directly observable by most persons); and (2) the pattern of behavioral activity during IHIB will vary in terms of its degree of similarity to the pattern of behavioral activity of performance.

On this basis, it was hypothesized that variables affecting the degree of similarity between IHIB and actual performance of the task will mediate the effects of IHIB on subsequence performance. Thus, the expectation was that an experimental examination of these possible variables would lead to a clearer understanding of IHIB and its effects on subsequent performance.

In the first two experiments, one identified variable that was hypothesized to affect the degree of similarity between IHIB and performance was task-specific auditory stimuli. Due to the hypothesized similarity of activity between IHIB and performance, it was reasoned that any variable that controls overt performance should also exert some control over IHIB. It was hypothesized that manipulating task-specific

auditory stimuli (auditory stimuli were assumed to have some control over overt performance) during IHIB procedures would affect the degree of similarity between IHIB and performance. Specifically, presentation of task-specific auditory stimuli during IHIB, compared to the absence of such auditory stimuli, would increase the similarity of IHIB to overt performance due to that variable's control over overt performance.

The elapsed time to complete the task during IHIB was measured and a degree of similarity between IHIB and target performance was calculated based on the same criteria used to award points for performance (e.g., duration equivalency scores). The results of Experiment 1 and 2 demonstrated that the degree of similarity between IHIB and target performance was affected by the presentation of task-specific auditory stimuli during IHIB procedures.

Presenting task-specific auditory stimuli during IHIB procedures increased the similarity of IHIB responses to target performance. Additionally, an increase in the similarity of IHIB to target performance over time was observed when physical performance of the task took place between periods of

IHIB with auditory stimuli presentation. No such changes in IHIB responses were observed during IHIB without such auditory stimuli presentation even though physical performance of the task took place between periods of this type of IHIB. In fact, approximately 80% of IHIB responses during IHIB without auditory stimuli presentation had duration equivalency scores of 0 points in both Experiment 1 and Experiment 2.

The results also found that responding during IHIB with auditory stimuli presentation was not different from responding during physical practice without feedback in respect to duration of response. The responses during both these treatment conditions were significantly different from the responses during IHIB without auditory stimuli presentation. This suggests that the presentation of auditory stimuli during treatment increases the similarity of treatment responses to target performance, and that when actual physical performance with feedback takes place between periods of treatment, treatment responses continue to increase in similarity to target behaviour. This physical performance with feedback likely strengthens the control of the auditory stimuli.

These results suggest that effective IHIB

procedures should incorporate variables that exert control over the target behaviour. Using such variable during IHIB would increase the similarity of the IHIB to target performance. For example, a golfer could hold a golf club (controlling variable) when engaged in IHIB.

The second hypothesis regarding IHIB concerned the mediating role of IHIB's similarity to the target behaviour on performance following IHIB. It had been speculated that the similarity between IHIB and the target behaviour varies considerably. This variability in similarity may be due to a variety of factors (e.g., different IHIB treatment procedures). Variability could also occur within a single individual across a set of responses due to the difficulty of applying systematic environmental contingencies to IHIB (Skinner, 1974). It was hypothesized that the effects of IHIB on subsequent performance vary as a function of the similarity of IHIB to target performance.

The results of Experiment 2 provide support for the mediating role of IHIB's similarity to target performance. Analysis of changes in performance before and immediately following IHIB found that performance was affected differently depending on two factors.

One factor is the degree of similarity that the IHIB response has to the target performance. It appears that for IHIB to affect subsequent performance at all, the IHIB response needs to demonstrate some minimal level of similarity to the target performance. Below this level, performance following IHIB appears to be indistinguishable from performance following a period of no practice. In Experiment 1, performance scores following IHIB responses with duration equivalency scores of 0 or 1 point were equally distributed across scoring categories in the same manner as the no practice controls. In Experiment 2, a comparison of performance change between these responses and responses following a period of no practice found no significant differences.

When IHIB responses are similar to the target performance and above this minimal level of similarity, IHIB appears to have a significant affect on subsequent performance. The effect that IHIB has on subsequent performance appears to be a result of an interaction between performance levels prior to IHIB and the degree of similarity that the IHIB response has to the target performance. When prior performance was a closer approximation to the target performance than the IHIB

response (as measured by elapsed time to complete the task), subsequent performance tended to decline below the level of prior performance. When the IHIB response and prior performance were equal in approximation to the target performance, subsequent performance showed no change from prior performance levels. When the IHIB response was a closer approximation to the target performance than prior performance, subsequent performance tended to increase above the level of prior performance.

In applied situations, this interaction of the similarity of IHIB and prior performance levels may prove to be critical in terms of designing and implementing effective IHIB procedures. For example, if a person is performing at a high level, for IHIB to be effective in facilitating performance improvement or maintaining performance at that high level, the IHIB response must be at least as good as if not a closer approximation of the target performance than is prior performance. This is a demanding requirement. However, if a person is performing at a beginner level (re: performance is poor), IHIB procedures may very well have a greater chance at facilitating performance improvement because it may be easier for the subject to

engaged in IHIB that satisfies the requirement of being a closer approximation to the target performance. For a person at the intermediate level, it becomes critical that the IHIB response is a closer approximation to the target response than prior performance levels for performance to improve otherwise, the person's performance may deteriorate.

Regarding the overall effectiveness of IHIB as a technique for improving performance, we have seen that IHIB is statistically indistinguishable from a period of no practice. The results of Experiments 1 and 2 have not demonstrated that IHIB, as a global technique, can improve performance. Nevertheless, they have identified a mediating factor (similarity of IHIB to target performance) and a method for manipulating that mediating factor (auditory stimuli). When these factors are taken into account, the effects of IHIB on subsequent performance appear to be clearer and more predictable.

In addition, there is reasonable evidence to suggest that the effects of IHIB on subsequent performance are most evident on the instance of performance immediately following IHIB. In Experiment 2, no treatment effect was found on the second test

trial following treatment. It is likely that the first instance of performance following IHIB, and the resulting feedback the subject receives about that performance, plays an important role in subsequent performance, thereby masking any effect of IHIB on the next and any subsequent trial.

Consequently, measures of performance which are used to evaluate the effects of IHIB on subsequent performance should include the first instance of performance following IHIB. Performance measures which include more than one instance of performance may minimize the effects of IHIB on subsequent performance. Evaluating the first instance of performance following IHIB may reveal more consistent results by eliminating the effects of repeated performance and the feedback the subject receives after each such performance on post IHIB testing.

In summary, the results of the experiments to this point suggest the following. One; the similarity of IHIB to the target performance is affected by the presence or absence of task specific stimuli during IHIB. IHIB procedures which include task specific stimuli increase the similarity of IHIB to target performance. Two, the similarity of IHIB to target

performance plays a mediating role on the effects of IHIB. First, for IHIB to affect subsequent performance at all, the IHIB response must be above a certain degree of similarity to target performance. Second, once this level is reached, the effect that IHIB has on subsequent performance is a function of the interaction of this similarity to the target behaviour and the level of prior performance. It appears that as long as the IHIB response is a closer approximation to the target performance than prior performance, subsequent performance is likely to show improvement. When prior performance is a closer approximation to the target performance than the IHIB response, subsequent performance is likely to be at a lower level than prior performance. If the IHIB response and prior performance are equal approximations to target performance, prior performance levels are maintained. Third, the effect of IHIB on performance is likely most evident on the first performance trial following the period of IHIB. The effect of IHIB on subsequent performance trials is likely confounded by any feedback the subject receives on these trials.

Experiment 3

The main purpose of Experiment 3 was to make an attempt at systematically manipulating characteristics of IHIB responses in order to demonstrate that IHIB, when the similarity of IHIB to target performance is taken into account, can result in significantly superior performance compared to a no-practice control group.

The results of the previous two experiments suggest several changes to the experimental design. First, a single instance (or trial) of performance following IHIB may be a more sensitive measure of the effects of IHIB on performance than multiple instances or trials. Therefore, performance was evaluated by single instances of performance following blocks of treatment. Second, evaluation of the no-practice control groups in the previous two experiments indicated that the amount of time spent in no-practice was not sufficient to differentiate this performance from the performance of a treatment group, including physical practice. Therefore, the length of no-practice periods was extended and the criteria for scoring points was made more restrictive in an attempt to make this task more difficult.

A third change derives from the interaction of the

similarity of IHIB to target performance and prior performance. Performance following IHIB is more likely to show improvement when the IHIB response is a closer approximation of the target performance than prior performance. Conversely, performance following IHIB is less likely to show improvement when the IHIB response is an inferior or equal approximation to target performance than the prior performance. Therefore, two different IHIB treatment groups were employed in Experiment 3: one IHIB group required the subject to perform IHIB until he/she emitted an IHIB response that maximized the likelihood of performance improvement; and the second IHIB group required the subject to perform IHIB until he/she emitted an IHIB response that would minimize the likelihood of performance improvement.

Finally, the results of the first two experiments indicated that IHIB with auditory stimuli increased the similarity of IHIB to the target performance as measured by the duration equivalency score. Results also indicated that the similarity of IHIB responses varied more under IHIB with auditory stimuli treatment than under IHIB without auditory stimuli treatment (e.g., 80% responses under IHIB without auditory

stimuli were 0 or 1 point duration equivalency scores with no indications of changes in responses over time). Therefore, both IHIB treatment groups in Experiment 3 were exposed to IHIB with auditory stimuli treatment.

Subjects

Thirty-five university students served as subjects. Data from five subjects were omitted; two subjects encountered equipment problems and three subjects failed to meet criteria of IHIB on at least three IHIB sessions. Therefore, thirty university students, 17 males and 13 females, were retained. The average age was 25.1 years (SD=5.5) with a range of 19 to 44.

Procedure

The experiment was divided into three periods: (a) the preliminary period, (b) TEST-1, and (c) TREATMENT period. A chart depicting the experimental design is presented in Appendix 3.1.

Experiment 3 began the same way as Experiments 1 and 2. The introductory instructions (see Appendices 3.3 and 3.4) were read and the consent form was explained and signed (see Appendix 3.5). The subject

then completed the two preliminary practice trials. The introduction to the task and the two practice trials (without scoring feedback) remained the same as for Experiments 1 and 2. This was followed by five TEST-1 trials which were identical to the five TEST-1 trials of Experiments 1 and 2. The scoring criterion of Experiment 1 was used (see Appendix 3.2) because it was more restrictive than Experiment 2, and therefore less likely to result in performance ceilings over the course of the experiment. Following TEST-1, each subject was required to wait for approximately 5 minutes during which time he/she was occupied with a wordfind puzzle. Following the 5-minute period, the TREATMENT period began, which consisted of alternating periods of treatment trials and test trials. Subjects were randomly assigned to one of three treatment groups.

Subjects in either of the two IHIB groups were asked to read the IHIB instructions (see Appendix 3.3), which were the same instructions used in Experiment 2 for the IHIB+ group. Subjects assigned to the No-Practice (NP) group continued doing the wordfind puzzle for the amount of time that IHIB subjects required to read the instructions. Each NP subject was matched on

the amount of time between test trials to an IHIB subject.

Once the IHIB subject finished reading the instructions and any questions were answered, the subject was required to complete a variable number of IHIB trials, ranging from 1 to a maximum of 10 trials. For the subjects assigned to the IHIB procedures designed to maximize performance improvement (IHIB-MAX), the subject engaged in IHIB until he/she emitted an IHIB response that met the following criteria: (1) the IHIB response was a closer approximation to the target performance than the previous test trial performance (i.e., the score on trial 5, the final test trial of TEST-1) as measured by the duration equivalency score; or (2) the IHIB response was an equal approximation to the target performance in comparison with the previous test trial performance and both of these responses were worth 4 or more points; or (3) the subject had completed 10 IHIB trials without reaching criterion 1 or criterion 2. Once criterion was reached, the subject was informed that he/she would physically perform the task and was reminded to score as many points as he/she could. The subject then performed one test trial which was identical to the

test trials of TEST-1.

For the subjects assigned to the IHIB procedures designed to minimize performance improvement (IHIB-MIN), the subject engaged in IHIB until he/she emitted an IHIB response that met the following criteria: (1) the IHIB response was a poorer approximation to the target performance than the previous test trial performance (i.e., the score on trial 5, the final test trial of TEST-1) as measured by the duration equivalency score; or (2) the IHIB response was an equal approximation to the target performance in comparison to the previous test trial performance and both of these responses were worth 3 or less points; or (3) the subject had completed 10 IHIB trials without reaching criterion 1 or criterion 2. Each subject in this group was matched, as closely as possible to an IHIB subject from the IHIB group designed to maximize performance improvement on number of IHIB trials. Once the subject reached criterion and performed the same number of IHIB trials (as close as possible to the same number) that the matched IHIB subject from the other group performed, (subjects in this group may have reached criterion more than once due to matching on number of trials), the subject was informed that he/she

would physically perform the task and was reminded to score as many points as he/she could. The subject then performed one test trial which was identical to the test trials of TEST-1.

Subjects in the NP group were matched on time spent between test trials to the IHIB subjects. The subject was then informed that he/she would physically perform the task and was reminded to score as many points as he/she could. The subject then performed one test trial which was identical to the test trials of TEST-1.

Once the subject completed this test trial, the subject was again exposed to the treatment procedures under the same conditions and with the same criteria as previously. For the IHIB subjects, the performance score criterion was now the score on the last test trial (i.e., the test trial they had just performed). Once criterion was reached, (matching of IHIB subjects on number of IHIB trials and matching of NP subjects in terms of time between test trials continued), the subject was required to complete a single test trial again. The alternating of treatment and test trials continued until the subject had been exposed to treatment 10 times and had completed 10 single test

trials after each exposure to treatment. Following this, the subject was debriefed and thanked.

Results

It was hypothesized that subjects exposed to the IHIB procedures designed to maximize performance (IHIB-MAX) would perform significantly better than subjects exposed to the no-practice (NP) condition or to the IHIB procedures designed to minimize performance (IHIB-MIN). In order to evaluate this hypothesis, a set of three scores for each subject was derived by summing the points scored on five consecutive test trials: BLOCK-1 was the sum of points scored for trials 1 through 5, BLOCK-2 was the sum of points scored for trials 6 through 10, and BLOCK-3 was the sum of points scored for trials 11 through 15. To examine the effects of the different treatment procedures on subsequent performance, a repeated measures analysis of variance (ANOVA) compared the three treatment groups on points scored across the three blocks. Table 3.1 presents the means and standard deviations of points scored for the different groups at each of the three blocks and summarizes the ANOVA and follow up analysis. The ANOVA revealed a significant effect of BLOCK,

$F(2,54) = 36.6$, $p < .05$, and a significant GROUP by BLOCK interaction, $F(4,54) = 2.67$, $p < .05$. The main effect of GROUP was not significant, $F(2,27) = 0.09$. Further analyses (see Table 3.1) revealed no between group differences on BLOCK-1 scores, $F(2,27) = 0.45$, or on BLOCK-2 scores, $F(2,27) = 1.93$. However, significant differences were found on BLOCK-3 scores, $F(2,27) = 3.88$, $p < .05$, and post hoc comparisons using Tukey's HSD ($\alpha = .05$) revealed that the IHIB-MAX group scored significantly more points on BLOCK-3 trials than the NP group.

Within group effects were examined using dependent t-tests (see Table 3.1). For the IHIB-MAX group, these analyses revealed a significant increase in points scored from BLOCK-1 to BLOCK-2, $t(9) = 3.46$, $p < .05$, and from BLOCK-2 to BLOCK-3, $t(9) = 3.39$, $p < .05$. For the IHIB-MIN group, there was no significant change in points scored from BLOCK-1 to BLOCK-2, $t(9) = 2.22$, or from BLOCK-2 to BLOCK-3, $t(9) = 1.71$. For the NP group, there was a significant increase in points scored from BLOCK-1 to BLOCK-2, $t(9) = 3.53$, $p < .05$, but no significant change from BLOCK-2 to BLOCK-3, $t(9) = -1.34$.

The number of treatment trials performed by each

of the two IHIB groups was compared to ensure that both treatment groups performed an equal number of treatment trials. For each subject, the total number of IHIB treatment trials performed during the first five treatment periods was calculated as was the total number of IHIB treatment trials performed during the second five treatment periods (see Table 3.2). A 2 (GROUP) by 2 (TREATMENT BLOCKS) repeated-measures ANOVA (see Table 3.2) revealed no significant main effect for GROUP, $F(1,18) = 0.57$, no significant main effect for TREATMENT BLOCK, $F(1,18) = 0.02$, and no significant interaction, $F(1,18) = 0.22$.

In addition, the percentage of subjects meeting the IHIB duration equivalency score criterion on the treatment trial prior to a test trial (see Procedure section above for criteria) appropriate for each of the two IHIB conditions was calculated for each treatment period as well as for a block of five treatment periods (see Table 3.3). At least 8 out of 10 subjects reached criterion at each treatment period with only one exception. For the IHIB-MAX group, only 6 out of 10 subjects reached criterion on the first treatment period. Nevertheless, for the IHIB-MAX group, 86% of IHIB responses met criterion in the first block of five

treatment periods and 86% of IHIB responses met criterion in the second block of five treatment periods. For the IHIB-MIN group, 90% of IHIB responses met criterion in the first block of five treatment periods and 96% of IHIB responses met criterion in the second block of five treatment periods.

To further compare IHIB duration equivalency scores on the treatment trials preceding a test trial, the ten treatment periods were collapsed into two blocks of five treatment periods each: treatment periods 1 through 5, and treatment periods 6 through 10. The five IHIB duration equivalency scores on those specific trials were summed, yielding scores representing the last IHIB response prior to a test trial (1) for the first five treatment periods and (2) for the second five treatment periods. It was expected that the IHIB-MAX group would obtain significantly higher scores on these measures than the IHIB-MIN group. The results are summarized in Table 3.4. Both the main effect of GROUP, $F(1,18) = 44.19, p < .05$, and the main effect of TREATMENT BLOCK, $F(1,18) = 7.59, p < .05$, were significant. The GROUP by TREATMENT BLOCK interaction was not significant, $F(1,18) = 0.23$. Post-hoc comparisons revealed that the IHIB-MAX group ($M =$

37.6, $SD = 5.8$) had significantly higher IHIB duration equivalency scores than the IHIB-MIN group ($M = 19.7$, $SD = 6.1$), $t(18) = 6.65$, $p < .05$. Additionally, there was a significant increase in IHIB duration equivalency scores, $t(19) = 2.81$, $p < .05$, from the first TREATMENT BLOCK ($M = 12.7$, $SD = 6.3$) to the second TREATMENT BLOCK ($M = 15.9$, $SD = 5.5$).

Discussion

As expected, the IHIB treatment procedures designed to maximize improvement resulted in significantly better performance than the no-practice condition on the final five test trials (i.e., Block-3), but not on the first or second sets of test trials (i.e., Block-1 or Block-2). The subjects exposed to the no-practice or the IHIB-MAX conditions both showed significant increases in points scored from the first block of five trials to the second block of five trials, but only the subjects exposed to the IHIB-MAX conditions showed a significant increase in performance from the second block to the third block. It is likely that this is due to the increase in IHIB similarity to target over time, as found in duration equivalency scores. During the initial stages of training, actual performance (with scoring feedback) enhances

performance to a maximum level reached by the second block of five test trials, as indicated by the non-significant change in scores from BLOCK-2 to BLOCK-3 in the NP group. The IHIB-MAX treatment procedures then further enhances performance above and beyond this limit, and it is only at BLOCK-3 trials that performance under these conditions can be discriminated from no-practice. Thus, it appears that the IHIB-MAX procedures used in this experiment, which incorporated task-specific stimuli during IHIB and controlled for the similarity of the IHIB response to target performance, did result in significantly enhanced performance compared to no-practice.

Contrary to predictions, there were no significant differences between the two IHIB groups. However, only subjects exposed to the IHIB-MAX treatment procedures showed progressive performance increases from the first to the second to the third block of test trials. The subjects exposed to the IHIB-MIN treatment procedures failed to show this significant increase across consecutive blocks of test trials. In fact, the IHIB-MIN group failed to show even the significant increase in performance from the first block to the second block of test trials observed in the no-practice group.

Two possible explanations for the lack of significant performance differences between the IHIB groups are offered, both focusing primarily on the IHIB responses performed by the IHIB-MIN group. First, the IHIB-MIN group was exposed to task-specific stimuli during IHIB. The results of both Experiment 2 and 3 indicate that when periods of actual task performance take place between IHIB periods of this type, there is an increase in IHIB similarity. Thus, performance in the IHIB-MIN group may have been enhanced to some degree by this increase in similarity.

Additionally, for the IHIB-MIN group, a substantial percentage of the IHIB responses preceding a test trial were duration equivalency scores of 0 or 1 points. In fact, 56% of IHIB criterion-trial responses for the IHIB-MIN group were of the 0 or 1 point value for the first block of five treatment periods, whereas only 22% of IHIB criterion-trial responses for the second block of treatment trials were of the 0 or 1 point value in this group. The results of previous experiments had indicated that IHIB responses at these values essentially have no effect on subsequent performance, unlike IHIB responses with 2 or more IHIB duration equivalency score points. Given this, it can

be argued that the greatest minimization of performance improvement in the IHIB-MIN group would be observed between the second and third block of test trials. In fact, the IHIB-MIN group improved only 2.6 points whereas the IHIB-MAX group improved 6.1 points, a large but non-significant difference. Consequently, the maximum effect of the IHIB-MIN condition was potentially less powerful than it could have been. If IHIB-MIN subjects had been required to perform an IHIB response of 2 or 3 points prior to performing a test trial, the impact on performance may have been greater.

General Discussion

A review of the literature on the performance-enhancing effects of IHIB reveals that, although IHIB can generally enhance performance, the effects of IHIB are far from reliable (Feltz & Landers, 1983; Murphy, 1990). Research in this area has been criticized for methodological problems as well as for its failure to provide an adequate theoretical model of the IHIB phenomenon (Feltz & Landers, 1983; Murphy, 1990; Weinberg, 1982). As a result, research has not been very successful in identifying the major factors that influence the performance enhancement effects of IHIB

(Feltz & Landers, 1983; Murphy, 1990; Weinberg, 1982).

In this dissertation, a model of IHIB, based on a radical behavioural perspective, was presented and a series of parametric studies conducted in order to evaluate the model in an attempt to identify factors that influence the performance enhancement effects of IHIB. It was reasoned that, when a subject is instructed to imagine performing a task, the behaviour that the subject engages in is similar to the overt performance of that task. Two critical characteristics of IHIB are (1) that IHIB is smaller in magnitude than the target performance, and (2) that the degree of similarity between IHIB and the target performance varies both within and between individuals. It was hypothesized that the greater the degree of similarity between IHIB and target performance, the greater the enhancement effects of IHIB. Based on this rationale, it was reasoned that the goal of IHIB procedures should be to increase the similarity of the IHIB to target performance. Therefore, to control the effects of IHIB, research should identify variables that affect this degree of similarity.

It was further hypothesized that, due to the similarity of IHIB to target performance, any variable

that exerts control over target performance would also exert some control over IHIB. The present series of experiments has therefore examined the effects of task-specific auditory stimuli on IHIB responding. It was reasoned that presenting such stimuli during IHIB procedures would result in IHIB responding that was more similar to target performance due to the control that such stimuli exert over target performance.

The results of these experiments clearly show that task-specific stimuli affected IHIB responding in the predicted manner. Presenting task-specific stimuli during IHIB procedures results in IHIB responses that are more similar to target performance. In addition, alternating periods of this type of IHIB with actual task performance results in IHIB responses that become progressively more similar to target performance.

It has also been demonstrated that similarity between the IHIB response and target performance mediates the performance enhancement effects of IHIB. It appears that for IHIB to have an effect on subsequent performance, the IHIB response must have some minimal degree of similarity to target performance, although it may well be that the specific measure of similarity used in these experiments

(duration equivalency scores) were not sufficiently sensitive at the lower levels of similarity, or that the measure of performance was not sufficiently sensitive to discriminate these effects. Nonetheless, once the IHIB response is at or above this minimal level of similarity, further variations in similarity do mediate the effects of IHIB. The results indicate that the effect of IHIB depends on the degree of similarity and its relation to the level of performance prior to IHIB: when the IHIB response is a closer approximation to target performance than prior performance (in terms of similarity to target performance), then IHIB enhances performance: when the IHIB response is a poorer approximation to target performance than prior performance (in terms of similarity to target performance), then IHIB does not appear to enhance performance and may, in fact, be detrimental to performance.

Therefore, the following guidelines may be offered for individuals who use IHIB to enhance performance. It is the goal of IHIB procedures to increase the similarity of the IHIB response to target performance. Specifically, one method of achieving a higher degree of similarity is incorporating stimuli that control

target performance during IHIB procedures. The specific stimuli used would vary depending on the performance in question: specific examples may be a golf club for a golfer, or a tennis racket for a tennis player. Another useful technique would be alternating periods of IHIB with actual task performance. This has shown to increase the similarity of IHIB to target performance. In addition, IHIB instructions should encourage subjects to 'imagine' all of the components of target performance including antecedent stimuli, the target behaviour, and the outcome of that behaviour. This may foster the performance of IHIB responses that are as similar as possible to ideal overt performance and to the conditions of that performance. In addition, the interaction of IHIB similarity and prior performance levels provide an important guideline to coaches and athletes. Training in the effective use of IHIB may ensure that individuals of differing skill levels will benefit from the use of IHIB. Specifically, individuals at a beginning level perform the task at levels that are poor approximations to ideal performance, whereas individuals who are at an advanced level perform the task close to or at ideal levels. Therefore, more highly skilled subjects may

require more extensive training in IHIB, because for IHIB to have the desired effects, the IHIB response must be at least as good if not a better approximation of the target performance than actual performance. Beginners, on the other hand, may with minimal training appear to derive greater effects because there are a larger set of IHIB responses that meet the criterion of better approximations to target performance that would be the case for skilled performers.

There are three limitations of the conclusions drawn from these experiments. First, the task used in the present experiments was a simple one and somewhat artificial in nature compared to the more complex behaviours typical of athletes who use IHIB to enhance their performance. More complex behaviours have many controlling variables; thus, the simplicity of the present task may limit the generalizability of the principle of similarity to more complex behaviours and the effective use of a single controlling variable.

Second, the periods of IHIB and measurement of performance occurred over relatively brief periods of time: the longest experiment for a single subject was about one hour, the longest period of IHIB was approximately 15 minutes, and performance on the task

was never more than 18 trials. Nevertheless, the simplicity of the task and the brief periods of experimentation did allow more rigorous control than would be found in research utilizing more complex tasks and longer durations.

A third limitation concerns the measure of similarity: in the present experiments, the measure of the degree of similarity between IHIB and target performance was based on time. Target performance was also evaluated with respect to time. It was assumed that an IHIB response taking the same amount of time to complete as the target behaviour would be highly similar to target performance. The similarity of IHIB to target performance should ideally be based on some form of the pattern of the IHIB behaviour that is directly comparable to target performance. However, measuring such things as muscle movements, eye movements, and other physiological activity is both intrusive and expensive since one would need to simultaneously measure both visual acuity and activity in several different muscle groups. The alternative of requesting self-reports of IHIB activity is not very reliable and also intrusive and may potentially disrupt the performance of an IHIB response and hence eliminate

any IHIB effect. Thus, in spite of its limitations, the present measure was selected as the least intrusive and hence the least likely to disrupt the IHIB effect.

In conclusion, the behavioural model of IHIB presented in this dissertation would seem to be worthy of future attention. It has been demonstrated that task-specific stimuli can increase the similarity of IHIB to target performance and that this similarity mediates the effects of IHIB. Future research should attempt to evaluate the generalizability of this principle to different and/or more complex tasks that require different and more integrated skills. In addition, the behavioural model provides a framework for identifying specific variables which may facilitate IHIB enhancement effects. Finally, the model also provides a means with which to evaluate other potential variables of interest in the area of IHIB. Future research may explore questions of a practical nature, such as the effects of number of IHIB trials on IHIB similarity, the interval between task performances, the delay between IHIB and task performance, and the possibilities of stimulus fading procedures for the controlling IHIB variable. In this manner, more effective and efficient procedures may be developed to

maximize the enhancement effects of IHIB on subsequent performance.

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Tables and FiguresExperiment 1

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Experiment 2

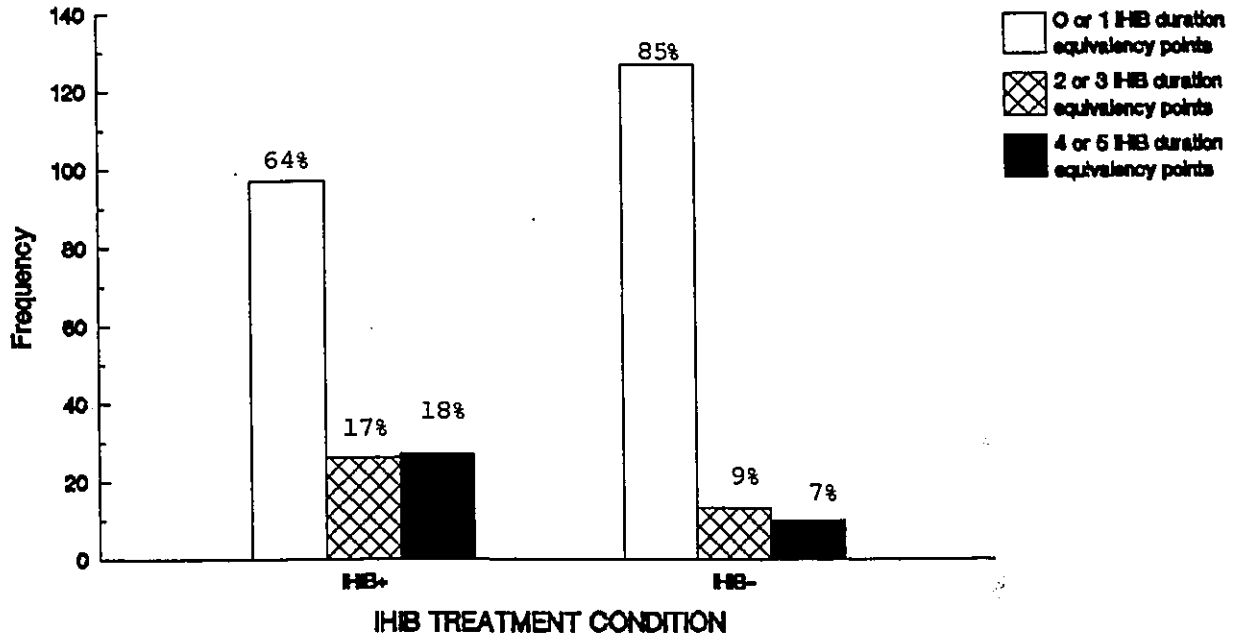
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Figure 1.1. Frequencies and percentage of responses with a (0 or 1), (2 or 3), (4 or 5) duration equivalency score during each of the two treatment periods for IHIB+ and IHIB- treatment conditions.

First Treatment Period



Second Treatment Period

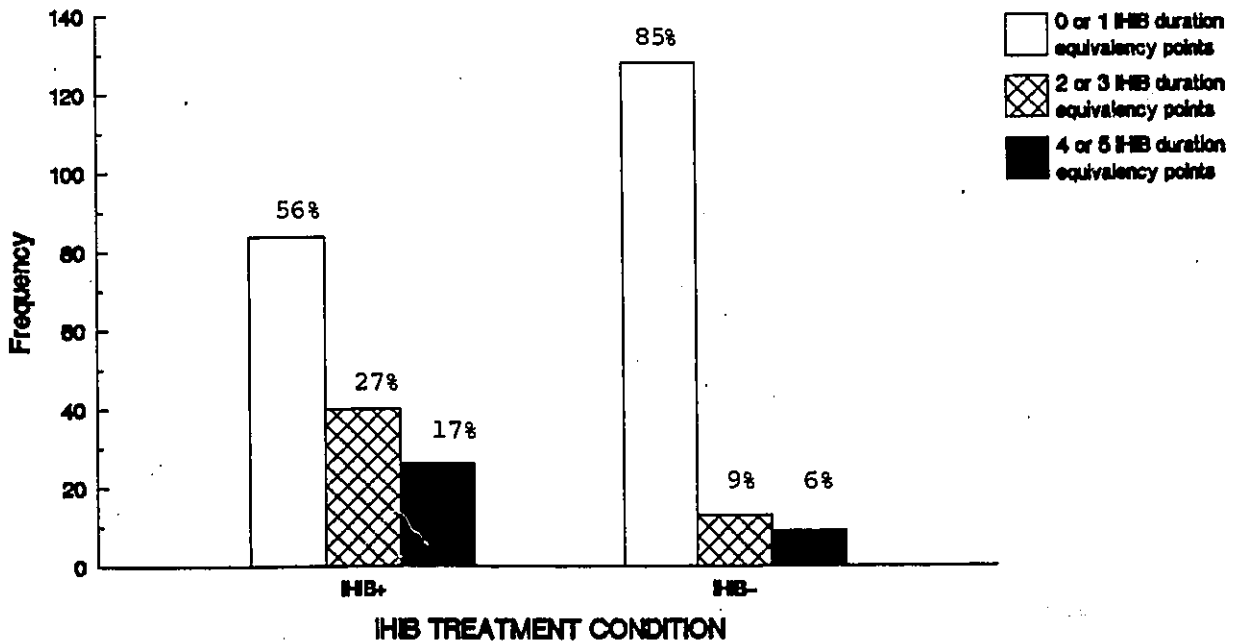


Table 1.1. Frequency and percentage of responses on the testing trial immediately following IHIB treatment (trials 11 and 21) for the three categories based on the duration equivalencies of the IHIB responses (trials 10 and 20) for the IHIB+ group, the IHIB- group, the IHIB -/+ group and the IHIB +/- group combined.

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	Test trial score on immediately following test trial (trials 11 and 21)				Totals
	0 or 1 point freq. percent	2 or 3 points freq. percent	4 or 5 points freq. percent	freq. percent	
Duration equivalency scores on IHIB trials 10 and 20	33 37.9%	26 29.8%	28 32.1%	87 72.5%	
0 and 1 point duration equivalency score	5 23.8%	12 57.1%	4 19.0%	21 17.5%	
2 and 3 point duration equivalency score	3 25.0%	1 8.3%	8 66.7%	12 10.0%	
4 and 5 point duration equivalency score	41 34.1%	39 32.5%	40 33.3%	120 100%	
Totals					

Table 1.2. Frequency and percentage of responses on testing trials based on the points scored on the immediately previous trials for the NP subjects.

FACTORS INFLUENCING

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Test trial scores on trials 10 and 20	Test trial score on immediately following test trial (trials 11 and 21)				Totals freqpercent
	0 or 1 point freq. percent	2 or 3 points freq. percent	4 or 5 points freq. percent		
0 and 1 point scores	5 62.5%	1 12.5%	2 25.0%	8 26.7%	
2 and 3 point scores	4 40.0%	5 50.0%	1 10.0%	10 33.3%	
4 and 5 point scores	4 40.0%	5 41.7%	3 25.0%	12 40.0%	
Totals	13 43.3%	11 36.7%	6 20.0%	30 100%	

Table 1.3. Means, standard deviations of self report questionnaire ratings for the IHIB+ group, the IHIB- group, the IHIB -/+ group and the IHIB +/- group for the first and second TREATMENT PERIOD and repeated measures ANOVA.

FACTORS INFLUENCING

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<u>Group</u>	<u>VIVIDNESS</u>		<u>KINETIC</u>		<u>ABILITY</u>		<u>IMPROVE</u>	
	<u>M</u>	<u>(SD)</u>	<u>M</u>	<u>(SD)</u>	<u>M</u>	<u>(SD)</u>	<u>M</u>	<u>(SD)</u>
IHIB-	treatment 1	4.0 (1.2)	3.6 (1.3)	4.0 (0.8)	3.7 (1.1)	3.7 (1.1)	3.7 (1.1)	3.7 (1.1)
	treatment 2	4.6 (0.9)	4.5 (0.8)	4.2 (0.7)	4.1 (0.7)	4.1 (0.7)	4.1 (0.7)	4.1 (0.7)
IHIB+	treatment 1	3.4 (1.2)	3.7 (1.3)	3.6 (1.1)	3.8 (0.7)	3.8 (0.7)	3.8 (0.7)	3.8 (0.7)
	treatment 2	4.1 (1.4)	4.3 (1.3)	4.4 (1.2)	4.3 (0.8)	4.3 (0.8)	4.3 (0.8)	4.3 (0.8)
IHIB-/+	treatment 1	4.1 (0.9)	3.6 (1.3)	3.5 (1.0)	3.4 (1.2)	3.4 (1.2)	3.4 (1.2)	3.4 (1.2)
	treatment 2	4.5 (1.1)	4.6 (1.3)	4.1 (1.1)	3.8 (1.5)	3.8 (1.5)	3.8 (1.5)	3.8 (1.5)
IHIB+/-	treatment 1	3.3 (1.1)	3.8 (1.4)	3.5 (1.3)	3.6 (0.9)	3.6 (0.9)	3.6 (0.9)	3.6 (0.9)
	treatment 2	4.0 (0.8)	4.2 (1.2)	3.8 (0.9)	4.0 (0.8)	4.0 (0.8)	4.0 (0.8)	4.0 (0.8)
Effect of treatment period	treatment 1	3.7 (1.2)	3.7 (1.3)	3.6 (1.0)	3.6 (1.0)	3.6 (1.0)	3.6 (1.0)	3.6 (1.0)
	treatment 2	4.3 (1.1)	4.4 (1.1)	4.1 (1.0)	4.0 (1.0)	4.0 (1.0)	4.0 (1.0)	4.0 (1.0)

ANOVA TABLE

df	F	F	F
Group (3, 56)	F = 1.68	F = 0.04	F = 0.76
Treatment period (1, 56)	F = 18.5*	F = 24.7*	F = 7.26*
Group by Treatment period (3, 56)	F = 0.30	F = 0.66	F = 0.04

* p < .05

Comparison Item #5	GROUP		
	IHIB-	IHIB+/+	IHIB+/-
Mean (SD)	4.7 (1.0)	4.4 (1.6)	4.7 (1.4)

ANOVA GROUP EFFECT F(3, 56) = 0.35; p > .05.

Table 1.4. Means, standard deviations of points scored at each of the three test periods for all treatment groups and repeated measures ANOVA.

FACTORS INFLUENCING

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GROUP	TEST-1		TEST-2		TEST-3	
	<u>M</u>	(<u>SD</u>)	<u>M</u>	(<u>SD</u>)	<u>M</u>	(<u>SD</u>)
IHIB -	9.9	(4.4)	15.2	(5.3)	17.3	(4.6)
IHIB +	10.1	(5.5)	16.0	(4.5)	17.8	(3.2)
IHIB -/+	9.4	(4.4)	13.2	(5.7)	15.6	(4.9)
IHIB +/-	9.3	(4.7)	15.9	(2.8)	16.8	(4.2)
No Practice	8.2	(4.0)	12.3	(6.4)	12.8	(5.4)
Grand Mean	9.4	(4.6)	14.5	(5.2)	16.0	(4.8)

ANOVA

EFFECT	df	Mean Square	F value	p
Within cells	70	39.84		
GROUP	4	93.00	2.33	.064
Within cells	140	14.80		
TIME	2	922.22	62.30	.000
GROUP by TIME	8	9.23	0.62	.757

Table 2.1. Means and standard deviations for responses made on treatment trials (for IHIB subjects responses are duration equivalency scores, for PP and PP WITHOUT FEEDBACK subjects, responses are points scored), ANOVA and follow up tests.

FACTORS INFLUENCING

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Trial #	PP WITHOUT FEEDBACK	PP	IHIB+	IHIB-
	M (SD)	M (SD)	M (SD)	M (SD)
6	2.4 (1.7)	2.2 (1.5)	1.9 (1.9)	0.4 (1.2)
7	2.4 (1.6)	3.4 (1.4)	2.2 (1.8)	0.8 (1.5)
6+7	4.8 (3.0)	5.6 (2.3)	4.1 (3.3)	1.2 (2.6)
10	3.2 (1.6)	3.0 (1.4)	3.0 (1.4)	0.8 (1.4)
11	2.7 (1.7)	3.7 (1.2)	2.6 (1.5)	0.5 (1.1)
10+11	5.9 (3.0)	6.8 (2.3)	5.6 (2.4)	1.4 (2.6)
14	3.3 (1.4)	3.6 (1.3)	2.7 (1.5)	0.8 (1.5)
15	3.4 (1.4)	3.8 (1.1)	3.5 (1.3)	0.9 (1.6)
14+15	6.7 (2.4)	7.4 (1.7)	6.2 (2.3)	1.7 (3.1)
18	3.6 (1.1)	4.1 (0.9)	3.4 (1.2)	0.5 (1.2)
19	3.2 (1.2)	4.0 (0.8)	3.1 (1.4)	0.8 (1.7)
18+19	6.9 (2.2)	8.1 (1.3)	6.6 (2.4)	1.3 (2.7)
22	3.8 (1.1)	4.2 (0.8)	3.5 (1.4)	0.7 (1.5)
23	3.6 (1.3)	4.4 (0.8)	3.2 (1.4)	0.3 (0.9)
22+23	7.4 (2.2)	8.6 (1.3)	6.7 (2.5)	1.0 (2.2)

REPEATED MEASURES ANOVA
(4 GROUPS by 5 TRIAL PAIRS)

EFFECT	df	Mean Square	F value	p
Within cells	76	10.06		
Constant	1	5454.90	542.44	.000
GROUP	3	353.11	35.11	.000
Within Cells	304	1.37		
TRIAL PAIR	4	25.60	18.67	.000
GROUP BY				
TRIAL PAIR	12	3.40	2.48	.004
Within Cells	76	1.00		
TRIAL	1	0.66	0.66	.418
GROUP BY TRIAL	3	3.39	3.40	.022
Within Cells	304	0.91		
TRIAL PAIR by				
TRIAL	4	3.14	3.44	.009
GROUP by TRIAL PAIR				
by TRIAL	12	1.19	1.30	.216

Follow up for GROUP by TRIAL

GROUP	<u>First</u> <u>treatment trial</u>		<u>Second</u> <u>treatment trial</u>	
	<u>M</u>	<u>(SD)</u>	<u>M</u>	<u>(SD)</u>
PP WITHOUT FEEDBACK	16.4	(5.2)	15.4	(5.6)
PP	17.2	(3.6)	19.3	(3.1)
IHIB+	14.6	(5.3)	14.7	(5.1)
IHIB-	3.3	(6.3)	3.3	(6.4)

ANOVA for first treatment trial:
 $F(3,76) = 30.3; p = .000$

Groups significantly different at alpha = .05
 (TUKEY'S HSD)
 IHIB- < PP WITHOUT FEEDBACK
 IHIB- < PP
 IHIB- < IHIB+

ANOVA for second treatment trial:
 $F(3,76) = 34.1; p = .000$

Groups significantly different at alpha = .05
 (TUKEY'S HSD)
 IHIB- < PP WITHOUT FEEDBACK
 IHIB- < PP
 IHIB- < IHIB+

Within GROUPS differences (first trial to second trial)

GROUP	<u>t</u> value (df)
PP WITHOUT FEEDBACK	$\underline{t}(19) = -1.39; p = .182$
PP	$\underline{t}(19) = 2.71; p = .014$
IHIB+	$\underline{t}(19) = 0.06; p = .950$
IHIB-	$\underline{t}(19) = 0.00; p = 1.00$

Follow up for GROUP by TRIAL PAIR
(Means and Standard Deviations on Table)

ANOVA for first trial pair:
 $F(3,76) = 8.85; p = .000$

Groups significantly different at alpha = .05
(TUKEY'S HSD)
IHIB- < PP WITHOUT FEEDBACK
IHIB- < PP
IHIB- < IHIB+

ANOVA for second trial pair:
 $F(3,76) = 16.4; p = .000$

Groups significantly different at alpha = .05
(TUKEY'S HSD)
IHIB- < PP WITHOUT FEEDBACK
IHIB- < PP
IHIB- < IHIB+

ANOVA for third trial pair:
 $F(3,76) = 21.7; p = .000$

Groups significantly different at alpha = .05
(TUKEY'S HSD)
IHIB- < PP WITHOUT FEEDBACK
IHIB- < PP
IHIB- < IHIB+

ANOVA for fourth trial pair:
 $F(3,76) = 35.4; p = .000$

Groups significantly different at alpha = .05
(TUKEY'S HSD)
IHIB- < PP WITHOUT FEEDBACK
IHIB- < PP
IHIB- < IHIB+

ANOVA for fifth trial pair:
 $F(3,76) = 51.0; p = .000$

Groups significantly different at $\alpha = .05$
(TUKEY'S HSD)

IHIB- < PP WITHOUT FEEDBACK

IHIB- < PP

IHIB- < IHIB+

IHIB+ < PP

Within group comparisons (dependent t-tests)
pairs significantly different where $p < .05$

PP WITHOUT FEEDBACK	pair 1 < pairs 3, 4, 5 pair 2 < pair 5
PP	pair 1 < pairs 2, 3, 4, 5 pair 2 < pairs 4, 5 pair 3 < pairs 4, 5
IHIB+	pair 1 < pair 2, 3, 4, 5 pair 2 < 5
IHIB-	no significant differences found.

Table 2.2. Number of responses and number of subjects for each IHIB duration equivalency score and for which treatment group these responses came from, the IHIB+ group or the IHIB- group.

IHIB Duration Equivalency Score

	5	4	3	2	1	0
number of responses analyzed	20	34	25	20	10	91
number of subjects accounting for these responses	14	19	16	16	5	28
maximum number of responses per single subject	2	3	3	4	3	5
Number of responses that were observed during IHIB+	16	30	18	15	10	11
Number of responses that were observed during IHIB-	4	4	7	5	0	80

Table 2.3. Means and standard deviations of performance prior to and performance subsequent to IHIB for IHIB duration equivalency scores of 2, 3, 4 and 5 points and ANCOVA for the IHIB+ group and the IHIB-group combined.

IHIB Duration equivalency score	Prior performance score <u>M(SD)</u>	Subsequent performance score <u>M(SD)</u>	Adjusted subsequent performance
2	3.35(1.56)	2.95(1.27)	2.950
3	3.12(1.26)	3.24(1.09)	3.294
4	3.38(1.23)	3.52(0.96)	3.522
5	3.55(0.99)	3.90(0.96)	3.854
Grand Mean	3.48(1.24)	3.46(1.20)	

ANCOVA

(subsequent performance for 4 IHIB duration equivalency scores (e.g. 2, 3, 4, and 5) with prior performance as covariate)

EFFECT	df	Mean Square	F value	p
Within cells	94	1.06		
Regression	1	8.34	7.88	.006
Constant	1	84.16	79.55	.000
GROUP	3	2.96	2.80	.044

Test for Homogeneity of Slopes

Group by Subsequent performance	3,91	4.23	4.43	.006
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ANOVA
(Prior performance)

EFFECT	df	Mean Square	F value	p
Within groups	95	0.71		
GROUPS	3	1.62	.44	.723

ANOVA
(Subsequent performance)

EFFECT	df	Mean Square	F value	p
Within groups	95	1.13		
GROUPS	3	3.41	3.00	.034

Follow up t-tests on subsequent performance

Duration equivalency scores compared

2 vs 3	$\underline{t}(43)$	= -0.82
2 vs 4	$\underline{t}(52)$	= -1.89
2 vs 5	$\underline{t}(38)$	= -2.65 *
3 vs 4	$\underline{t}(57)$	= -1.08
3 vs 5	$\underline{t}(43)$	= -2.12 *
4 vs 5	$\underline{t}(52)$	= -1.36

* $p < .05$

Table 2.4. Means and Standard Deviations of performance change scores (Subsequent performance - prior performance) for the three different classes of IHIB responses (using only IHIB duration equivalency scores of 2 or more points) for the IHIB+ group and the IHIB- group combined; when IHIB duration equivalency score is less than prior performance score, when IHIB duration equivalency score is equal to prior performance score, and when IHIB duration equivalency score is greater than prior performance score.

Class	Performance Change (Subsequent - Prior)	
	<u>M</u>	(<u>SD</u>)
IHIB duration equivalency score is less than prior performance score (n = 32)	-0.96	(1.3)
IHIB duration equivalency score is equal to prior performance score (n = 23)	0.04	(1.0)
IHIB duration equivalency score is greater than prior performance score (n = 44)	0.84	(1.1)
GRAND MEAN	0.07	(1.4)

ANOVA
(Performance change)

EFFECT	df	Mean Square	F value	p
Within groups	96	1.41		
CLASSES	2	30.34	21.4	.000

Tukey follow up tests:

Each class is significantly different from each other.

Table 2.5. Means and standard deviations for points scored at TEST-1 and TEST-2 (raw and adjusted) for the six treatment groups and ANCOVA.

GROUP	TEST-1 MEAN (SD)	TEST-2 MEAN (SD)	ADJUSTED TEST-2 MEAN
NT No Treatment	10.6 (5.5)	17.2 (4.0)	17.266
NP-2 No practice	12.6 (4.0)	20.5 (2.7)	20.366
PP WITHOUT FEEDBACK	10.9 (5.0)	19.5 (3.3)	19.531
PP	10.9 (4.9)	21.2 (1.4)	21.286
IHIB+	12.1 (3.4)	20.4 (2.5)	20.311
IHIB-	10.3 (5.2)	20.2 (3.4)	20.291
GRAND MEAN	11.3 (4.5)	20.3 (2.8)	

ANCOVA

EFFECT	df	Mean Square	F value	p
Within cells	113	9.19		
Regression	1	26.01	2.83	.095
Constant	1	6135.07	667.28	.000
GROUP	5	37.94	4.13	.002

Test for Homogeneity of Slopes

GROUP by TEST-1	5	11.84	1.31	.267
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Groups significantly different at alpha = .05
(TUKEY'S HSD)
NT < NP, PP, IHIB+, IHIB-

Table 2.6. Means and standard deviations for points scored on the performance trials during the TREATMENT period (trials 8, 9, 12, 13, 16, 17, 20, 21, 24, and 25 immediately followed each of the five treatment blocks) for the five groups (NP-2, PP WITHOUT FEEDBACK, PP, IHIB+, IHIB-). Repeated measures ANOVA (5 GROUPS by 5 BLOCKS by 2 TRIALS) and follow up tests.

TRIAL	GROUP				
	NP-2 M (SD)	PP W/O FEEDBACK M (SD)	PP M (SD)	IHIB+ M (SD)	IHIB- M (SD)
8	3.3 (1.0)	2.1 (1.4)	3.3 (1.5)	2.7 (1.4)	2.9 (1.5)
9	2.9 (1.2)	3.1 (1.4)	3.3 (1.3)	3.5 (1.3)	3.6 (1.3)
12	3.1 (1.6)	2.5 (1.5)	4.0 (1.0)	3.5 (0.8)	3.6 (1.1)
13	3.7 (1.2)	3.3 (1.4)	3.9 (1.0)	3.3 (1.3)	3.5 (1.1)
16	3.4 (0.9)	3.0 (1.1)	4.0 (1.0)	3.5 (1.3)	3.5 (0.9)
17	3.8 (1.1)	4.0 (0.8)	3.7 (1.3)	3.6 (0.9)	3.7 (1.0)
20	4.1 (1.2)	3.4 (1.1)	4.2 (0.6)	3.7 (1.0)	3.8 (0.8)
21	4.3 (0.8)	3.6 (1.3)	4.2 (0.7)	3.7 (1.4)	3.7 (0.9)
24	3.8 (0.9)	3.1 (1.3)	3.8 (0.9)	3.6 (1.2)	3.5 (1.0)
25	4.3 (0.8)	4.0 (1.0)	4.4 (0.5)	4.2 (0.6)	3.9 (0.9)

REPEATED MEASURES ANOVA
(4 GROUPS by 5 TRIAL PAIRS)

EFFECT	df	Mean Square	F value	p
Within cells	95	4.37		
Constant	1	12931.22	2960.9	.000
GROUP	4	11.37	2.60	.041
Within Cells	380	1.13		
TRIAL PAIR	4	22.62	20.06	.000
GROUP BY TRIAL PAIR	16	0.97	0.86	.612
Within Cells	95	1.06		
TRIAL	1	24.96	23.65	.000
GROUP BY TRIAL	4	3.39	3.21	.016

Continued on next page

Within Cells	380	0.97		
TRIAL PAIR by				
TRIAL	4	2.04	2.11	.079
GROUP by TRIAL				
PAIR by TRIAL	16	1.21	1.25	.226

Follow up for GROUP by TRIAL

GROUP	<u>First scoring</u>		<u>Second scoring</u>	
	<u>M</u>	<u>(SD)</u>	<u>M</u>	<u>(SD)</u>
NP-2	17.7	(3.8)	19.1	(3.5)
PP WITHOUT FEEDBACK	14.3	(4.9)	18.0	(4.2)
PP	19.3	(2.6)	19.6	(3.1)
IHIB+	17.1	(3.6)	18.5	(3.2)
IHIB-	17.4	(2.9)	18.5	(4.0)

ANOVA for first scoring trial:
 $F(4,95) = 4.89; p = .001$

Groups significantly different at alpha = .05
 (TUKEY's HSD)
 PP WITHOUT FEEDBACK < NP-2
 PP WITHOUT FEEDBACK < PP

ANOVA for second scoring trial:
 $F(4,95) = 0.52; p = .717$

Within GROUPS differences (first trial to second trial)

GROUP	<u>t</u> value (df)
NP-2	$\underline{t}(19) = 1.57; p = .132$
PP WITHOUT FEEDBACK	$\underline{t}(19) = 5.07; p = .000$
PP	$\underline{t}(19) = 0.55; p = .587$
IHIB+	$\underline{t}(19) = 2.42; p = .026$
IHIB-	$\underline{t}(19) = 1.26; p = .223$

Table 3.1. Means, standard deviations, ANOVA and follow-up analysis of points scored for BLOCKS of five test trials for each of the three treatment groups.

GROUP	BLOCK-1 (trials 1-5) <u>M</u> (<u>SD</u>)	BLOCK-2 (trials 6-10) <u>M</u> (<u>SD</u>)	BLOCK-3 (trials 11-15) <u>M</u> (<u>SD</u>)
IHIB-MAX	9.8 (2.7)	14.5 (3.8)	20.6 (3.0)
IHIB-MIN	11.0 (4.3)	16.1 (4.4)	18.7 (3.0)
NP	11.2 (3.4)	18.0 (3.6)	16.7 (3.2)

REPEATED MEASURES ANOVA
(3 GROUPS by 3 BLOCKS)

EFFECT	df	Mean Square	F value	p
Within cells	27	10.71		
Constant	1	20732.84	1936.0	.000
GROUP	2	1.017	.09	.910
Within Cells	54	13.74		
BLOCK	2	503.51	36.64	.000
GROUP BY BLOCK	4	36.73	2.67	.042

Follow up for GROUP by BLOCK

ANOVA for BLOCK-1 (trials 1 - 5):
 $F(2,27) = 0.45, p = .638$

ANOVA for BLOCK-2 (trials 6 - 10):
 $F(2,27) = 1.93, p = .163$

ANOVA for BLOCK-3 (trials 11 - 15):
 $F(2,27) = 3.88, p = .033$

Group's significantly different at alpha = .05
(Tukey's HSD)
IHIB-MAX > NP

Within GROUPS differences

GROUP	(BLOCK-1 to BLOCK-2) \underline{t} value (df)	(BLOCK-2 to BLOCK-3) \underline{t} value (df)
IHIB-MAX	$\underline{t}(9) = 3.46, p = .007$	$\underline{t}(9) = 3.39, p = .008$
IHIB-MIN	$\underline{t}(9) = 2.22, p = .054$	$\underline{t}(9) = 1.71, p = .122$
NP	$\underline{t}(9) = 3.53, p = .006$	$\underline{t}(9) = -1.34, p = .212$

Table 3.2. Means, standard deviations, and ANOVA of number of IHIB trials for each TREATMENT BLOCK of five treatment periods for the two IHIB groups.

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GROUP	TREATMENT BLOCK-1 (treatment periods 1-5)	TREATMENT BLOCK-2 (treatment periods 6-10)
	<u>M</u> (SD)	<u>M</u> (SD)
IHIB-MAX	15.3 (6.3)	16.0 (9.0)
IHIB-MIN	13.6 (10.6)	16.9 (7.4)

REPEATED MEASURES ANOVA
(2 GROUPS by 2 TREATMENT BLOCKS)

EFFECT	df	Mean Square	F value	p
Within cells	18	69.83		
Constant	1	9548.10	136.74	.000
GROUP	1	40.00	0.57	.459
Within Cells	18	75.36		
BLOCK	1	1.60	0.02	.886
GROUP BY BLOCK	1	16.90	0.22	.642

Table 3.3. Percentage of subjects reaching criterion during IHIB treatment periods for each IHIB group during each IHIB treatment period.

PERIOD	IHIB-MAX		IHIB-MIN	
	%	subjects reaching criterion ¹	%	subjects reaching criterion ²
1		60%		80%
2		90%		90%
3		100%		90%
4		80%		100%
5		100%		90%
BLOCK (1-5)		86%		90%
6		90%		100%
7		90%		100%
8		90%		100%
9		80%		90%
10		80%		90%
BLOCK (6-10)		86%		96

Criterion¹: IHIB duration equivalency score was greater than the score on the last test trial or IHIB duration equivalency score was equal to the score on the last test trial and that score was 4 or more points.

Criterion²: IHIB duration equivalency score was less than the score on the last test trial or IHIB duration equivalency score was equal to the score on the last test trial and that score was 3 or less points.

Table 3.4. Means, standard deviation, ANOVA and follow up analysis of IHIB duration equivalency scores on the treatment trial preceding a test trial for each IHIB treatment group.

TREATMENT BLOCK	IHIB-MAX <u>M</u> (SD)	IHIB-MIN <u>M</u> (SD)
BLOCK-1 (1-5)	17.5 (4.4)	8.0 (4.0)
BLOCK-2 (6-10)	20.1 (3.9)	11.7 (3.2)

REPEATED MEASURES ANOVA
(2 GROUPS by 2 TREATMENT BLOCKS)

EFFECT	df.	Mean Square	F value	p
Within cells	18	18.13		
Constant	1	8208.23	452.87	.000
GROUP	1	801.02	44.19	.000
Within Cells	18	13.07		
BLOCK	1	99.23	7.59	.013
GROUP BY BLOCK	1	3.02	0.23	.636

Follow up:

Block-1 (M = 12.7, SD = 6.3) vs BLOCK-2 (M = 15.9, SD = 5.5): $t(19) = 2.81$, $p = .011$.

IHIB-MAX (M = 37.6, SD = 5.8) vs IHIB-MIN (M = 19.7, SD = 6.1): $t(18) = 6.65$, $p = .000$.

Appendix 1

APPENDIX I.1
EXPERIMENT #1 - EXPERIMENTAL DESIGN

TRIALS	PERIOD	TIME ELAPSED	Groups (n = 15 per group)				
			NP	IHIB -	IHIB +	IHIB -/+	IHIB +/-
2 trials	preliminary	3 - 5 minutes	practice no feedback (a.s.p.)	practice no feedback (a.s.p.)	practice no feedback (a.s.p.)	practice no feedback (a.s.p.)	practice no feedback (a.s.p.)
5 trials (1 - .5) record score	TEST-1	2 - 3 minutes	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)
5 trials (6 - 10) record ihib duration	TREATMENT-1	5 - 8 minutes	talk to researcher	ihib- (no a.s.p.)	ihib+ (a.s.p.)	ihib- (no a.s.p.)	ihib+ (a.s.p.)
5 trials (11 - 15) record score	TEST-2	1 - 2 minutes	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)
5 trials (16 - 20) record score or ihib duration	TREATMENT-2	3 - 5 minutes	talk to researcher	ihib- (no a.s.p.)	ihib+ (a.s.p.)	ihib+ (a.s.p.)	ihib- (no a.s.p.)
5 trials (21 - 25) record score	TEST-3	1 - 2 minutes	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)	test trials with feedback (a.s.p.)

(a.s.p. = auditory stimuli present)

APPENDIX 1.2Experiment #1
FEEDBACK WITH SCORING SYSTEM

The scoring system (contingencies) is based on the deviation of the time it took the subject to complete the sequence, from 9 seconds. The time it took to complete the sequence was measured starting from the first auditory stimulus presentation (Stimulus-1) until the completion of the last move of the sequence. The computer timer measured time in 1/60th of a second. The following table defines the point equivalents for times to complete the sequence.

POINTS AWARDED	MINIMUM TIME	MAXIMUM TIME
0 points	0.00	7.49
1 points	7.50	7.82
2 points	7.83	8.15
3 points	8.16	8.49
4 points	8.50	8.82
5 points	8.83	9.16
4 points	9.17	9.50
3 points	9.51	9.83
2 points	9.84	10.16
1 points	10.17	10.50
0 points	10.51	or longer

In addition to the points, the computer provided feedback on the monitor screen as to whether the time it took to complete the sequence was slower than or faster than a 5 point response.

If the subject's response was 5 points, then the following appeared on the screen:

YOUR SCORE IS 5

YOU MUST BE A PRO!

YOU SCORED A PERFECT 5 !

If the subject's response took more time than what was required for a 5 point response, then the following appeared on the screen:

TOO SLOW! YOUR SCORE WAS X.

(X is the actual points awarded to the subject for that trial)

If the subject's response took less time than what was required for a 5 point response, then the following appeared on the screen:

TOO FAST! YOUR SCORE WAS X
(X is the actual points awarded to the subject for that trial)

Regardless of the subject's score, the following reminder appeared on the screen:

REMEMBER A PERFECT SCORE IS 5

APPENDIX 1.3

Experiment #1

Introduction

Thank you for coming to participate in the experiment. This experiment is trying to assess the effects of practice on the performance of a simple motor task. You will be required to do a series of moves with the joystick and the telegraph key using JUST YOUR RIGHT HAND. The sequence of moves you are going to do is:

move the joystick to the RIGHT
push the KEY
move the joystick DOWN
push the KEY
move the joystick to the LEFT
push the KEY
move the joystick UP
push the KEY

So the sequence of moves you are going to do is an alternating of the joystick and the telegraph key. Starting with moving the joystick to the right, then pushing the key, then moving the joystick down, then pushing the key, then moving the joystick down, then pushing the key, then moving the joystick up then finally pushing the key to finish the sequence. At the start of each trial, you will hear a tone and see a list of words appear on the television screen. The list of words will appear like this

RIGHT
KEY
DOWN
KEY
LEFT
KEY
UP
KEY

As soon as you hear the tone and see the list of words appear on the screen, begin doing the sequence of moves. The list of words is a reminder to you on the exact sequence of moves you are to do. As you complete each move of the sequence properly, the tone will change to a slightly different tone and a little black ball beside the move on the list of words on the television screen will fall to the next word on the list. This indicates that you have correctly completed that move and can go on to the next move.

The little black ball beside the word will indicate to you what move you are on in case you get lost or forget which move you are on. If you do not complete the move correctly, the tone will not change and the little black ball on the computer screen will not move. If this happens, it means you did not do that move correctly, so try to do that move again. Once you have finished doing the eight moves of the sequence, the tones will stop indicating you have finished the task. To start, you will do two warm-up trials to get familiar with the task and how it works. When you understand these instructions and are ready to begin, tell the experimenter you are ready.

Experiment #1
Part 1 - Scoring Instructions

Now that you understand how to do the task, you will now be required to do 5 trials for which you will score points on each trial. The object is to score as many points as you can. The most points you can score for a single trial is 5, this is the best score. The least amount of points you can score is 0, this is the worst score. When you have finished doing the eight moves of the sequence and the tones stop, the computer will calculate your score and show it to you on the computer screen. This feedback will tell you the amount of points that you scored on that trial and whether you were TOO FAST or TOO SLOW or PERFECT. Different scores represent very small differences in times. The more points you score, the closer you are to a perfect time and score of 5 points. The points can range from "0, 1, 2, 3, or 4 points - too slow", to "Perfect you scored 5 points" to "0, 1, 2, 3 or 4 points - too fast". Remember, the higher your points score is, the closer you are to the perfect score. Let the experimenter know when you have finished reading these instructions so you may continue.

Experiment #1
IHIB INSTRUCTIONS

In the next part of the experiment, you will covertly practice the task 5 times. Covert practice is a specific method to imagine practising a specific behaviour. In other words, you will not actually be doing the task rather you will be imagining yourself performing the task.

The first step of proper covert practice is knowing what type of performance you will imagine. In all 5 of the covert practice trials, you are to imagine doing the same sequence of moves you have just been doing. The experimenter will tell you prior to the start of each covert practice trial the specific type of performance that you are to try imagining. For example, on one covert practice trial the experimenter may tell you to "Imagine doing the task that results in the feedback being TOO SLOW - YOU SCORED 0 POINTS". How you covertly practice this performance should be slightly different then when the experimenter tells you "On the trial, imagine doing the task that results in the feedback being TOO FAST - YOU SCORED 0 POINTS".

The second step of proper covert practice is the placement of your first finger of your right hand on the period (.) key on the computer keyboard. You are to push this . key each time you imagine yourself doing each of the 8 moves of the sequence while doing covert practice. In other words, as you are imagining yourself moving the joystick to the right, you ACTUALLY push the . key on the keyboard at the same time. Then as you imagine pushing the telegraph key, you ACTUALLY push the . key again. For one trial of covert practice, you will end up pushing the . key 8 times in all, once for each of the eight moves of the sequence.

The third step of proper covert practice is the actual imagining yourself performing the sequence. You begin by closing your eyes and imagining seeing the computer screen completely blank. Imagine moving your right arm and hand to the joystick getting ready to start. When you have clearly imagined seeing and feeling your arm and hand move into position ready to begin, say aloud to the experimenter, READY. The experimenter will give you a cue to begin doing the

sequence (before the series of covert practice trials, the experimenter will clearly tell you what this cue is). Once you hear the cue to start, imagine what it feels like as your hand moves back and forth from the joystick to the key. As you imagine doing each move of the sequence, you are to push the . key on the computer keyboard. When you imagine seeing yourself doing the moves, it is important to try to see things as if your eyes were open and as if you were really do the task. Once you have completed the last move of the sequence, it is really important that you imagine seeing the feedback on the screen. Read it to yourself quietly. Once you have finished reading the imagined feedback, tell the experimenter you have finished the trial.

If you understand these instructions, tell the experimenter you are ready to begin, if not re-read them. If you still do not understand how to do covert practice properly, ask the experimenter to clarify it to you. Remember, you will do 5 covert practice trials in all. before each trial, the experimenter will tell you what point scoring performance you are to imagine doing. Then you place your first finger of your right hand on the . key of the computer keyboard and close your eyes and try to imagine yourself getting ready to begin by imagining your arm and hand getting in position and the computer screen completely blank in front of you. You then tell the experimenter you are READY. On the cue to begin,, you start to imagine yourself doing the sequence of moves, imagine seeing yourself as if your eyes were open and your arm and hand were moving. Try to feel your arm and hand moving to complete the moves, and as you imagine completing each move, you are to push the . key. After you have imagined completing the entire sequence of moves, you are to imagine seeing your feedback and score and read it quietly to yourself. Once you have finished reading the imagined feedback to yourself, you tell the experimenter you have finished that trial. This process will be repeated 5 times, once for each covert practice trial.

APPENDIX 1.4EXPERIMENT #1
EXPERIMENTER SCRIPT

1. LET SUBJECT READ INTRODUCTION. THEN SAY,
Now that you have read the introduction, I want to point out that your name will not be used in connection with the analysis or reporting of the data and at any time during the experiment, if you wish to stop, you may do so. Would you like to continue?

IF YES

Thank-you. Could you please read over this consent form and sign it.

WHEN FINISHED WITH THE CONSENT FORM
THEN YOU SAY,

The first part of the experiment gives you 2 warm-up trials to familiarize you with the sequence and how it works. Remember, once the list of words comes on the screen and you hear the tone, you begin doing the sequence. After your last move of the sequence, the screen will clear for a few seconds. Then the list of words will come on the screen and the tone will sound indicating you are to do the sequence again. You will have 2 trials like this for practice. Are you ready to begin?

TYPE -RUN- THEN HIT ENTER
AFTER THE 2 PRACTICE TRIALS ARE OVER,
GIVE THE SUBJECT THE NEXT INSTRUCTIONS PART-1

AFTER SUBJECT READS THEM SAY,
Remember, try to score as many points as possible. There will be five trials so do not stop, I'll let you know when you have finished. As soon as you are ready, we will begin.

ONCE SUBJECT IS READY, PUSH THE -N- KEY
TWICE.

MENTAL PRACTICE RUNS 1 AND 2
AFTER 5 TRIALS
GIVE SUBJECT MP INSTRUCTIONS
AFTER READING INSTRUCTIONS SAY,

DURING MP IF THERE ARE NO TONES-YOU SAY "GO" IF THERE ARE TONES (SD+) THEN TELL SUBJECT TO BEGIN AT THE SOUND OF THE TONE.

Do you understand how you will do mental practice? (IF YES GOOD) (IF NO, GO OVER STEPS WITH THEM). There is

one more thing you are to do, place your finger of your LEFT hand on the Z button. You are to push the Z button each time you imagine completing a move. So you will end up pushing the Z button 8 times for each trial, once for each move. O.K.?

IF OK, THEN TELL SUBJECT, Remember, you will begin imagining doing the sequence when

(SD-) I say "GO".

(SD+) you hear the tone.

O.K. lets begin. The first performance you are to imagine is a too fast scoring 0 points. O.K. close your eyes and visualize the screen in front of you and tell me when it is clear. (WAIT FOR S TO SAY READY- THEN PUSH "N" KEY - WAIT FOR ARROW ON TOP OF SCREEN TO APPEAR AND WHEN YOU SEE IT SAY) "GO". (COUNT SUBJECTS Z PUSHES AND MAKE SURE IT IS 8 AND WHEN SUBJECT SAYS FINISHED, PUSH "F")

REPEAT THIS 5 TIMES as follows

performance 1=too fast scoring 0

performance 2=too slow scoring 0

performance 3,4,and 5=perfect scoring 5

AFTER MP TRIALS-GIVE IMAGINING QUESTIONNAIRE

POST-TEST 1 AND 2

TELL SUBJECT,

O.K. Now you are going to do the sequence again just as you did the first time you scored points. Remember, there are 5 trials and you are to score as many points as possible. I'll tell you when you have finished. Tell me when you are ready to begin.

WHEN SUBJECT IS READY- PUSH "N" TWICE
MENTAL PRACTICE SECOND RUN TELL SUBJECT,

The next part of the experiment will involve mental practice again. You will do the same as you did before. Please read over the five steps involved in a mental practice trial and let me know when you have finished.

***** GOTO NUMBER 4 *****

APPENDIX 1.5EXPERIMENT #1
CONSENT FORM

I Have listened to a description of the experiment and I wish to participate. From the description of the experiment I understand that:

- a) The experiment is concerned with the effects of various kinds of practice on the subsequent performance of a simple motor task.
- b) I will be required to make a series of moves using the computer joystick.
- c) There is no known discomfort or risk associated with the procedure.
- d) My name will not be used in connection with the analysis or reporting of the data.
- e) the session will last 20 to 40 minutes.
- f) I may, without any necessity of giving an explanation, discontinue my participation at any time and such action will not affect my class marks.
- g) A summary of the results will be available when the study is completed.

DATE: _____

PARTICIPANT'S NAME (print): _____

PARTICIPANT'S SIGNATURE: _____

EXPERIMENTER'S SIGNATURE: _____

APPENDIX 1.6.1

IMAGINING QUESTIONNAIRE

(Form 1)

Subject # _____
 Age _____
 Sex _____
 Telephone number _____

Rate yourself on the following items by circling a number,

1) The vividness of my visual imagery was

1-----2-----3-----4-----5-----6
 as clear as really seeing completely unlike actually seeing, fuzzy and indistinct

2) The feeling of movement in my arm and hands while doing covert practice was

1-----2-----3-----4-----5-----6
 could feel my arm and hand imagining moving imagine and felt no muscle movement

3) I would rate my ability to do covert practice as

1-----2-----3-----4-----5-----6
 really high because my imagery is so real really low because I can't imagine at all

4) I would predict that the covert practice I just did will result in my point scoring performance of the task

1-----2-----3-----4-----5-----6
 improving greatly getting worse

APPENDIX 1.6.2

IMAGINING QUESTIONNAIRE

(Form 2)

Subject # _____

Rate yourself on the following items by circling a number,

1) The vividness of my visual imagery was

1-----2-----3-----4-----5-----6
 as clear as really seeing completely unlike actually seeing, fuzzy and indistinct

2) The feeling of movement in my arm and hands while doing covert practice was

1-----2-----3-----4-----5-----6
 could feel my arm and hand imagining moving imagine and felt no muscle movement

3) I would rate my ability to do covert practice as

1-----2-----3-----4-----5-----6
 really high because my imagery is so real really low because I can't imagine at all

4) I would predict that the covert practice I just did will result in my point scoring performance of the task

1-----2-----3-----4-----5-----6
 improving greatly getting worse

5) Which covert practice session did you prefer the most?

1-----2-----3-----4-----5-----6
 the first session much better the second session much better

Appendix 2

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APPENDIX 2.1
EXPERIMENT #2

		GROUPS (n = 20 subjects per group)							
TRIALS	PERIOD	TIME ELAPSE D	PP	PP without feedback	IHIB -	IHIB +	NP	NT	
2 trials	preliminary	3 - 5 minutes	practice task without feedback on score (a.s.p.)						
5 trials (1-5) record score	TEST-1	2 - 3 minutes	test trials with feedback (a.s.p.)						
2 trials (6-7) treatment trials	treatment pair #1	2 - 4 minutes	test trials with feedback (a.s.p.)	practice without feedback (a.s.p.)	ihib- (no a.s.p.)	ihib+ (a.s.p.)	talk to researcher		
2 trials (8-9) performance trials	perform pair #1	1 - 2 minutes	test trials with feedback (a.s.p.)						
2 trials (10-11) treatment trials	treatment pair #2	1 - 3 minutes	test trials with feedback (a.s.p.)	practice without feedback (a.s.p.)	ihib- (no a.s.p.)	ihib+ (a.s.p.)	talk to researcher		
2 trials (12-13) performance trials	perform pair #2	1 - 2 minutes	test trials with feedback (a.s.p.)						
2 trials (14-15) treatment trials	treatment pair #3	1 - 3 minutes	test trials with feedback (a.s.p.)	practice without feedback (a.s.p.)	ihib- (no a.s.p.)	ihib+ (a.s.p.)	talk to researcher	read a book during entire period	
2 trials (16-17) performance trials	perform pair #3	1 - 2 minutes	test trials with feedback (a.s.p.)						
2 trials (18-19) treatment trials	treatment pair #4	1 - 3 minutes	test trials with feedback (a.s.p.)	practice without feedback (a.s.p.)	ihib- (no a.s.p.)	ihib+ (a.s.p.)	talk to researcher		
2 trials (20-21) performance trials	perform pair #4	1 - 2 minutes	test trials with feedback (a.s.p.)						
2 trials (22-23) treatment trials	treatment pair #5	1 - 3 minutes	test trials with feedback (a.s.p.)	practice without feedback (a.s.p.)	ihib- (no a.s.p.)	ihib+ (a.s.p.)	talk to researcher		
5 trials (24-28) record score	TEST-2	1 - 2 minutes	test trials with feedback (a.s.p.)						

(a.s.p. = auditory stimuli present)

APPENDIX 2.2Experiment #2
FEEDBACK WITH SCORING SYSTEM

The scoring system (contingencies) is based on the deviation of the time it took the subject to complete the sequence, from 9 seconds. The time it took to complete the sequence was measured starting from the first auditory stimulus presentation (Stimulus-1) until the completion of the last move of the sequence. The computer timer measured time in 1/60th of a second. The following table defines the point equivalents for times to complete the sequence.

POINTS AWARDED	MINIMUM TIME	MAXIMUM TIME
0 points	0.00	6.66
1 points	6.67	7.18
2 points	7.19	7.70
3 points	7.71	8.34
4 points	8.35	8.73
5 points	8.74	9.25
4 points	9.26	9.76
3 points	9.77	10.28
2 points	10.29	10.80
1 points	10.81	11.31
0 points	10.32	or longer

In addition to the points, the computer provided feedback on the monitor screen as to whether the time it took to complete the sequence was slower than or faster than a 5 point response.

If the subject's response was 5 points, then the following appeared on the screen:

**YOUR SCORE IS 5
YOU MUST BE A PRO!
YOU SCORED A PERFECT 5 !**

If the subject's response took more time than what was required for a 5 point response, then the following appeared on the screen:

TOO SLOW! YOUR SCORE WAS X.
(X is the actual points awarded to the subject for that trial)

If the subject's response took less time than what was required for a 5 point response, then the following appeared on the screen:

TOO FAST! YOUR SCORE WAS X

(X is the actual points awarded to the subject for that trial)

Regardless of the subject's score, the following reminder appeared on the screen:

REMEMBER A PERFECT SCORE IS 5

APPENDIX 2.3

Experiment #2

INTRODUCTION

Thank you for coming to participate in the experiment. This experiment is trying to assess the effects of practice on the performance of a simple motor task. You will be required to do a series of moves with the joystick and the telegraph key using JUST YOUR RIGHT HAND. The sequence of moves you are going to do is:

move the joystick to the RIGHT
push the KEY
move the joystick DOWN
push the KEY
move the joystick LEFT
push the KEY
move the joystick UP
push the KEY

So, the sequence of moves you are going to do is an alternating of the joystick and the telegraph key. Start by moving the joystick to the right, then pushing the key, then moving the joystick down, then pushing the key, then moving the joystick left, then pushing the key, then moving the joystick up and then finally pushing the key to finish the sequence. At the start of each trial, you will hear a tone and see a list of words appear on the television screen. The list of words will appear like this:

RIGHT
KEY
DOWN
KEY
LEFT
KEY
UP
KEY

As soon as you hear the tone and see the list of words appear on the screen, begin doing the sequence of moves. The list of words is a reminder to you of the exact sequence of moves you are to do. As you complete

each move of the sequence properly, the tone will change to a slightly different tone and a little black ball beside the move on the list of words on the television screen will fall to the next word on the list. This indicates that you have correctly completed that move and can go on to the next move. The little black ball beside the word will indicate to you what move you are on in case you get lost or forget which move you are on. If you do not complete the move correctly, the tone will not change and the little black ball on the computer screen will not move. If this happens, it means you did not do that particular move correctly, so try to do that move again. Once you have finished doing the eight moves of the sequence, the tones will stop. This indicates that you have finished the task.

To begin, you will do two warm-up trials to get familiar with the task and how it works. When you understand these instructions and are ready to begin, tell the experimenter you are ready.

Experiment #2
SCORING INSTRUCTIONS

Now that you understand how to do the task, you will now be required to do 5 trials for which you will score points on each trial. The object is to score as many points as you can. The most points you can score for a single trial is 5. This is the best score. The least amount of points you can score is 0. This is the worst score. When you have finished doing the eight moves of the sequence and the tones stop, the computer will calculate your score and show it to you on the computer screen. This feedback will tell you the amount of points that you scored on that trial and whether you were TOO FAST or TOO SLOW or PERFECT. Different scores represent very small differences in times. The more points you score, the closer you are to a perfect time and score of 5 points. The points can range from '0, 1, 2, 3, or 4 points - too slow' to 'Perfect, you scored 5 points' to '0, 1, 2, 3, or 4 points - too fast'. Remember, the higher your points score is, the closer you are to the perfect score. Let the experimenter know when you have finished reading these instructions so you may continue.

Experiment #2IMAGINED PRACTICE - INSTRUCTIONS

In the next part of the experiment, you will imagine yourself performing the task. In these trials you will imagine completing the same sequence of moves that you have just been doing, but you won't be touching the joystick or the telegraph key.

During each trial, you will imagine scoring a perfect score of 5 points. In other words, you will imagine performing the trial that would result in the feedback being, 'YOU SCORED A PERFECT 5 - WHAT A PRO!'

The experimenter will have you prepare for the imagined trial by placing the first finger of your right hand on the period (.) key of the computer keyboard. You will push this key as you imagine completing each move of the sequence. For example, as you imagine yourself moving the joystick to the right, you will actually push the period key at the same time. Then, as you imagine pushing the telegraph key, you actually push the period key again. You will push the period key once for each move of the sequence (ie. RIGHT, KEY, DOWN, KEY, LEFT, KEY, UP, KEY).

Once your right index finger is resting on the period key, the experimenter will have you close your eyes and imagine seeing the computer screen completely blank. Imagine moving your right arm and hand to the joystick as if you were getting ready to start. When you have clearly imagined seeing and feeling your arm and hand move into a position ready to begin, say aloud to the experimenter, READY. The experimenter will give you a cue to begin doing the sequence (before the series of imagined practice trials, the experimenter will clearly tell you what this cue is). Once you hear the cue to start, imagine what it feels like as your hand moves back and forth from the joystick to the key.

As you imagine doing each move of the sequence, you are to push the period key on the computer keyboard. When you imagine seeing yourself doing the moves, it is important to try to see things as if your eyes were open and as if you were really doing the task. Once you have completed the last move of the sequence, it is very important that you imagine seeing the feedback on the screen. Read it to yourself quietly. Once you have finished reading the imagined feedback (ie. YOU WERE PERFECT - YOU SCORED 5 POINTS), tell the experimenter that you are finished.

If you understand these instructions, tell the experimenter you are ready to begin. If not, re-read

them. If you still do not understand how to do imagined practice properly, ask the experimenter to clarify it to you. Before each trial, the experimenter will remind you to imagine doing the task perfectly and scoring 5 points. Then, you place your first finger of your right hand on the period key of the computer keyboard and close your eyes. Imaging yourself getting ready to begin by imagining your arm and hand getting into position and that the computer screen is completely blank in front of you. You then tell the experimenter you are READY. On the cue to begin, you start to imagine yourself doing the sequence of moves. Imagine seeing yourself as if your eyes were open and your arm and hand were moving. Try to feel your arm and hand moving to complete the moves. As you imagine completing each move, you are to push the period key. After you have imagined completing the entire sequence of moves, you are to imagine seeing your feedback and score. Read it quietly to yourself. Once you have finished reading the imagined feedback to yourself, tell the experimenter you have finished that trial. This process will be repeated for each imagined practice trial.

APPENDIX 2.4
Experiment #2
Experimenter Script

Plug in all equipment and turn power on. Printer on 5. Insert cassette into machine (side a is NP-1 and side b contains the remaining conditions). Type LOAD, return and press play on tape.

Give S introduction. When finished reading say

Now that you have read the introduction, I want to point out that your name will not be used in connection with the analysis or reporting of the data and at any time during the experiment, if you wish to stop, you may do so.

Give S consent form, then say

Please read this over and sign it.

When finished signing say:

The 1st part of the experiment gives you 2 warm-up trials to familiarize yourself with the task and how it works. Remember, once you hear the tones and see the list of words on the screen, start doing the task. After your last move of the sequence, the tones will stop for a few seconds. Then you will hear the tones again signalling you to begin doing the task again. You will have two trials like this just for practice. Are you ready. Remember, begin when you hear the tone and see the list of words and only use your right hand.

Type RUN, hit ENTER. This is all you need to begin the NP-1 condition. For all other conditions, you must then select group type, hit enter and then press N. After practice trials, give S scoring instructions to read. When finished say

Remember, try to score as many points as possible. There are five trials so don't stop. Always begin when you hear the tones and see the list of words on the screen. Are you ready. Push N key twice. After 5 trials, proceed with appropriate treatment condition.

1. If the NP-1, have the S read for approximately 7 minutes.
2. If the NP mixed with PP, initially have S read for 3-4 minutes and then complete two trials (say that there will be two trials with a short pause between), then read for 1 minute, then complete two trials (again emphasizing that they should score as many points as they can), then read for 1 minute again, then complete two more trials, then read again, then complete the final two trials and finally read for the last 1 minute period. Then proceed with the post-test. (NOTE: During the treatment phase, experimenter must initiate each real trial pair by pressing N once. In addition, while the S is reading, the experimenter must press N and wait for the arrow to appear; then she/he must press the period key 8 times or until the arrow is off the screen. This must be done two times each time the S is reading.)
3. If the PP, have the S complete 9 pairs of real trials again emphasizing that they should score as many points as they can. Tell the S that they will be completing several trials; inform them if there are two in a row or not. NOTE: The experimenter must initiate trial 1 and 2 with an N press for each trial. However, trial 3 and 4 will only require one N press. This pattern will be repeated for all 9 pairs of trials.
4. If the PP with and without feedback, explain to the S that they are now going to complete the task. There will be several trials. During all the trials, the S is to try to score as many points as possible, 5 being a perfect score. Tell the S that on some trials, he/she will get feedback on performance and on other trials, the word GOOD will appear on the screen. Repeat pairs, alternating feedback and non-feedback. Total of 9 pairs of trials. Same NOTE as above.
- 5 & 6. If the CP+ or CP-, have the S read the Imagining Instructions.
When the S is finished reading, say
Do you understand how to do imagined practice.
If not, GO OVER INSTRUCTIONS. Then say
Your cue to start imagining doing the sequence is when you hear a tone. Let's begin. Put your finger on the period key (don't let S push it before you start the trial). Close your eyes and imagine seeing the television screen completely blank and see and feel your arm and hand move in a position to start. When this is clear and you can imagine the feelings in your arm and hand, tell me you are ready. Now

remember, I want you to imagine being perfect and scoring 5 points. Ready.

When S says ready, press N key once. When S has finished the trial, he should signal finish. If he doesn't, remind him to. Also, remind the S to envision the feedback on the screen at the end of the imagined trial. Repeat the above and then proceed to the two real trials (press N to start trial pair), again emphasizing that they should try to score as many points as possible, 5 being the highest score. Also emphasize that the S shouldn't stop during the real trials because there will be two in a row. Alternate between IHIB and real trials for the appropriate number of times. Then proceed with the post-test. Say

In the next part of the experiment, you are going to do the task again, scoring as many points as you can. If

you would like to read over the scoring instructions again, you can. Do you.

Once S is ready, say

Remember, try to score as many points as you can and start when you hear the tones and see the list of words on the screen. Are you ready. There are 5 trials so don't stop. OK.

Once S is ready, hit N key twice. After trials are complete, debrief and thank the S. (NOTE: For all conditions, but NP-1 the data will begin printing after post-test. For NP-1, the experimenter must press N once and complete 1 trial, then the data will print.

APPENDIX 2.5
Experiment #2
CONSENT FORM

I have listened to a description of the experiment and I wish to participate. From the description of the experiment I understand that:

- a) The experiment is concerned with the effects of various kinds of practice on the subsequent performance of a single motor task.
- b) I will be required to make a series of moves using the computer joystick.
- c) There is no known discomfort or risk associated with the procedure.
- d) My name will not be used in connection with the analysis or reporting of the data.
- e) The session will last 20 to 40 minutes.
- f) I may, without any necessity of giving an explanation, discontinue my participation at any time and such action will not affect my class marks.
- g) A summary of the results will be available when the study is completed.

DATE: _____

PARTICIPANT'S NAME (print): _____

PARTICIPANT'S SIGNATURE: _____

PARTICIPANT'S PREFERRED HAND _____

PARTICIPANT'S AGE _____

EXPERIMENTER'S SIGNATURE _____

APPENDIX 3



Appendix 3.1
Experiment #3 - Experimental Design

Period	Trial	Time Elapsed	Treatment Groups	
			IHIB - Maximize (n=10)	IHIB - Minimize (n=10)
Preliminary		2 minutes	2 preliminary trials (no scoring feedback received. auditory stimuli presented)	
TEST-1	1 to 5	5 minutes	5 testing trials with feedback	
	treatment	5 minutes	5 minute rest period doing word find puzzles	
	6	9 minutes	IHIB to criteria ¹	IHIB to criteria ²
	treatment	1 minute	Perform one testing trial with feedback	
	7	2 minutes	IHIB to criteria ¹	IHIB to criteria ²
	treatment	1 minute	Perform one testing trial with feedback	
	8	2 minutes	IHIB to criteria ¹	IHIB to criteria ²
	treatment	1 minute	Perform one testing trial with feedback	
	9	2 minutes	IHIB to criteria ¹	IHIB to criteria ²
	treatment	1 minute	Perform one testing trial with feedback	
	10	2 minutes	IHIB to criteria ¹	IHIB to criteria ²
	treatment	1 minute	Perform one testing trial with feedback	
	11	2 minutes	IHIB to criteria ¹	IHIB to criteria ²
	treatment	1 minute	Perform one testing trial with feedback	
	12	2 minutes	IHIB to criteria ¹	IHIB to criteria ²
treatment	1 minute	Perform one testing trial with feedback		
13	2 minutes	IHIB to criteria ¹	IHIB to criteria ²	
treatment	1 minute	Perform one testing trial with feedback		
14	2 minutes	IHIB to criteria ¹	IHIB to criteria ²	
treatment	1 minute	Perform one testing trial with feedback		
15	2 minutes	IHIB to criteria ¹	IHIB to criteria ²	
treatment	1 minute	Perform one testing trial with feedback		
	30 seconds		Perform one testing trial with feedback	

IHIB to criteria¹ - IHIB duration equivalency score is greater than performance score on the test trial immediately preceding this set of treatment trials or the IHIB duration equivalency score is greater than or equal to 4 points and is equal to the performance score on the test trial immediate preceding this set of treatment trials or criteria has not been reached after 10 IHIB trials.

IHIB to criteria² - IHIB duration equivalency score is less than performance score on the test trial immediately preceding this set of treatment trials or the IHIB duration equivalency score is less than or equal to 3 points and is equal to the performance score on the test trial immediate preceding this set of treatment trials or criteria has not been reached after 10 IHIB trials: Subjects yoked on number of IHIB trials as closely as possible to an IHIB - Maximize subject.

APPENDIX 3.2Experiment #3
FEEDBACK WITH SCORING SYSTEM

The scoring system (contingencies) is based on the deviation of the time it took the subject to complete the sequence, from 9 seconds. The time it took to complete the sequence was measured starting from the first auditory stimulus presentation (Stimulus-1) until the completion of the last move of the sequence. The computer timer measured time in 1/60th of a second. The following table defines the point equivalents for times to complete the sequence.

POINTS AWARDED	MINIMUM TIME	MAXIMUM TIME
0 points	0.00	7.49
1 points	7.50	7.82
2 points	7.83	8.15
3 points	8.16	8.49
4 points	8.50	8.82
5 points	8.83	9.16
4 points	9.17	9.50
3 points	9.51	9.83
2 points	9.84	10.16
1 points	10.17	10.50
0 points	10.51	or longer

In addition to the points, the computer provided feedback on the monitor screen as to whether the time it took to complete the sequence was slower than or faster than a 5 point response.

If the subject's response was 5 points, then the following appeared on the screen:

YOUR SCORE IS 5

YOU MUST BE A PRO!

YOU SCORED A PERFECT 5 !

If the subject's response took more time than what was required for a 5 point response, then the following appeared on the screen:

TOO SLOW! YOUR SCORE WAS X.

(X is the actual points awarded to the subject for that trial)

If the subject's response took less time than what was required for a 5 point response, then the following appeared on the screen:

TOO FAST! YOUR SCORE WAS X

(X is the actual points awarded to the subject for that trial)

Regardless of the subject's score, the following reminder appeared on the screen:

REMEMBER A PERFECT SCORE IS 5

APPENDIX 3.3

Experiment #3

INTRODUCTION

Thank you for coming to participate in the experiment. This experiment is trying to assess the effects of practice on the performance of a simple motor task. You will be required to do a series of moves with the joystick and the telegraph key using JUST YOUR RIGHT HAND. The sequence of moves you are going to do is:

move the joystick to the RIGHT
push the KEY
move the joystick DOWN
push the KEY
move the joystick LEFT
push the KEY
move the joystick UP
push the KEY

So, the sequence of moves you are going to do is an alternating of the joystick and the telegraph key. Start by moving the joystick to the right, then pushing the key, then moving the joystick down, then pushing the key, then moving the joystick left, then pushing the key, then moving the joystick up and then finally pushing the key to finish the sequence. At the start of each trial, you will hear a tone and see a list of words appear on the television screen. The list of words will appear like this:

RIGHT
KEY
DOWN
KEY
LEFT
KEY
UP
KEY

As soon as you hear the tone and see the list of words appear on the screen, begin doing the sequence of moves. The list of words is a reminder to you of the exact sequence of moves you are to do. As you complete

each move of the sequence properly, the tone will change to a slightly different tone and a little black ball beside the move on the list of words on the television screen will fall to the next word on the list. This indicates that you have correctly completed that move and can go on to the next move. The little black ball beside the word will indicate to you what move you are on in case you get lost or forget which move you are on. If you do not complete the move correctly, the tone will not change and the little black ball on the computer screen will not move. If this happens, it means you did not do that particular move correctly, so try to do that move again. Once you have finished doing the eight moves of the sequence, the tones will stop. This indicates that you have finished the task.

To begin, you will do two warm-up trials to get familiar with the task and how it works. When you understand these instructions and are ready to begin, tell the experimenter you are ready.

Experiment #3
SCORING INSTRUCTIONS

Now that you understand how to do the task, you will now be required to do 5 trials for which you will score points on each trial. The object is to score as many points as you can. The most points you can score for a single trial is 5. This is the best score. The least amount of points you can score is 0. This is the worst score. When you have finished doing the eight moves of the sequence and the tones stop, the computer will calculate your score and show it to you on the computer screen. This feedback will tell you the amount of points that you scored on that trial and whether you were TOO FAST or TOO SLOW or PERFECT. Different scores represent very small differences in times. The more points you score, the closer you are to a perfect time and score of 5 points. The points can range from '0, 1, 2, 3, or 4 points - too slow' to 'Perfect, you scored 5 points' to '0, 1, 2, 3, or 4 points - too fast'. Remember, the higher your points score is, the closer you are to the perfect score. Let the experimenter know when you have finished reading these instructions so you may continue.

Experiment #3IMAGINED PRACTICE - INSTRUCTIONS

In the next part of the experiment, you will imagine yourself performing the task. In these trials you will imagine completing the same sequence of moves that you have just been doing, but you won't be touching the joystick or the telegraph key.

During each trial, you will imagine scoring a perfect score of 5 points. In other words, you will imagine performing the trial that would result in the feedback being, 'YOU SCORED A PERFECT 5 - WHAT A PRO!'.

The experimenter will have you prepare for the imagined trial by placing the first finger of your right hand on the slash (/) key of the computer keyboard. You will push this key as you imagine completing each move of the sequence. For example, as you imagine yourself moving the joystick to the right, you will actually push the slash key at the same time. Then, as you imagine pushing the telegraph key, you actually push the slash key again. You will push the slash key once for each move of the sequence (ie. RIGHT, KEY, DOWN, KEY, LEFT, KEY, UP, KEY).

Once your right index finger is resting on the slash key, the experimenter will have you close your eyes and imagine seeing the computer screen completely blank. Imagine moving your right arm and hand to the joystick as if you were getting ready to start. When you have clearly imagined seeing and feeling your arm and hand move into a position ready to begin, say aloud to the experimenter, READY. The experimenter will give you a cue to begin doing the sequence (before the series of imagined practice trials, the experimenter will clearly tell you what this cue is). Once you hear the cue to start, imagine what it feels like as your hand moves back and forth from the joystick to the key.

As you imagine doing each move of the sequence, you are to push the slash key on the computer keyboard. When you imagine seeing yourself doing the moves, it is important to try to see things as if your eyes were open and as if you were really doing the task. Once you have completed the last move of the sequence, it is very important that you imagine seeing the feedback on the screen. Read it to yourself quietly. Once you have finished reading the imagined feedback (ie. YOU WERE PERFECT - YOU SCORED 5 POINTS), tell the experimenter that you are finished.

If you understand these instructions, tell the experimenter you are ready to begin. If not, re-read

them. If you still do not understand how to do imagined practice properly, ask the experimenter to clarify it to you. Before each trial, the experimenter will remind you to imagine doing the task perfectly and scoring 5 points. Then, you place your first finger of your right hand on the slash key of the computer keyboard and close your eyes. Imaging yourself getting ready to begin by imagining your arm and hand getting into position and that the computer screen is completely blank in front of you. You then tell the experimenter you are READY. On the cue to begin, you start to imagine yourself doing the sequence of moves. Imagine seeing yourself as if your eyes were open and your arm and hand were moving. Try to feel your arm and hand moving to complete the moves. As you imagine completing each move, you are to push the slash key. After you have imagined completing the entire sequence of moves, you are to imagine seeing your feedback and score. Read it quietly to yourself. Once you have finished reading the imagined feedback to yourself, tell the experimenter you have finished that trial. This process will be repeated for each imagined practice trial.

APPENDIX 3.4
Experiment #3
Experimenter Script

Plug in all equipment and turn power on. Printer on 5. Insert cassette into machine (side a is NP-1 and side b contains the remaining conditions). Type LOAD, return and press play on tape.

Give S introduction. When finished reading say

Now that you have read the introduction, I want to point out that your name will not be used in connection with the analysis or reporting of the data and at any time during the experiment, if you wish to stop, you may do so.

Give S consent form, then say

Please read this over and sign it.

When finished signing say:

The 1st part of the experiment gives you 2 warm-up trials to familiarize yourself with the task and how it works. Remember, once you hear the tones and see the list of words on the screen, start doing the task. After your last move of the sequence, the tones will stop for a few seconds. Then you will hear the tones again signalling you to begin doing the task again. You will have two trials like this just for practice. Are you ready. Remember, begin when you hear the tone and see the list of words and only use your right hand.

Type RUN, hit ENTER.

SELECT 5 for IHIB and hit ENTER

After practice trials, give S scoring instructions to read. When finished say

Remember, try to score as many points as possible. There are five trials so don't stop. Always begin when you hear the tones and see the list of words on the screen. Are you ready.

Push N key twice. After 5 trials, proceed with appropriate treatment condition.

1. If the NP-1, have the S read for approximately 10-

15 minutes.

IHIB subjects;

Have the S read the Imagining Instructions.

When the S is finished reading, say

Do you understand how to do imagined practice.

If not, GO OVER INSTRUCTIONS. Then say

Your cue to start imagining doing the sequence is when you hear a tone. Let's begin. Put your finger on the period key (don't let S push it before you start the trial). Close your eyes and imagine seeing the television screen completely blank and see and feel your arm and hand move in a position to start. When this is clear and you can imagine the feelings in your arm and hand, tell me you are ready. Now remember, I want you to imagine being perfect and scoring 5 points. Ready.

When S says ready, press N key once. When S has finished the trial, he should signal finish. If he doesn't, remind him to. Also, remind the S to envision the feedback on the screen at the end of the imagined trial. Repeat the above and then proceed to the two real trials (press 5 to start each pair), again emphasizing that they should try to score as many points as possible, 5 being the highest score. Also emphasize that the S shouldn't stop during the real trials because there will be two in a row. Alternate between IHIB and real trials for the appropriate number of times. Then proceed with the post-test. Say

In the next part of the experiment, you are going to do the task again, scoring as many points as you can. If

you would like to read over the scoring instructions again, you can. Do you.

Once S is ready, say

Remember, try to score as many points as you can and start when you hear the tones and see the list of words on the screen. Are you ready. There are 5 trials so don't stop. OK.

Once S is ready, hit N key twice. After trials are complete, debrief and thank the S. (NOTE: For all conditions, but NP-1 the data will begin printing after post-test. For NP-1, the experimenter must press N once and complete 1 trial, then the data will print.)

APPENDIX 3.5
Experiment #3
CONSENT FORM

I have listened to a description of the experiment and I wish to participate. From the description of the experiment I understand that:

- a) The experiment is concerned with the effects of various kinds of practice on the subsequent performance of a single motor task.
- b) I will be required to make a series of moves using the computer joystick.
- c) There is no known discomfort or risk associated with the procedure.
- d) My name will not be used in connection with the analysis or reporting of the data.
- e) The session will last 40 to 60 minutes.
- f) I may, without any necessity of giving an explanation, discontinue my participation at any time and such action will not affect my class marks.
- g) A summary of the results will be available when the study is completed.

DATE: _____

PARTICIPANT'S NAME (print): _____

PARTICIPANT'S SIGNATURE: _____

PARTICIPANT'S PREFERRED HAND _____

PARTICIPANT'S AGE _____

EXPERIMENTER'S SIGNATURE _____