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# The effect of mental practice type on dart-throwing performance

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# The Effect Of Mental Practice Type On Dart-Throwing Performance

by

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# Dedication

This thesis is dedicated to my family and friends who have supported me throughout my academic career. Without their support, I would never have been able to accomplish what I have. Thank you guys, I love you.

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I would like to thank the faculty and staff of the Psychology department at USF for their continued support of my graduate education. I would specifically like to thank my advisor, Dr. Mark Pezzo, for all of his guidance on this project. His comments and suggestions were crucial to the success of this endeavor. I would also like to thank my committee members, Dr. James Eison and Dr. Douglas Rohrer for their help on this project. Their suggestions were extremely helpful. Additionally, I'd like to express my gratitude to my research assistant, Alexis Scher, without whom this project would never have been completed. Her hard work and dedication to the project really made it a success. Finally, I would like to thank Dr. Douglas Maynard of the State University of New York at New Paltz for instilling in me a sense of the scientific nature of psychology. Without his early (and continued) mentoring, I would not be where I am today. Thank you all.

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ABSTRACT

The present study used a sample of 171 college students from the University of South Florida to examine the effects of different types of mental practice on dart-throwing performance. This study examined the effects of imagery and video modeling on an immediately following physical task As suspected, the video modeling condition under these circumstances was associated with poorer performance than the imagery and control conditions. The imagery condition, however, resulted in no difference in performance from the control condition. Discussions of the results and future avenues of research (including gender effects) are also mentioned.

## Introduction

Mental Practice is a broad term that refers to any non-physical practice of a physical task. Suinn (1997) defines it as a "generic term, covering a diverse set of activities" (p. 190) aimed at improving performance. These can range from thinking abstractly about performing a task to simulating internally all of the sights and sounds and feelings associated with the task in order to bring about an improvement in performance.

Studies have shown that athletes in many sports use mental practice techniques. These include golf (McMaster, 1993), marksmanship (Barabasz, Barabasz, & Bauman, 1993; Kim & Tennant, 1993), tennis (DeFrancesco & Burke, 1997), gymnastics (Ligget & Hamada, 1992), archery (Robazza & Bortoli, 1998), and darts (Straub, 1989), among others. Studies have also shown the effectiveness of particular types of mental practice, or mental practice in general (Barabasz et al., 1993; Butler, 1996; Gould & Damarjian, 1996; Hardy & Callow, 1999; Kim & Tennant, 1993; Ligget & Hamada, 1993; McMaster, 1993; Roure, Collet, Deschaumes-Molinaro, Delhomme, Dittmar, &Vernet-Maury, 1999; Suinn, 1996; Vealy & Walter, 1993).

Many types of mental practice exist. For example, Defrancesco and Burke (1997) discovered as many as seven, non-physical performance-enhancing techniques used by professional tennis players. These included imagery, mental preparation, relaxation, goal-setting, self-talk, thought reframing, and self-hypnosis. According to Annett (1995), one particular form of practice, imagery (sometimes called "motor imagery"), can be further subdivided according to the perspective one takes while imaging. For example, one may take an *interior* view to recreate the physical experience. This could involve a kinesthetic component in which the person imaging is expected not only to see the actions taking place, but also to actually "feel" them. The kinesthetic component focuses on the sensations experienced in one's muscles as if they were physically performing the task (although the task is not actually performed). In contrast, an *exterior* view generally ignores the kinesthetic aspects of the task, and instead focuses entirely on seeing the actions being performed, either by one's self or by another person.

Most studies, however, do not distinguish between different types of mental practice in their studies. Often times, researchers will not even report what type of mental practice was used! Murphy (1994) attributes this to what he calls the "mental practice model." This is a paradigm that leads most researchers to treat all mental practice as equal. As a result, most studies do not compare different types of mental practice, but merely compare mental practice to a no-practice control condition or to an effective form of physical practice. Further, few studies actually manipulate mental practice. Instead, they “correlate” the self-reported use of mental practice by athletes with measures of their performance (Murphy, 1994). Consistent with the undifferentiated “mental practice model” described above, mental practice regimens used by athletes often consist of a conglomeration of several different varieties, with little or no information reported about the relative contribution of each. Understandably, Murphy suggests that we may have reached the limit of the amount of knowledge we can obtain through this type of research. It is important that researchers be more specific about what type of mental practice is used in their studies.

Modeling is a process by which a person learns or improves at a task by mimicking another person performing the task (Bandura, 1986). Much research has been done showing that this is a strong mechanism for learning behaviors. The "target" behavior may be presented either in person, or in some other mode (e.g. instructional video). For example, using 40 elite child table-tennis players, Li-Wei, Qi-Wei, Orlick, and Zitzelsberger (1992) compared the effectiveness of a mental practice regimen (including video modeling) condition and a video modeling alone condition to a control condition. The results showed that for these elite players, the mental regimen produced an improvement in performance, while the other two conditions did not. The mental practice regimen condition included (among other things) use of internal imagery (an interior view).

Although much research has been done on mental practice in general, very few studies have been done comparing the effectiveness of different types of mental practice techniques and their varying effects on differentially skilled individuals. One exception comes from Straub (1989), who compared the effect of 3 different mental training programs, physical practice, and a no practice condition on the dart-throwing performance of high and low skilled participants (a 5x2 between subjects factorial design). His 3 mental training programs were commercially available tools designed to improve physical task performance. One program consisted of a set of 6 audiocassettes designed to teach athletes to "relax, set goals, image, and improve their self-esteem" (Straub, 1989, p. 134). This training regimen also used self-hypnosis. A second program also used self-hypnosis, in addition to training athletes to relax, concentrate, problem solve, and mentally rehearse. The final comprehensive program examined by Straub consisted of "seven major psychological skills: attention control, emotional control, self-rejuvenation and energization, body awareness, developing and maintaining self-confidence, programming the subconscious mind, and cognitive restructuring" (p 134). Straub made two important findings. First, over all, those receiving mental training performed better than those in the no practice control condition (although only two of the programs differed from the control condition in a post hoc analysis). Second, an interaction occurred between the original skill level of the participant and the type of practice received. Although all mental training programs were equally effective for highly skilled participants, they differed in their effectiveness for unskilled participants. No explanation for this was offered. Straub also found that, as expected, highly skilled participants performed better, on average, than lower skilled participants.

Although some studies have shown that mental practice is often as effective as physical practice (e.g. Straub, 1989), others have not found this to be the case (e.g. Millard, Mahoney, & Wardrop, 2001; Hird, Landers, Thomas, & Horan, 1991). For example, Millard et al. found that mental practice was not effective at improving novices' performance of a "wet exit" kayak skill, although physical practice was.

Rushall and Lippman (1998) suggest one possible explanation for this discrepancy. They contend that mental practice procedures vary depending upon the goal that the athlete has, with the two most common goals being *skill development* and *performance preparation*. A person interested in learning a new skill will employ mental practice techniques differently than someone trying to mentally prepare in the minutes prior to competition. Although individuals with either goal can benefit from using some of the same techniques (e.g. imagery), implementation of these techniques is usually quite different. In a skill-learning setting, the individual may participate in mental practice several times a week for 15 minutes or more at a time. In a performance-preparation setting, the individual may only engage in mental practice for a few minutes directly prior to competition. Strategies that are effective for one goal, may not be effective for the other, and may even be detrimental. Using Rushall and Lippman's approach, the programs examined by Straub (1989) appear to focus on skill development rather than on performance preparation. In contrast, the program of Millard et al. (2001) may be better suited to immediate performance enhancement of experts than to skill development of novices.

The programs evaluated by Straub (1989) all used a variety of popular mental training techniques including relaxation, visualization, goal setting, concentration training, self-hypnosis, and self-esteem improvement. While some of these seem to fall squarely in the realm of mental training (e.g., visualization), others may not clearly belong (e.g., self-esteem). Although the pursuit of ecological validity may suggest that we should combine as many real-life aspects of mental training into a study as possible (as in Straub & Li-Wei, et al.), it seems wise at this point to focus on the component parts of those programs. The current study aims to tease apart some of these confounded variables inherent in studies of comprehensive mental training programs.

One theory of mental practice is of particular interest to those studying the effects of mental imagery. The *neuromuscular theory* holds that imagery activates procedural memories for both the stimuli and the physiological responses associated with the activity they are imaging (Suinn, 1997). This, in turn, activates the central nervous system and causes neuromuscular innervations almost as strong as those associated with the actual physical task (Suinn, 1997). This stimulation strengthens the connections between the motor cortex and the associated muscles, creating better performance of the mentally practiced task in the future (Suinn, 1997). Rushall and Lippman (1998) discuss this phenomenon in some detail, referring to it with the term, the "ideo-motor effect." This model also implies that if a person physically or mentally practices an improper technique (due to experience with an incorrect physical technique), then their performance of the incorrect technique will be enhanced, not the performance of the proper, desired technique. Other theories of mental practice that are based on general arousal, relaxation, or motivation mechanisms wouldn't predict that mentally practicing an improper technique would result in poorer performance (for a discussion of various classical theories of mental practice, see Grouios, 1992).

So, under the general neuromuscular model, mental practice is believed to enhance performance by repeatedly activating the neuromuscular pathway via a mental representation of the task. Results of a study by Hardy and Callow (1999) seem to support this model. In their study, karateists (experts) were taught a new kata in one experiment and sport science students (novices) were taught a new gymnastics floor routine in another. They were then given either internal or external imagery instructions with or without a kinesthetic imagery component. Imagery in both of these experiments occurred over several weeks. In both experiments, an external imagery was more effective in improving performance than was an internal imagery. In addition, kinesthetic imagery had no effect. This is expected under the model, because none of these participants had an internal representation of the physical task, since it was a new task to them. In a third experiment, high ability rock climbers improved their performance using both visual imagery and kinesthetic imagery for just 2 minutes prior to task performance. This again makes sense under the neuromuscular theory, because the rock-climbing task they were asked to do is presumably extremely similar to things they have done before. Tasks such as rock climbing require the repeated use of familiar techniques, whereas learning a new kata or floor routine likely involves the use of novel techniques or muscle use sequences. In addition to behavioral evidence supporting the neuromuscular theory, some physiological evidence also exists. For example, Decety and Ingvar (1990) showed that some of the same areas of the brain that are involved in coordinating physical activity are also activated by mental imagery. Decety, Jeannerod, Germain, and Pastene (1991) also seem to support the neuromuscular theory, having found additional physiological evidence consistent with common neurological structures being in use during imagery and physical performance.

It should be pointed out, however, that although the majority of researchers (e.g. Jeannerod, 1995) seem convinced that some form of neuromuscular theory best explains the mechanism behind imagery enhancing performance, some do not agree. Jowdy and Harris (1990) did not find any significant difference in neuromuscular activation between high and low skilled jugglers who were imagining themselves juggling. This study does not seem to be a real threat to these neuromuscular theories. Even though Jowdy and Harris seemed to use an internal perspective with a kinesthetic component, the small sample sizes used (n=23 high-skilled, n=15 low-skilled) makes it hard to believe they would have had enough power to find a real effect if one did exist.

The present experiment was designed to study the effects of these different types of mental practice on the performance of a physical task (dart-throwing). I compared the effects of 3 different experimental conditions (imagery, instructional video, and control) on dart-throwing performance, controlling for initial ability (as measured by a dart-throwing pretest. In this study, the mental practice was utilized to fulfill a competition-performance-preparation type of goal described by Rushall and Lippman (1998). This means that the mental practice was carried out for a short duration directly prior to performance measurement. Additionally, initial ability was used to make performance predictions.

I hypothesize that participants in the current study will perform best when their mental practice best mirrors the proper techniques involved in the physical task. I assume that highly skilled people will have a more effective physical technique than low-skilled people on any particular task. For this particular study, I will compare the improvement in dart-throwing ability of differentially skilled participants under instructional video and an internal-kinesthetic imagery condition.

For highly skilled participants, who already have a personalized, accurate internal model of the skills used in performing the task, the imagery condition will give them a chance to mentally practice their proven personal techniques, thus priming them for actual performance. This is because the imagery condition has a kinesthetic component, one important aspect of strengthening under the neuromuscular model of mental practice (Fery & Morizot, 2000; Rushall & Lippman, 1998). I believe that for highly skilled participants, the instructional video will be of little help. Indeed, it may impair performance, by interfering with the activation of brain/muscle connections already associated with successful performance (Rushall & Lippmann, 1998). Additionally, incorporating new techniques into the performance of a task may lead to over-thinking about the task during performance. Because thinking too much about a task during performance can lead to a decline in performance (McMaster, 1993), we may see a decline in performance for those in the video condition on the post-test.

My expectations for low skilled participants in the imagery condition are the opposite of those for highly skilled participants. I do not expect that the internal-kinesthetic imagery condition will improve performance to any large degree, because there will be no well-established physical or mental routine to strengthen or prime. In fact, since they may be mentally practicing improper techniques, an imagery condition may result in poorer performance than that found in the control participants (as a result of a stronger performance of the unsuccessful technique). In addition, because low skilled individuals do not have an accurate internal model of the correct techniques involved in the task, an instructional video, which demonstrates proper technique, should do the best job at enhancing their performance in the long term. However, because the goal of this mental practice is immediate preparation, low skilled participants may not have sufficient time to accurately assimilate the new technique.

Overall, I hypothesize that conditions allowing freedom to rehearse a personal internal model of a task will be more beneficial to highly skilled participants while those offering greater degrees of guidance will be more beneficial to participants with low skill levels. However, it is possible that too much guidance may result in over-thinking during performance, which may actually result in poorer performance. This study will use the task of dart throwing to test these hypotheses. The dependent variables will be the summed score based on the radial distance from the center of a bull's-eye and the improvement in skill from pre-test to post-test.

# Method

*Participants*

I recruited 171 (130 female, 41 male) participants through the USF psychology department's online participant pool, which is mainly populated by undergraduate psychology students. The participants for this study ranged in age from 18 to 34 years with a mean of 20.65. Each participant had normal vision (or corrected to normal) and hearing and had no other physical impairments that would have limited their participation in the study. The self-reported dart throwing skill level of the participants ranged from 1-9 with a median of 3 and a mean of 3.44 (measured on a self-report scale which ranged from 1-10, with 1 being the worst dart-thrower in the world and 10 being the best dart-thrower in the world).

*Design*

This study compared 3 levels of the independent variable (mental practice) while controlling for the covariate of initial ability (as measured by the mean radial error on a dart-throwing pre-test). Mean radial error on a post-test of dart-throwing performance was the dependent variable. Primary analyses will be conducted using a 3 x 2 (Condition: video, control, imagery x Skill: expert, novice) completely factorial design Gender and a self-rating of dart-throwing ability were also measured for subsequent analysis.

*Materials*

Materials for this study consisted of a set of specific imagery directions for the participants in the imagery condition. The instructions were designed to promote an internal-kinesthetic imagery perspective in those listening (see Appendix 1). A five-minute, professionally produced instructional dart-throwing video segment was used to test the hypotheses involving modeling through instruction (see Appendix 2 for a description). For the control condition, a typewritten essay on the history of dart throwing was used (Appendix 3). All conditions were designed to be the same duration (5 minutes). Printed participant directions were used to make the procedures standardized (they were read to the participant by the researcher, instructions for all conditions can be found in Appendix 1).

During the performance assessment phase of the study, five metal tipped generic-brand darts were used. A 4'x4' piece of 1" thick light blue Styrofoam insulation board was used as a target. A red 4cm diameter bull's-eye was painted in the center with black concentric circles painted at radii of 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, and 60 cm. Numbers were written in the spaces between the circles, representing the distance from the center of the bull's-eye. Any dart landing outside the largest circle was counted as 60 cm of error. This system eliminated the need to measure the exact distance of each dart from the exact center of the target.

The board was hung so that the center of the bull's-eye was 68 inches from the floor and a piece of marking tape was placed on the floor 8' from the wall that the board was hung on as a mark for people to stand behind while throwing the darts (both standard distances for recreational dart-throwing).

*Procedure*

Upon arrival, participants read and signed an informed consent form, and then were randomly assigned to one of three experimental conditions (imagery, instructional video, or control). The researcher then obtained some demographic information (age and gender) as well as a self-rating of their own dart-throwing ability (on a scale from 1 (worst) to 10 (best)). The entire administration was done individually, not in groups (to minimize performance anxiety).

Initial dart-throwing ability was then measured by having each participant throw 5 darts 3 times each in succession for a total of 15 throws. The error for each of the darts thrown was recorded and a mean radial error for each person was determined (this was the pre-test score).

All participants were then asked to be seated and to relax. Each participant then received one of the three treatment conditions. Those in the imagery condition were read a set of directions, designed to emphasize an internal perspective with particular focus on the kinesthetic aspects of the task. Those in the instructional video condition were shown video footage of dart-throwing world champion Paul Lim (Chesney Communications, 1997) in which he explained and demonstrated the proper dart-throwing technique. They were asked to pay close attention to the techniques that were used. Those in the control condition were given an essay about the history of darts and asked to read it until the researcher came back into the room. Participants in all conditions were informed that their "practice" would last for 5 minutes.

Finally, each participant was asked to repeat the dart-throwing task, again providing a total of 15 throws (3 sets of 5 throws). The mean radial error was determined and recorded. This was the post-test score. Participants were then debriefed and released.

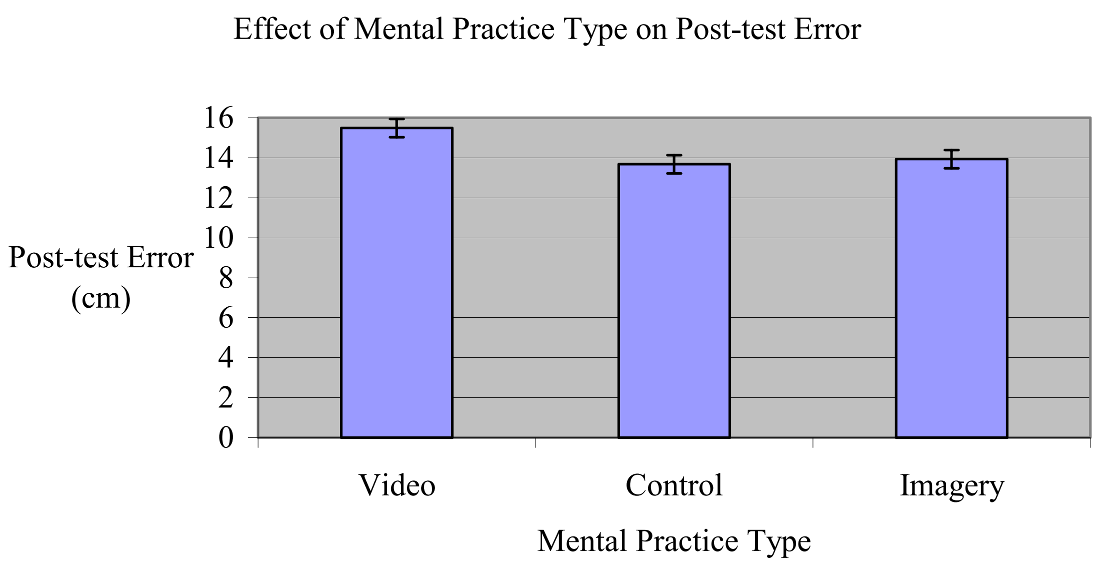
Results

An Analysis of Variance (ANOVA) showed that on the pre-test, there were no significant differences between the groups, $F$ (2, 168) = .46, $p > .05$. I used an Analysis of Covariance (ANCOVA) to determine if there was any effect of the manipulation on post-test performance. The results of the ANCOVA showed that there was a significant difference between groups in the mean radial error on the post-test, $F$ (2, 167) = 4.46, $p <$ .05, *partial* $\acute{\eta}^2 = .051$, after controlling for the significant covariate of initial ability, as measured by a pre-test, $F$ (1, 167) = 129.04, $p < .05$, *partial* $\acute{\eta}^2 = .436$. A Levene's test of equality of error variances showed that there was heterogeneity of variance, $F$ (2, 168) = 6.33, $p < .05$. However, since violations of this assumption are unlikely to lead to a severely biased ANCOVA when all groups are of equal size (Meyers & Well, 1995), no corrections were needed. The observed power for the omnibus test was .76. Additionally, no participants performed sufficiently well or poorly to indicate that I should be concerned with ceiling or floor effects (mean radial error scores on the pre-test ranged from 7.67cm. to 41cm.). An analysis was done, removing all outliers, and no change in the results occurred. Therefore, outliers were included in the final analysis.

Since comparisons between all conditions were planned in the case of a significant omnibus test, Least Significant Difference (LSD) follow-up tests were performed to find out which pairwise comparisons were causing the significant omnibus test. Results showed that the estimated marginal mean radial error for the video condition ($M$ = 15.48, $SE$ = .46) was significantly greater than that of both the imagery condition ($M$ = 13.93, $SE$ = .46) and the control condition ($M$ = 13.67, $SE$ = .46), $p < .05$.

No significant difference was found between the control and imagery conditions, $p > .05$ (see figure 1).

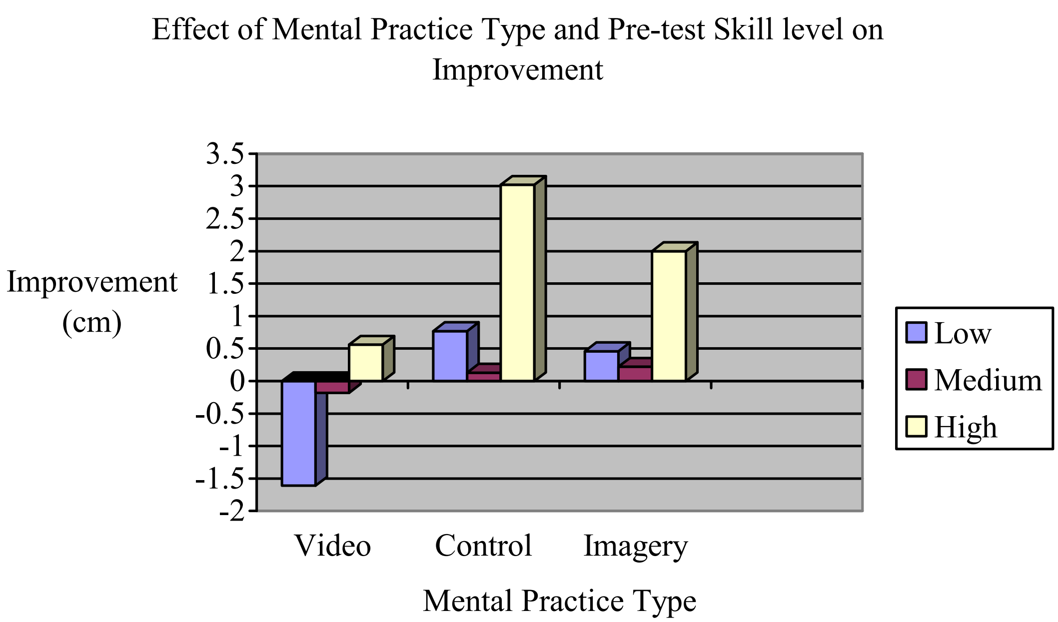
FIGURE 1




In addition to the primary analyses involving the experimental manipulation, I also thought it would be interesting to see how closely the participants' self-report of ability mirrored their actual ability (as measured by the pre-test). The correlation between self-report of ability and mean radial error on the pre-test was -.37, $p < .05$. This means that as self-rating of ability increased, error on the task decreased. Thus, although people's perceptions of their abilities are not totally dissociated from their actual performance, they are only moderately predictive of such.

An investigation into the relationship between skill level and condition and its effect on improvement (as measured by the difference between pre and post test) was also performed. A tertiary split was done on the pre-test data to form 3 levels of skill. An Analysis of Variance (ANOVA) showed significant main effects of initial ability level $F$ (2, 162) = 5.54, $p < .05$ and mental practice condition, $F$ (2, 162) = 3.60, $p < .05$, but did not show a significant interaction between skill level and condition, $F$ (4, 162) = .623, $p >$ .05. However, the observed power for this interaction was only .20. Figure 2 shows the improvement (difference in mean radial error from pre-test to post-test) for the condition x skill level analysis. When post-test score was used as the dependent variable (to avoid the high variance associated with difference scores), a significant interaction was still not found, $F$ (2, 162) = 1.54, $p > .05$. The observed power for the interaction in this analysis was only .47.

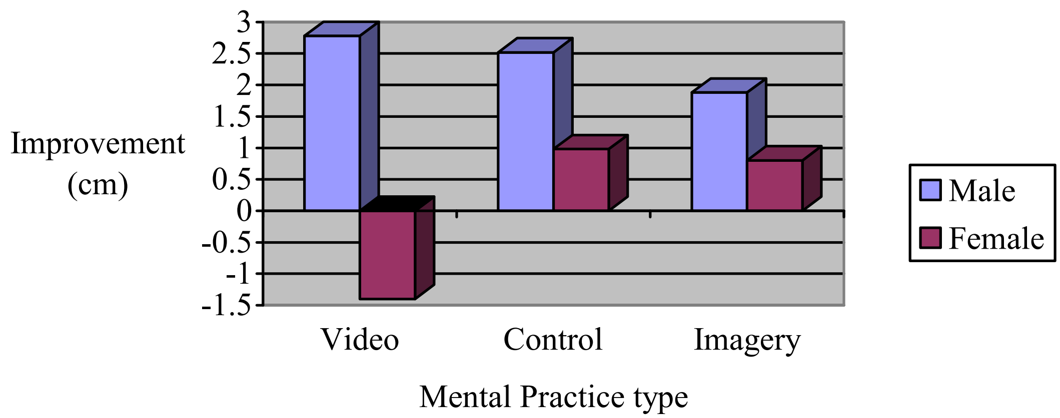
FIGURE 2



An additional supplemental analysis showed that men performed better (lower mean radial error) than women on the dart-throwing task during both the pre-test (*M* = 12.17, *SD* = 2.95 vs. *M* = 15.89, *SD* = 4.00, respectively), and the post-test (*M* = 10.80, *SD* = 2.40 vs. *M* = 15.48, *SD* = 4.72, respectively). A brief exploration into a possible Condition x Gender interaction effect (using pre-test score as a covariate) on post-test performance was also performed. Gender was not included in the primary analysis because of its negative effect on statistical power. When gender was included in the ANCOVA as a fixed independent variable, I found that a significant main effect of gender did exist $F$ (1, 164) = 11.85, $p < .05$ (consistent with the primary analysis). Males, on average, decreased their mean radial error from 12.17cm to 10.80cm while women only decreased their error from 15.89cm to 15.48cm. However, the results of this ANCOVA showed no significant main effect of condition, $F$ (2, 164) = .98, $p > .05$, and no significant interaction between gender and condition $F$ (1, 164) = 2.45, $p > .05$ (see figure 3). These results may be due to the lack of observed power (.22 and .49, respectively) that was anticipated prior to the initial analysis. This point of view is supported by the fact that the interaction was significant at the ά = .09 level.

FIGURE 3

Effect of Mental Practice Type and Gender on Improvement



# Discussion

The results of this study were generally consistent with my expectations. I hypothesized that those people who were in the video condition could possibly have a decrease in performance. This was due to the fact that watching the video would interfere with the normal mental warm-up techniques of highly skilled dart-throwers. I also believed that the instructional video would cause all participants to over-think what they were doing, causing them to perform poorly.

These predictions were based on the fact that participants only had 5 minutes to practice and thus were in a situation similar to someone with a performance preparation goal. If I were investigating the effects of these mental practice techniques under a skill learning/acquisition goal - that is, if participants had had considerably more time to practice, I would expect that the instructional video would actually be helpful to both novices and experts. Since the video would not be shown directly before task performance, I would not expect it to interfere with the normal mental warm-up of highly skilled participants. This would also likely lessen the decrement that is known to be associated with the over-thinking (McMaster, 1993). Additionally, if low-skilled people had time to incorporate the techniques from the video into their mental representation of the task (as would be the case if we were using procedures to achieve a learning goal), they would likely improve.

In addition to expecting that the video condition would lead to smaller gains in performance (if any) than other techniques, I also thought that the imagery condition might lead to improved performance, especially for highly skilled participants. According to the neuromuscular theory of mental practice, as a person participates in mental imagery, they activate the procedural memories (not necessarily explicit) for the stimuli and physiological responses associated with the activity they are imaging (Suinn, 1997). Since this imagery would likely facilitate mental warm-up, I thought it reasonable to expect that imagery might improve performance on the post-test in the present study. However, as mentioned earlier, the neuromuscular theory implies that a strong mental representation of the procedure is needed for any benefits to be experienced. I believe that I did not find improved performance for those in the imagery condition because novices, who did not have a strong mental representation of the proper techniques, constituted a large part of the sample. This is evidenced by the fact that the mean self-rating of dart-throwing ability within the sample was only 3.44 ($SD$ = 1.88) on a scale from 1 to 10 (with 1 being the worst dart-thrower in the world and 10 being the best dart-thrower in the world) and that participants, on average, were 15 cm from the bull's-eye on each throw.

I believe that this study is a good step toward a better understanding of the mechanisms behind the effects of mental practice. This study compared different mental practice techniques in singular form (not as part of a comprehensive program). It also looked at effectiveness in relation to only one goal (competition performance preparation), which is something that most prior research has not done (Rushall & Lippmann, 1998). Additionally, this study controlled for initial ability when comparing these techniques, something else that is not always done in mental practice research.

Although I believe that controlling for initial ability (using it as a covariate in an ANCOVA) was adequate in the present study, I think that in the future it may be a good idea to investigate how differentially skilled participants are affected by additional mental practice techniques. As mentioned throughout this paper, there is reason to believe that highly skilled participants' performance would be affected differently by different techniques. Further experimental investigation of those differences seems warranted.

Additionally, further investigation into the role that gender plays in mental practice mechanisms also seems to be warranted. The present data suggests that males and females may react differently to mental practice. Males, on average, decreased their mean radial significantly more than women do. Also, a marginally significant interaction indicated that women seemed to get worse in the instructional video condition, while men did not. Although I cannot speculate on the cause, this appears to indicate some unique influence of gender on the effectiveness of mental practice.

I also believe that it would be wise to look at the degree to which different types of mental practice work for different tasks. While dart-throwing seems to be a physical task that can be almost entirely planned out, other physical tasks require the participant to react to ever changing stimuli (e.g., hitting a baseball, trying to score a goal in soccer, etc.). It seems quite likely that mental practice that works for darts may not work for a sport that requires quick thinking and reaction. I think this emphasizes the need to examine specific mental practice types in specific contexts. And not only do we need to look at the effects for different physical tasks, we also ought to look at the effects of mental practice duration and proximity to performance on skill enhancement. Transfer of mental training skills from one sport to another can also be examined, along with the effects of feedback and relaxation in combination with traditional mental practice. In short, there are many directions in which research into mental practice can go in the future. The current study is one step on which to build future research.

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Appendices

## Appendix 1

*Mental Practice Instructions:*

Please take a seat and get relaxed. For the next 5 minutes I would like you to close your eyes and imagine yourself throwing darts at the dartboard. With each throw, I would like you to imagine the dart hitting directly in the center of the bull's-eye. Try and make the imaginary experience as real as possible. Try and feel the dart between your fingers, try and feel the muscles working in such a way that you make a perfect dart throw. See the dart leave your hand, travel through the air, and hit the center of the bull's-eye. Do you have any questions? (Answer any questions they may have.) OK, please begin; I will let you know when 5 minutes has elapsed.

*Control Condition Instructions:*

Please take a seat and get relaxed. For the next 5 minutes I would like you to read this article about darts. Take your time; you will have 5 minutes to read it. If you finish it, please start at the beginning and read it again. Do you have any questions? (Answer any questions they may have.) OK, please begin; I will let you know when 5 minutes has elapsed.

*Note: no participants finished reading the entire article

*Instructional Video Instructions:*

Please take a seat and get relaxed. For the next 5 minutes you will be watching a clip from an instructional dart-throwing video. I will stop the tape after 5 minutes. Do you have any questions? (Answer any questions they may have.) OK, let's begin (start the tape); I will let you know when 5 minutes has elapsed.

Appendix 2

*Description of instructional video*

The five-minute segment of the instructional video used in the current study featured world champion dart-thrower Paul Lim. During the segment, Mr. Lim physically demonstrated the proper technique for accurately throwing darts. At the same time, he also gave verbal instructions to the viewer aimed at clarifying what techniques should be used. He focused on describing the proper stance, grip, arm and shoulder position, and throwing motion.

Appendix 3

**The Development and Organization of the Sport of Darts**
**(from: http://yjkoh.freeservers.com/about.html 1/25/04)**

The sport of darts is unique in several ways: the equipment required to play is reasonably inexpensive, a relatively small amount of space is required to play, and special clothing is not required. Age, gender, size and physical strength/endurance have almost no effect on a player's ability to do well. These factors combine to make darts the appealing and popular game it is today.

The game of darts is hundreds of years old...rumor has it that the sport originally began as a contest between bored warriors during respites from battle. The soldiers hurled short throwing spears into the upturned ends of wine barrels. As their competition progressed, a more critically marked target became necessary, which led to the use of a slice of a tree as a target. The natural rings of the tree proved perfect for scoring purposes, as did the radial cracks which appeared as the wood dried out. The winter forced the sport indoors, and shorter darts and basic indoor rules were adopted. As the game caught on, even the nobility tried their hand: in 1530 Anne Boleyn gave Henry VIII a set of "dartes of Biscayan fashion, richly ornamented," and even our Pilgrim fathers are said to have played darts on the Mayflower (1620), using the butt of a wine cask as a "board".

The game retained its military affiliations through to the establishment of the British Empire, when soldiers' drinking clubs with their built-in dartboards stretched over the whole of the Empire. Locals in many countries adopted the sport, but the British players remained dominant until very recently.

The dart itself became more or less standardized as the practice of throwing "missiles" at targets became a general pastime -- the barrel was typically a piece of wood about 4 inches long with a metal point stuck in one end and feathers on the other. An American patented a folded-paper flight in 1898, and the all-metal barrel was patented by an Englishman in 1906. Also around this time, the numbering system on the dartboard was devised and gained acceptance.

The standardization of the throwing distance took place around the same time, although there is still more than one "standard" in use. It is said that the throwing distance was marked by placing three crates end to end from a brewery called Hockey & Sons (which supplied beer to the Southwest of England). The crates were three feet long, making the distance from the line to the board nine feet. The size of the Hockey & Sons crates was eventually reduced to two feet, and four crates lined up to mark the distance (eight feet). The 8-foot distance remained the standard for many years -- and still exists in some places.
The phrase "toeing the hockey" is said to have been brought about by the use of the Hockey & Sons crates, and the toe line is still called the "hockey", though it is more often spelled oche, and is pronounced without the "h".

**The Development of Organized Darts**

In 1908 a decision was made by the Magistrates in Leeds, England which effectively ensured the eventual popularity of darts as a sport. At that time, "games of chance" were illegal in public houses (pubs). A pub owner called "Foot" Anakin was accused of operating a game of chance and prosecuted for allowing darts at his establishment. Foot argued that darts was not a game of chance, and obtained permission for a board to be set up in the courtroom. It is said that Anakin threw three darts in the 20 and invited any magistrate to do the same. The challenge was accepted, however the court officials were unable to duplicate Foot's shot, thus proving darts was indeed a game of skill and not of chance; the case was dismissed. The years afterward saw the progression of the game in British public houses; by World War II the majority of pubs had dartboards, and teams and matches with other pubs were arranged on a regular basis.

The first major step towards making darts the international game it is today occurred when The News of the World, a British Sunday newspaper, instituted its championship in 1927. Originally confined to the London area, the event nevertheless drew large numbers of participants, and due to its success became a national competition after World War I. This event grew into one of the most prestigious and sought-after international titles in the sport, but was suspended in 1990. It returned in 1997, but is now restricted to players in the UK.

Major credit for promotion of the game goes to The News of the World and also to the National Darts Association of Great Britain (NDA), formed in 1954, for their contributions in creating both an international forum for the sport, and establishing basic acceptable rules of play.

The NDA drew together various county and London groupings, and began holding English national competitions in 1957. The British Darts Organisation (BDO) was formed in 1973 by Olly Croft, and coordinated the strengths of the various county associations and the development of various county championships, with the organization of international events following soon after. The BDO's primary focus at that time was acquiring sponsors and running special events for television. In 1978 the BDO organized the Embassy World Professional Championships -- one of the biggest events in darts.

In 1976 the BDO was a major force in setting up the World Darts Federation (WDF), which was formed by representatives from 15 countries to govern and promote the sport of darts on an international basis. Among the first decisions of the WDF were the recommendation of a standard throwing distance for all countries, and the inauguration of the World Cup, an international event held every two years since 1977 in which top players compete for their respective countries. Today the WDF is comprised of the national darts organizing body from each of 49 member countries, representing six continents. Other tournaments have been established (also on a bi-annual basis) to further promote the sport:

The Asia Cup, open to WDF member nations in Asia
The Europe Cup, open to European nations
The Pacific Cup, open to Pacific Rim nations (which includes the US)
The WDF maintains an individual ranking system for members based on participation in more than 30 regional, national, and world events staged by the organization itself and its member organizations.

The American Darts Organization was formed in 1976 under the guidance of Tom Fleetwood, and is the only governing body of darts in the United States recognized by the WDF (1977). The Organization was chartered with 30 local member clubs, representing approximately 7,500 players. Today, more than 300 associations, representing some 75,000 players in all 50 states, Guam and Puerto Rico, are affiliated with the ADO. The ADO is a "grassroots" organization, meaning that every player has the opportunity to compete to represent the US through the ADO Playoff Program. Local winners advance to the Regional level, and Regional winners advance to National competition. National winners comprise the ADO Pacific Cup, All-Star and World Masters teams. Almost 300 tournaments a year are sanctioned by the ADO. Players earn Championship Points by placing in singles events at these tournaments, and the ADO keeps a national ranking system based on these point totals, as well as naming a Men's and Ladies' National Champion at the end of each year.