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## **Abstract**

The present experiment investigated the influence of training in timing on the accuracy of performance in golf. During pre- and post-testing, forty-one participants hit golf balls with four different clubs in a golf course simulator. The dependent measure was the distance in feet the ball was from the pin. Between the pre- and post-test, participants in the experimental condition received 10 hours of training in timing using a metronome. The participants in the control condition read literature about how to improve their golf swing. The results indicated that the experimental participants significantly improved their accuracy relative to the control participants.

## **Introduction**

Cochran and Stobbs (1968) attempted to simplify the complexity of golf swing by postulating a double pendulum model. The model is a two lever system in which the levers rotate about a fixed pivot. The fixed point is between the golfer's shoulders. The one lever corresponds to the arms and shoulders and the other lever corresponds to the wrists. A fundamental assumption of this model is that in order for the levers to work effectively, it is essential that the levers be timed. Jagacinski, Greenberg, and Liao (1997) referred to timing as those forces that are applied to the golf club during the swing. We assumed that the proper timing of the levers in this complicated skill, particularly at the expert level (Ericsson, 1996; Ericsson & Lehmann, 1996) requires extensive and effortful practice before it becomes automatic.

Given the enormous importance that is attached to timing (as well as the components of timing, i.e., rhythm and tempo) by instructors (e.g., Leadbetter, 1990, 1993) and golfers (e.g., Nicklaus, 1974; Watson, 1998), it is surprising to find little empirical literature concerning the timing properties of the golf swing. The present experiment examined this aspect of the golf swing. In particular, we asked whether extensive training in timing would improve performance accuracy. We choose accuracy over distance as the major dependent measure because even though distance is an important determinant of performance (Cockron & Stobbs, 1968), greens in regulation (an index of accuracy) accounts for more of the variance in golf scores than any other single measure (Riccio, 1995). The design of our study was relatively simple. First, all participants were pre-tested using accuracy as the measure of golf performance. Second, the participants were then randomly assigned to the experimental or control conditions. The experimental group received about 10 hours of training on timing using a metronome whereas the control group read golf instruction literature. Third, after five weeks, both groups were post-tested using the same procedure and measure that was used in the pre-test measure. We hypothesized that training in timing would improve accuracy.

The more important consideration in the design of the study was the timing parameter. Unfortunately because there are no known empirical studies that experimentally test for the effects of timing on golf, and also little, if any, theoretical guidance, we had to set the timing parameter largely based on experience and intuition. We fixed the value at a relatively slow pace of 54 bpm for all of the motor tasks across all of the training sessions.

## **Method**

### Participants

Participants were recruited via advertisements that were posted in local golf retail shops, driving ranges, and pro shops of area country clubs. In order to qualify for participation individuals had to be 25 years of age or older and possess at least a basic skill level in golf. The first 50 individuals who met the above requirements were selected and randomly assigned to the two conditions with the restriction that each condition contained 25 participants. Of the 50 participants who started the study, nine failed to complete it. The sample of participants who completed the study consisted of 6 females and 35 males that ranged in age between 25 and 61 years ( $\underline{M} = 37$ ,  $\underline{SD} = 11.57$ ).

### Apparatus

Pre- and post- test accuracy was measured using a Full Swing golf Simulator<sup>tm</sup> (1995) located in an indoor 10' x 10' x 20' booth in a local retail golf shop. The indoor booth allowed for a controlled testing environment. The Full Swing golf simulator allows the golfer to execute a full swing and to hit a golf ball onto a screen which contains a picture of a golf hole including the tee box, fairway and green with a pin and flag. Based on a dual-tracking system those cycles in excess of 2 million infra-red beams per second, the simulator monitors ball flight within 1/10 of an inch.

An Interactive Metronome (1997) was used to train and analyze the golfer's ability to match a variety of movements to a steady beat. The Interactive Metronome includes a computer program (written in c++ for Windows 95/98) with peripherals, which include standard stereo headphones and a set of motion-sensing triggers. One trigger attaches to the participant's hand or foot via a Velcro<sup>TM</sup> strap. When the participant claps or pats a hand or steps with a foot, the attached trigger sends a signal to the program. A second trigger is contained in a floor pad on which the participant steps or taps. The computer program produces an auditory fixed reference beat that can be set at any number of beats per minute. Participants are required to complete various hand and foot exercises in synchrony with the beat. The objective on the part of the participant is to move her/his limb at the same time as that set on the metronome.

The program immediately analyzes the timing relationship between the participant's movements and the beat to the nearest millisecond. The beat resonates in both ears. The movements include variations of clapping both hands together, hitting the right or left hand on the side of the leg, tapping both toes or heels on the footpad, or tapping the right

or left toe or heel on the footpad. The program provides feedback to the participant by transposing the timing information into three distinctively different sounds that indicate an early movement (i.e., a movement that precedes the beat), a late movement (i.e., a movement that follows the beat) and a movement which matches the beat within + or - 15 msec. All of the experimental participants received their training in a room that contained five desktop computers arranged at the points of a pentagon.

### Procedure

Participants were randomly assigned to the two conditions prior to the pre-test. Each participant was scheduled for a one-hour appointment and instructed to bring his/her golf clubs. The pre-test consisted 15 shots each with the nine, seven, and five iron and the driver for a total of sixty shots. There was a 1-minute rest period between each set of 15 shots. Participants were instructed to aim for the pin and to proceed at their own pace. The experimenter recorded each score (i.e., the distance in feet from the pin). The post-test was the same as the pre-test and occurred for both groups after the experimental participants had received their training.

The participants in the experimental group ( $n = 20$ ) received ten hours of metronome training. The training sessions began the day after the completion of the pre-test. The 50 minute training sessions were scheduled for the next 5 weeks. All of the experimental participants were tested in the same room that contained the five computer stations. An experimenter was present for all sessions. The sensors were attached to the participant's hands or feet and the headphones were then placed on the head. The experimenter stressed the importance of using controlled, smooth (non-ballistic) motions in matching the movement to the beat of the metronome. Furthermore, it was emphasized to the participants that they should not aim, think about, adjust one motions or listen to the guidance sounds but rather that they focus their attention on the metronome only and that whenever they got off beat to just focus their attention back onto the beat.

The beat of the metronome was set at 54 bpm for all twelve sessions. The metronome training consisted of 10 hours of training (a total of 28025 beats) spread over the five-week period. The movements included hand clapping (with the other hand or the side of the leg), toe, and heel tapping. Some of the tasks required a combination of movements, for example, tapping the hand against the leg on one beat and tapping the toe opposite to leg on the next beat. All of the tasks were completed with the participant in a comfortable standing position. There were no exercises that paralleled the motions in the golf swing. By incorporating variability in the movements that were required, we thought it would be more likely to generalize or transfer to another motor activity (Schmidt, 1988), that is, participants would become more sensitive to the timing properties necessary to execute the golf swing

In order to determine whether timing performance improved over the 10 hours, experimental participants completed a 10 minute pre- (before training) and post-test (after training) on each of the movements that were used in the training sessions. Two dependent measures were recorded during the pre- and post-tests and the training

sessions: the number of milliseconds the participant deviated from on-target performance and the number of IARs (in-a-row) the participant completed for each task. F tests indicated that metronome training significantly reduced target deviation ( $M_{pre} = 68.74$  msec,  $M_{post} = 29.39$  msec) and significantly increased the number of IARs ( $M_{pre} = 1.97$  msec,  $M_{post} = 3.74$ )

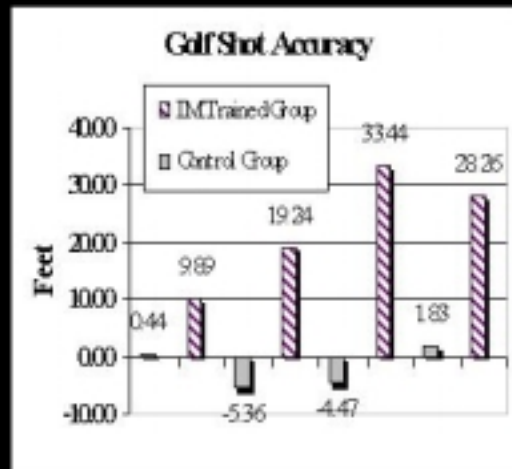
In contrast to the participants in the experimental group, the participants in the control group ( $n = 21$ ) received a letter indicating that the attached 12 pages of golf tips were to be read at least once a day before the post-test. The golf tips were taken from popular golf magazines and books. The control participants were not contacted again until they were scheduled for the post-test.

## Results

Accuracy was measured by the distance (in feet) between the pin and the ball's final resting place. The scores were averaged over 15 trials for each club for each participant. Table 1 displays the mean accuracy as a function of club, treatment group, and test (pre and post). A 2 (group: experimental and control)  $\times$  4 (club: nine iron, seven iron, five iron, and driver)  $\times$  2 (test: pre- and post-test) indicated that the main effect of club,  $F(3, 117) = 111.15$ ,  $MSE = 855.56$ ,  $p < .01$ , and the group  $\times$  test interaction effect,  $F(1, 117) = 4.88$ ,  $MSE = 855.56$ ,  $p < .05$ , were significant. The main effect of group,  $F(1, 39) = 3.10$ ,  $MSE = 17308.23$ , and test,  $F(1, 117) = 3.50$ ,  $MSE = 855.56$ , approached significance ( $p < .10$ ). Independent  $t$ -tests indicated that the treatment groups did not differ from each other on the pre-test,  $t(39) = 1.00$ . However, on the post-test, the experimental group was significantly more accurate than the control group,  $t(39) = 3.02$ . Furthermore, paired-sample  $t$ -tests indicated that there was a significant increase in accuracy between the pre- and post-test for the experimental group,  $t(19) = 2.90$  but not for the control group,  $t(20) < 1.00$ .

## Interactive Metronome® - Research

- Adults golfers with varying handicaps
- Overall average improvement 20%
- <15 handicap improved 35-40%
- Study published by International Golf Science Journal
- Benefits of IM training relate to all sports that require timing and precision performance



### Discussion

The results indicate that training in timing improves accuracy and that the improvement in accuracy was consistent across golf clubs. We think that the metronome training increased accuracy because the temporal properties of the golf swing were improved. The problem is that we did not take direct measures of these properties and therefore, we can only speculate about the nature of the changes that may have occurred. However, a survey completed by the experimental participants three weeks after the post-test indicated that of the 16 individuals who returned the survey, 69% reported that the timing of their golf swing had improved. An alternative explanation is that the improvement was simply an artifact of demand characteristics. Participants in the control group were not asked to come to the laboratory to engage in activities that could possibly improve their golf swing. It is, therefore, possible that the experimental group improved independent of the training. It is difficult to rule out this possibility without further investigations in which other groups would be tested using other motor exercises. It would also be useful to determine whether metronome training without any feedback would increase accuracy. In other words, does merely engaging in the exercise lead to the improvement or does it require that the timing become more precise. Although it is possible that these alternative explanations are correct, we are more inclined to believe that the improvement in accuracy had something to do with timing. It is a commonly reported experience that improvement in golf, as in any highly skilled behavior, requires extensive and effortful

practice with feedback (Ericsson, 1996). We therefore doubt that the transient nature of demand characteristics or training without feedback can account for our results.

In summary, the present experiment indicated that training in timing improved accuracy in golf. Future research will be necessary to order further delineate the phenomenon and to develop a theory that can explain how the property of timing influences this complex motor activity. However, it is important to note that this is the first experimental demonstration of the effectiveness of training in timing on a complex motor activity and that now there is evidence to indicate that using the metronome as a golf aid may improve one's performance in golf. We envision that the metronome could not only be used for overall training in timing but also to fine tune one's swing before and during competition. Finally, we agree with Cochran and Stobbs (1968) that the terminology and concepts describing the temporal properties of the golf swing are elusive even though there is nothing more obvious than the gracefulness of a well timed golf swing.

### **Authors Notes and Acknowledgments**

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This research was supported by Interactive Metronome® Orlando, FL. Interactive Metronome® is a registered trademark of Synaptec, LLC dba Interactive Metronome®, 500 Winderley Place, Suite 108, Maitland, FL 32751. United States Patent #5, 529, 498 & 5, 743,744. Web site: [interactivemetronome.com](http://interactivemetronome.com).

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