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Performance is not Related to Perception of Target Width in Fitts' Law

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Abstract

We report a new experiment in a series of studies in which research participants perform a Fitts' Law repetitive task, and then are required to judge the width of the target that was utilized. The first two experiments previously reported showed no relation between perception and performance. However in those two experiments subjects were never provided with feedback on their performance. In the current study, we provided participants with their performance score. Providing their performance score did not produce a relation between target width perception and performance. We posit that sports studies that have shown this relation are the results of intimate knowledge of what it means to perform well. Our inexperienced Fitts' Law participants lacked such an understanding.

1. Introduction

It is crystal clear that in order to control movement, information from the environment must be coordinated with information from the person to achieve the task at hand. In baseball (or cricket) the batter must move their bat in a fashion dictated by the ball flight. Skilled batters, of course, have good days playing the game and bad days. On their good days do batters "see" the ball as being larger?

Witt and Proffitt [1] showed that in American slow-pitch softball that batters who had a better batting average on a particular day judged the ball as being larger. This study provides support that perception is related to action.

In a follow-up study Witt et al. [2] demonstrated a similar relation between perception of the size of the cup in golf putting, and their overall level of performance on that day. Again, the inference is that perception and performance are intimately related.

Zelaznik, Witt and Forney [3] were interested in whether the effect observed in the sports domain was generalizable to motor performance in the laboratory. We chose to study Fitts's Law, in which a research participant attempts to repetitively move between two targets of width, W, without missing a target too often. Fitts [4] over 50 years ago described the relation between the movement time, T, movement distance, D, and target width, W, as

$$T = a + b \, \mathrm{Log}_2 (2D / W),$$

a and *b* are empirically determined constant. Fitts' Law is one of the most robust relations in all of motor performance and control.

Furthermore, Grosjean and colleagues [5] have shown that people understand Fitts' law perceptually. They can judge whether certain combinations of D, W and T are feasible or not. Thus, we decided to examine whether individual differences in Fitts' Law performance were correlated with judgments of target width.

In our previous study, participants performed eight versions of a repetitive Fitts' Law task. The target widths were either 1.0 or 0.5 cm. After each five trial set at each D-W combination, we presented on a sheet of standard paper, 11 targets ranging from -10% to +10% of the standard in 2% intervals. These targets were randomly organized on the sheet, and were randomly numbered from 1 to 11. Participants picked a number. We found that how well a participant performed in Fitts' Law was not significantly correlated with their judgment of target width.

In the previous study, participants made many judgments of target width (eight), and also did not know how well they performed relative to any performance standard. In the real-life sports research conducted by Witt and colleagues [1,2], participants clearly knew how well they performed. Thus, in the presently reported study, we reduced the number of Fitts' Law tasks to two, and provided the participant with an understandable performance score after they completed their two tasks.

Because we had data on over 80 subjects in previous Fitts' Law tasks, we computed the reciprocal of each subject's Fitts' Law slope, which Fitts [4] originally called the index of performance. We

computed the z distribution of these scores and then scaled these scores so that a score three z-scores above the mean was 150 and a score three z-scores below the mean was 50. A score of 100 was average. This scale was thus very much like an IQ score. We believed that research participants would "know" what that score meant to know how well they did relative to their peers.

2. Methods

2.1 Participants. Thirty six undergraduate students served as research participants, for credit in introductory psychology course at Purdue. Nineteen participants performed in the Ten% group and seventeen participants performed in the Twenty% group. Participants were provided with informed consent in accordance with the university IRB procedures, and their approval.

2.2 Tasks and Apparatus. There were two tasks. The Fitts' Law tasks required a subject to move between two targets, 1.0 cm wide as quickly as possible without missing more than 1/20 movements. There were two versions of the Fitts' task. These tasks were a 10 cm and a 20 cm distance. The second task required the subject to judge the width of the Fitts' Law target. For the Twenty% participants a sheet of 11 targets of widths .80, .84, .88, .92, .96, 1.00, 1.04, 1.08, 1.12, 1.16 and 1.20 cm were located on a piece of standard paper, in a random fashion, not in size order. The Ten% widths were .90, .92, .94, .96, .98, 1.00, 1.02, 1.04, 1.06, 1.08, and 1.10 cm. The targets also were randomly numbered. The task required the subject to pick the target that matched the target they previously used in the Fitts' Law tasks.

A 1 cm diameter hollowed hard rubber tube served as the Fitts' Law instrument. A Polhemus Liberty receiver (8 x 4 x 4 mm) was inserted within the tube. Adhesive tape was then wrapped around the tube and receiver. The bottom of the instrument was the receiver end.

2.3 Procedures. There were two kinds of tasks. The Fitts' Law task began by the participant holding the instrument with the index finger and thumb. The instrument was placed in the left-most target width. The experimenter determined that the participant was ready, and engaged the computer to produce a 500 ms 800 Hz beep, and the Liberty system began recording the location of the receiver at 240 Hz. The participant commenced to move from the left target to the right, back and forth repetitively for 22.5s. There was a 15-s rest between trials. Eight trials were performed at one distance before performing the second Fitts' Law task.

Immediately following completion of the eight trials, the experimenter covered the Fitts' law task sheet, the participant released the instrument and placed it away from view. The participant was then given their performance score, and reminded that 100 was average and 150 meant they were one of the best subjects ever tested, and a score of 50 meant they were one of the worst. Following presentation of their performance score the experimenter placed the perception target sheet in front of the participant. Within 15 seconds, the participant told the experimenter the target number that represented the target that they aimed at. Prior to leaving the laboratory the participant was told that their performance score was not a reliable and valid measure of their motor performance. That this score was just generated for this study.

The order for the two Fitts' conditions was counterbalanced. Obviously, the perception task had to be performed last. We did not perform the judgment task after each Fitts' task in order to not have the judgment task influence the subsequent Fitts' task.

3. Results

First, as expected there were no differences between the two percent width groups in terms of movement time. Second, the 20-cm movement distance had a greater movement time than the 10-cm distance. As we only have two data points to examine Fitts' Law, this exercise is not fruitful.

Regardless of the percent width group, there was no relation between the index of performance and the judgment of target size. The correlations between performance and judgment were not significant (values were less than .30). In other words, subjects who did well on the Fitts' task did not judge the target to be wider. This result occurred even though the participant was given their performance score.

4. Discussion

Our results replicate our previous two experiments and of course, do not show the performance judgment size effect observed by Witt [1,2]. There are several reasons why we did not find a relation between performance and perception. First, it is quite possible that our performance score just does not have the salience compared to baseball, or golf, and as such the performer does not have additional motivational and/or emotional energy. Second, both in baseball and in golf, the performer either moves around the target or the ball moves toward them. The performer might be learning the relation between their sensorimotor

experience and the external world [6]. This relation builds over developmental time. Our participants only were in the lab for 30 minutes. Third, our participants do not get feedback per attempt, as happens in baseball or golf, such that perception might not be apt to change.

Our future work will attempt to make feedback more salient, attempt-by-attempt to determine whether there is a true link between perception and action in performance.

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