A Fitts' Law experiment design

Lukas Lamm, David Lechler

1   Introduction

The goal of the experiment is to measure the amount of time a person needs for a Fitts' Law pointing task with a computer mouse in one dimension. Therefore the participants faced different combinations of target widths and target distances. Their task was to move the mouse cursor from a defined starting point to the target and click it.

2   Related Work

According to Gokturkey (2013) Fitts' Law is essentially an empirical model that explains the tradeoff characteristics between speed and accuracy of human muscle movement. Paul Fitts' "early experiments on pointing movements targeted tasks that might be related to the worker efficiency problem, such as production line and assembly tasks" (Gokturkey, 2013). Based on an early theorem, analogue to Shannon's channel capacity theorem, Fitts derived the succeeding equation, which is nowadays known as Fitts' Law:

$$MT = a + b * \log_2 * \left(\frac{2 * A}{W} \right)$$

Here **MT** stands for the required time to hit the target, **a** and **b** are empirically found constants, **A** is the distance of the center of the target from the starting point and **W** is the width of the target. Gokturkey states that in most cases the empirically determined constants **a** and **b** represent a constant time, like depressing a mouse button (Gokturkey, 2013).

In simpler words Fitt's Law states that there is a relationship between the duration of motion and the ratio of target distance over target size. (Goldberg, Faridani & Alterovitz, 2013)

Drewes (2013) found that there are at least two additional formulas for Fitts' Law. One which is known as the Welford formulation:

$$T = a + b * \log_2 \left(\frac{A}{W} + 0.5 \right)$$

The other is from MacKenzie who names it Shannon formulation:

$$T = a + b * \log_2 \left(\frac{A}{W} + 1 \right)$$

According to Drewes, MacKenzie criticizes Fitts' multiplication of the distance of the center of the target from the starting point with 2. MacKanzie argues that adding 1 instead of multiplying with 2 will guarantee positive values for Fitts' Index of Difficulty (ID). The ID is a "measure of the task difficulty" (Gokturkey, 2013) and is defined as follows:

$$ID = \log_2 \left(\frac{2 * A}{W} \right)$$

MacKenzie made up nine hypotheses and tested them in three different experiments. The hypotheses are about correlation and independence between the time to hit a target, the index of performance and the index of difficulty. He also tested influences of devices or tasks on the index of performance, the error rate and the movement time. In his first experiment MacKenzie tried to replicate Fitts' original experiment with a computer mouse, a tablet with a stylus and a trackball. The second experiment was designed to test different angles in hitting the target. The third experiment combined the two designs to show the ability to model consecutive tasks (MacKenzie, 1991).

3 Experimental Setup

3.1 Raised data

The experiment was designed to test Fitts' Law for a computer mouse as pointing device. Therefore the time needed to hit the targets for specific combinations of target widths and target distances has been logged. The raised dependent variable of needed time is influenced by two independent variables, the target width and the target distance.

To reduce noise in the results, some variables were fixed.

3.2 Test objects

The Fitts' Law experiment was conducted with four different target widths (35, 60, 100 and 170 pixels) and four different target distances (170, 300, 450 and 700 pixels). The variations between target size and distance results in 16 different combinations, where each combination was tested with four repetitions for each participant. All target objects were represented as circles.

3.3 Test setting

The experiments were conducted on a Dell XPS15 Notebook with a display size of 15.6 inches and a resolution of 1920 x 1080 pixels. The operating system was Xubuntu 14.04 in an Oracle VirtualBox setup. As pointing device a Logitech V550 Nano wireless mouse was used. Also the movement direction was set during all tests as left-to-right. The mouse speed was set to the same medium value with deactivated acceleration in each trial.

3.4 Test procedure

For each combination of width and distance the subjects had to start the time measuring with a click on a starting position. Then the target in form of a circle got displayed and the timer began. When the user successfully clicked the target, the time stopped and a row in the log file was created. To start the next combination the participant had to click in the starting position again. After 64 clicks (four repetitions of 16 combinations) the tool closed itself and the test was finished.

3.5 Participants

All participants were students of different departments at the University of Regensburg. The age varied between 23 and 26 years. The experiment was conducted with two female and two male participants, each right-handed. Two participants of the study had experience in the basic concepts of Fitts' Law.

References

Gokturkey, M. (2013). Fitts's Law. Retrieved 22 April 2014 from http://www.interaction-design.org/encyclopedia/fitts_law.html

Drewes, H. (2013). A Lecture on Fitts' Law. Retrieved 22 April 2014 from http://www.cip.ifi.lmu.de/~drewes/science/fitts/A%20Lecture%20on%20Fitts%20Law.pdf

Goldberg, K., Faridani, S. & Alterovitz, R. (2013). A New Derivation and Dataset for Fitts' Law of Human Motion. Retrieved 22 April 2014 from http://www.eecs.berkeley.edu/Pubs/TechRpts/2013/EECS-2013-171.pdf

MacKenzie, I. S. (1991). *Fitts' law as a performance model in human-computer interaction.* Doctoral dissertation. University of Toronto: Toronto, Ontario, Canada. Retrieved 26 April 2014 from http://www.yorku.ca/mack/phd.html