Evaluating the speed accuracy tradeoff

Science

Abstract

Fitt's Law is a predictive model of human movement that considers the relationship between amplitude, accuracy and movement time. The theory specifies that increases in the ratio of the distance between targets (amplitude) and target width will result in a longer movement time. The purpose of this analysis was to investigate the competing elements of accuracy and speed in human reaching.

To evaluate this theory, we conducted time trials over six different conditions, in which the participant was instructed to continuously tap between two identical targets, while the amplitude and the target width were altered. This allowed us to assess the effect of varying target widths and movement amplitudes on total movement time, which were then used to calculate the index of difficulty using the formula: log2(2A/W). We hypothesized that with an increase in the index of difficulty, the time required to complete the movement between targets would increase. Our results proved our hypothesis to be correct, demonstrating an increase in movement time with an increasing index of difficulty, as well as a positive correlation (r2= 0. 98) between the two variables. These results are important in the development graphical user interfaces to best match the human motor system.

Results

All data collected and subsequently used for analysis of movement time and index of difficulty. For each trial, the number of taps, as well as taps outside of the target (erroneous taps) were recorded. Movement amplitude (cm) and target width (cm) were measured using a ruler. The conditions were arranged in a progressive manner, with a decreasing index of difficulty. As the participant progressed through the conditions, a decrease in movement time was observed

Condition 6, with the smallest index of difficulty, corresponded with the shortest average movement time. The average movement time (MT) of each given condition. The y-value is the average of the three trials that the participant was required to complete. The data also demonstrated a positive correlation between the index of difficulty and the movement time. The correlation coefficient was calculated to be 0. 9805, further providing evidence of a strong positive correlation. Movement time plotted against the index of difficulty. Each dot represents the average movement time, over three completed trials of a given condition.

Discussion

The data provided from the experiment is in support of our hypothesis that an increase in the index of difficulty will lead to an increase in the required movement time. Movement time was evaluated using the formula: MT= 20/Number of Taps, and the index of difficulty was assessed using: ID= log2(2Amplitude/Width). Consistent with the theoretical understanding of movement time, we would expect to see an increase in movement time paired with an increasing index of difficulty (Tang, Shen, Sang, Song, & Goodale, 2017).

With the progressive decrease in amplitude in each condition, we witnessed a consequential decrease in movement time. Coinciding with this, the constantly changing target width allowed us to discern that a decrease in target width resulted in an increase in movement time. The condition that was designed with the smallest ratio of amplitude to target width, condition six, proved to elicit the shortest movement time. Our results are therefore consistent with the principle of Fitt's law, which states an increase in movement time is dependent upon a decrease in the index of difficulty (Tang et al., 2017). Our r2 value of 0. 98 further supports this claim, as it demonstrates the degree to which movement time is influenced by the index of difficulty. In addition to this, our results also support past projects in which movement time was demonstrated to decrease with a decreasing ratio of amplitude to target width (Cockburn & Firth, 2004; Grossman & Balakrishnan, 2005).

These results provide important guidance to software designers, that work towards develop software that optimizes the graphical user interface. Fitt's Law was designed as a model of how human motor system operates and can be valuable in teaching designers the innate goals of their consumers (Mackenzie, 1992). A significant source of error that may possibly have influenced our data collection, was the inability of our experimenter to determine which dots were inside of the target, and which ones should be labelled as erroneous. One suggestion in the direction of experimental design for future projects, is to use a computer program to simulate the experiment. This would allow for the proper allocation of erroneous strikes, providing virtually perfect calculations of error for a given trial.

References:

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