Displays and Controls: Hick's Law and Fitts' Law

ISYE 348 Fall 2024 Lab 6

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This lab assignment is due by 23:59 on 2024-10-22. If you have any questions or need clarification, please reach out to me via email or during office hours. The report will be graded on **20 points** based on the following criteria:

Criteria	Points
Introduction (your own words; 50-100 words)	1
Methods (your own words; 100-200 words)	1
Results	6
Discussion	6
Improvements	3
Conclusion	3

Submission: Please submit your report as a PDF file on Canvas. Make sure to include your name and your partner's name at the beginning of the report. Include any code, plots, or tables as needed to support your answers. Make sure to answer all questions thoroughly and provide detailed explanations where necessary. Cite any external sources used. Submit one single pdf file with all the answers.

Collaboration with your classmates is encouraged, and you will work in pairs for this lab to complete the report. Please list your partner's name at the beginning of the report. Only one submission per group is required. Must include data from both partners in the report.

Late submissions will be penalized by a 1 point deduction every hour past the deadline.

$$\text{score} = \max(20 - \text{hours\_late}, 0)$$

Please read the course policy on academic integrity and collaboration on the course syllabus. If you have any questions about what is permissible, please ask before submitting your work.

1. Introduction

This lab explores two fundamental principles in human-computer interaction and user interface design: Hick's Law and Fitts' Law. These laws help us understand how humans interact with displays and controls, providing insights into decision-making time and movement time when interacting with user interfaces.

1.1 Hick's Law

Hick's Law, also known as the Hick-Hyman Law, describes the time it takes for a person to make a decision as a function of the number of choices available. The law states that the decision time increases logarithmically as the number of choices increases.

Mathematically, Hick's Law is expressed as:

$$RT = a + b \log_2(n)$$

Where: - RT is the average reaction time - a and b are constants that can be determined empirically - n is the number of equally probable choices

The logarithm is base 2 because the decision-making process is often modeled as a series of binary choices.

1.2 Fitts' Law

Fitts' Law is a predictive model of human movement, particularly relevant in human-computer interaction and ergonomics. It predicts that the time required to rapidly move to a target area is a function of the ratio between the distance to the target and the width of the target.

The mathematical formulation of Fitts' Law is:

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

Where: - MT is the movement time - a and b are empirical constants - D is the distance from the starting point to the center of the target - W is the width of the target measured along the axis of motion

The term $\log_2 \left(\frac{2D}{W} \right)$ is called the Index of Difficulty (ID)

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

Fitts' Law can also be expressed in terms of the Index of Performance (IP), which is a measure of the information processing capacity of the human motor system:

$$IP = \frac{ID}{MT}$$

These mathematical formulations provide a quantitative basis for understanding and predicting human performance in user interface interactions. Throughout this lab, we will explore how these laws manifest in practical experiments and discuss their implications for interface design.

2. Objectives

By the end of this lab, students should be able to:

1. Understand the concepts of Hick's Law and Fitts' Law and their implications in user interface design.
2. Conduct controlled experiments to measure reaction times in decision-making tasks and movement times in target acquisition tasks.
3. Analyze the relationship between the number of choices and reaction time (Hick's Law).
4. Analyze how target size and distance affect movement time (Fitts' Law).
5. Evaluate whether the experimental results support both laws.
6. Discuss the practical applications of these laws in various fields, such as user experience (UX) design, human-computer interaction, and cognitive psychology.

3. Materials

- Computer with a web browser
- Hick's Law Experiment: https://nimrobotics.com/hicks/
- Fitts' Law Experiment: https://nimrobotics.com/fitts/
- Spreadsheet software (e.g., Microsoft Excel, Google Sheets) or any programming language of your choice for data analysis

4. Methods

4.1 Hick's Law Experiment

- Open the Hick's Law Experiment tool online to conduct the experiment.
- Familiarize yourself with the instructions provided on the screen.
- For each trial:
  - Click the red "Click" button at the top of the screen to start the trial.
  - Quickly find and click the button with the target number displayed on the screen.
- After completing all trials, the experiment will automatically end, and a CSV file with your results will be downloaded.
- Calculate the average reaction time for each number of choices across all participants.
- Create a scatter plot with the number of choices on the x-axis and the average reaction time on the y-axis.
- Fit a logarithmic trendline to the scatter plot and calculate the coefficient of determination (R^2).

4.2 Fitts' Law Experiment

- Open the Fitts' Law Experiment tool online to conduct the experiment.
- Familiarize yourself with the instructions provided on the screen.
- Each group member should complete 100 target acquisition trials (the trials will vary in target size and distance at random).
- The experiment will record the movement time for each trial and provide a CSV file experiment data at the end.
- Calculate the average movement time for each condition within your group.
- Calculate the Index of Difficulty (ID) for each trial using the formula:

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

- Create a scatter plot with ID on the x-axis and movement time on the y-axis.
- Calculate the Index of Performance (IP) using the formula: IP = ID / MT

5. Results

Include the following results in your report:

- For Hick's Law:
  - A scatter plot showing the relationship between the number of choices and average reaction time.
  - The logarithmic trendline fitted to the data points.
  - The coefficient of determination (R^2) for the trendline.
- For Fitts' Law:
  - A data table with the trial number, target size, distance, average movement time, Index of Difficulty, and Index of Performance.
  - A scatter plot showing the relationship between the Index of Difficulty and movement time.

Include plots for the class data and your individual data.

6. Discussion

1. How well do the experimental results support Hick's Law and Fitts' Law? Explain your reasoning based on the data analysis.
2. What factors might contribute to deviations from the expected relationships in both experiments?
3. How might individual differences (e.g., age, cognitive abilities) affect the results of these experiments?
4. Discuss potential applications of Hick's Law and Fitts' Law in fields such as user interface design, website navigation, or emergency response systems.
5. Compare and contrast Hick's Law and Fitts' Law. How do they complement each other in understanding human-computer interaction?

6. How do your individual results compare to the class results? Are there any notable differences or similarities? Report any observations or insights from this comparison.

7. Improvements

What are some limitations of these experiments, and how might you improve the experimental designs?

7. Conclusion

Summarize your findings and discuss whether they support or contradict Hick's Law and Fitts' Law. Reflect on the implications of these results for understanding human decision-making and movement processes, and their applications in various fields, particularly in the design of displays and controls.

References

1. Hick, W. E. (1952). On the rate of gain of information. Quarterly Journal of Experimental Psychology, 4(1), 11-26.
2. Hyman, R. (1953). Stimulus information as a determinant of reaction time. Journal of Experimental Psychology, 45(3), 188-196.
3. Seow, S. C. (2005). Information theoretic models of HCI: A comparison of the Hick-Hyman law and Fitts' law. Human-Computer Interaction, 20(3), 315-352.
4. Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology, 47(6), 381-391.