Analysis Report

"Empirical evaluation of Fitts's law - User pointing Experiment"

Implementation of pointing experiment proposed from the Ergonomics Web at Cornell University.

1. **General Terms:**
   - **A** - Amplitude of the movement
   - **W** - Width of the target
   - **ID** - Index of difficulty of the task
   - **MT** - Movement time

2. **Definitions:**

a) Fits Law:

- The law 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.
- Example: To reach a target we move the mouse cursor and click/select on it, Fitts' law describes how the distance between the start point and the target (A), and the size of the target (W) impacts on the index of difficulty of the task (ID).

b) Amplitude of the movement (A):

- The distance between the start point and the target.

c) Width of the target (W):

- The size of the target.

d) Index of difficulty (ID):

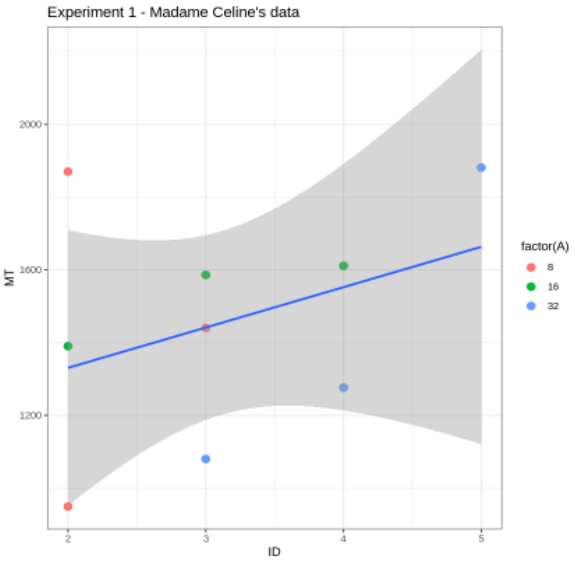
- The formulation of Fitts's index of difficulty (carries the unit "bits") is most used in the human–computer interaction and is called Shannon formulation.
- $ID = log2(A/W + 1)$

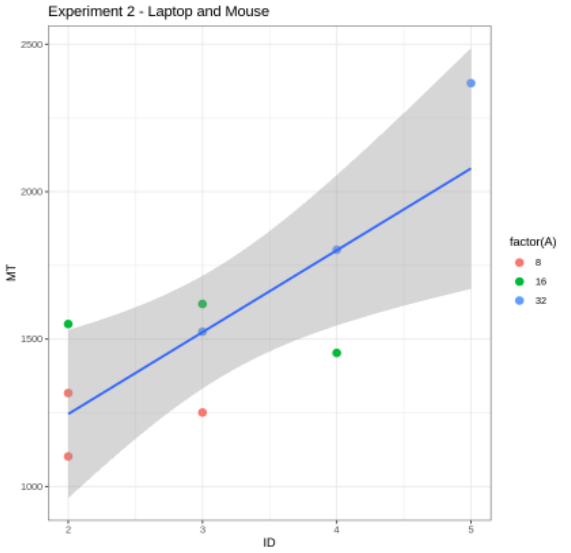
e) Movement Time (MT):

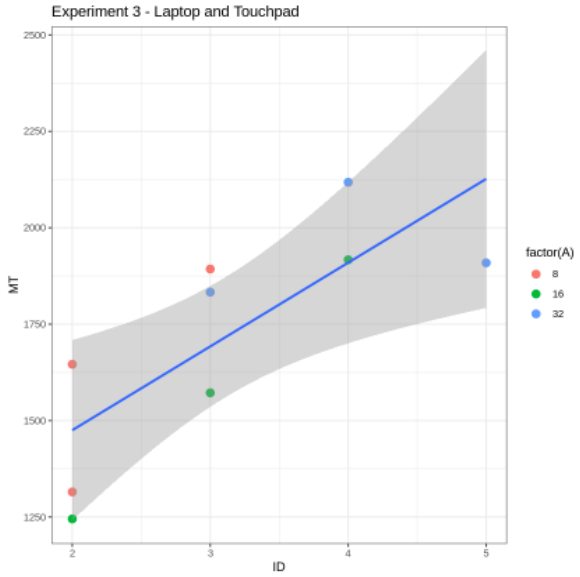
- The time MT needed for a user to reach a target is linearly correlated to the index of difficulty ID.
- $MT = a + b \times ID$

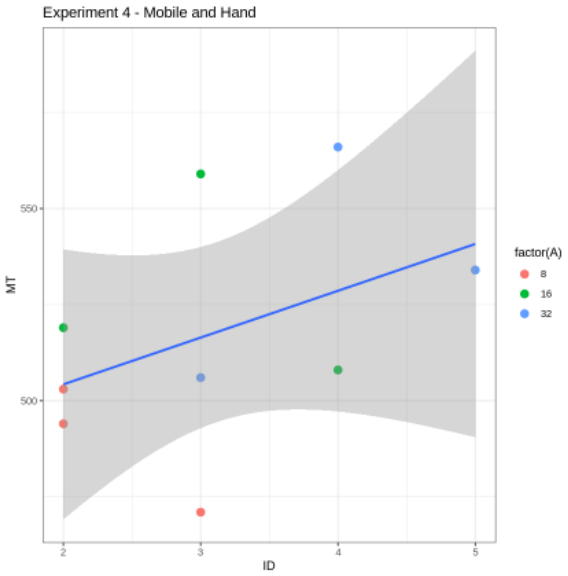
  where a and b are constants determined through linear regression.

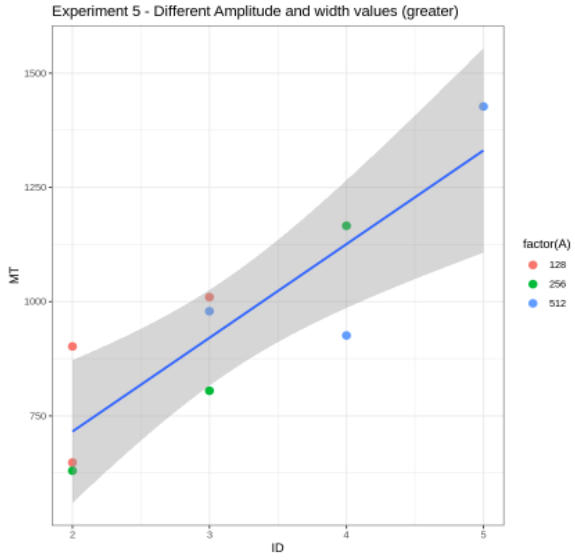
3. Plotting the data together with linear regression for mean MT data of different experiments:



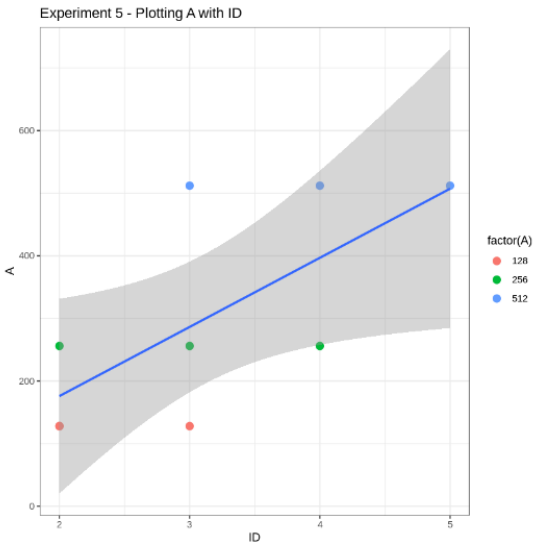


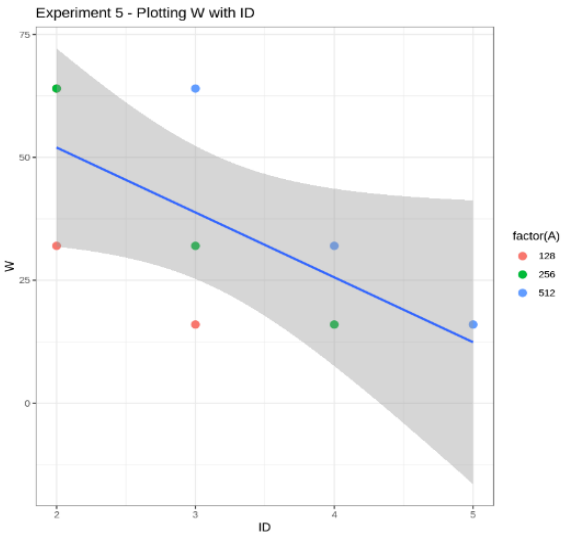


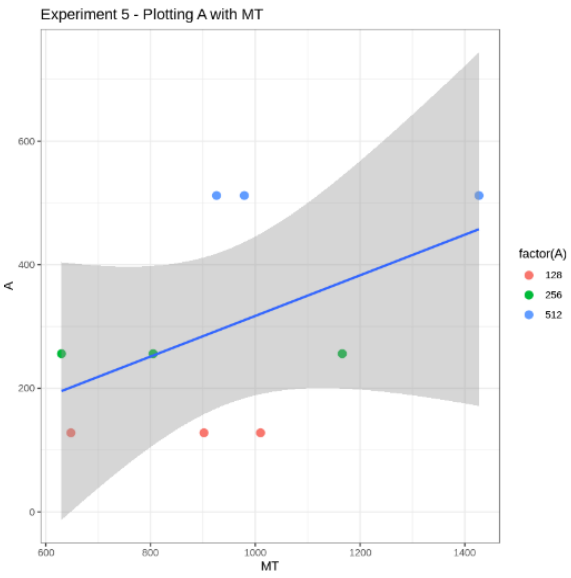


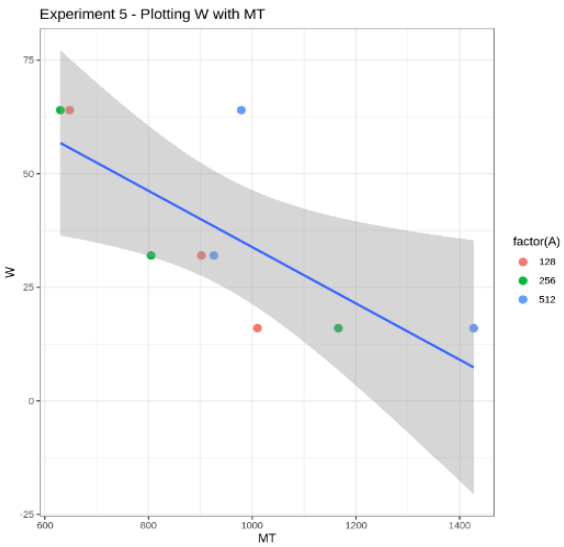


4. **Plotting the data with A and W against ID , A and W against MT to observe the correlation; if any (experiment 5 for testing):**









5. Analysis:

- Five distinct experiments were conducted in order to analyze Fitts' law's empirical evaluation utilizing the Implementation of Pointing Experiment, which was proposed by Cornell University's Ergonomics Web.
- The initial set of data used in the study belonged to Celine. Additionally, four tests were conducted, three of which used identical Celine data; the only differences were in the values of the constants 'a' and 'b'.
- The final experiment was conducted with amplitude and width values that were higher than those of the previous one.

The input and output values observed are tabulated below.

No.	Experiment	Amplitude A	Width W	Error	MT	R2 (from experiment software)	R2 (from linear model – R)
1	Celine's data	8,16,32	1,2,4	4	MT = 1001.293 + 140.589 log(A/W + 1)	0.218	0.008
2	Mouse Laptop	8,16,32	1,2,4	8	MT = 700.250 + 265.425 log(A/W + 1)	0.589	0.574
3	Touchpad Laptop	8,16,32	1,2,4	2	MT = 1007.858 + 220.150 log(A/W + 1)	0.639	0.549
4	Mobile Hand	8,16,32	1,2,4	0	MT = 479.654 + 11.869 log(A/W + 1)	0.172	0.058
5	Different A & W values	12,82,56,512	16,32,64	0	MT = 286.806 + 204.191 log(A/W + 1)	0.768	0.718

- Strangely, ID does not appear to have an effect on the MT movement time in experiment 1 (Celine's data) and experiment 4 (Mobile Hand), despite what Fitts' law states.
- Additionally, the R2 values I discovered here by linear modelling, which are **R2=0.008** in experiment 1 and **R2 = 0.058** in experiment 4, differ from the R2 values supplied by the experimental software, which are **R2=0.218** in experiment 1 and **R2 = 0.172** in experiment 4.
- Given that the R2 values are more than 0.5, Experiments 2 and 3 appear to have a marginally better ID effect on MT.
- The greatest value of R2, 0.768, is obtained in Experiment 5 with larger width and amplitude. This does not imply that it would occur on a regular basis.

- The R2 differs regardless of the error, there is no correlation between the error and the linear model of every experiment.
- Since different kinds of amplitude appear to be linear at each moment, there is no correlation with the amplitude factor. The same applies for the width factor too.
- The value of R2 found by R linear modelling and the value found by the experiment software appear to be quite close in this two experiments (2 & 3).
- Plotting the Amplitude and Width against ID and MT in my previous set of analyses revealed no linear relationship between them. Furthermore, the linearity of model is not more affected by the values of the constants a and b.
- Remodelling the datasets using the same formula from the experimental software led to the proposal of new ID and new MT. I noticed something intriguing, the R2 value was 1 across all of them with perfect linearity. However, this cannot be confirmed to be true as it needs more analysis and find the flaws, reassure principle formula, calculation methods (R programming) and results. (to be continued on trailing on this…)
- For the experimental software, the Fitts law principle cannot be satisfied by any particular collection of experiments because all trials yield ambiguous findings. Certain experiments exhibit some degree of linearity, whereas others do not.
- Overall, the analysis provides insight into the experimental model's lack of accuracy and signifies that conducting our own modelling could yield a more comprehensive knowledge of Fitts law linearity while adhering to the principle.

6. References:

a) Experiment from Ergonomics Web at Cornell University: https://ergo.human.cornell.edu/FittsLaw/FittsLaw.html
b) Fitts Law:
c) https://en.wikipedia.org/wiki/Fitts%27s_law
d) Journal of Experimental Psychology - Fitts 1954: http://www2.psychology.uiowa.edu/faculty/mordkoff/InfoProc/pdfs/Fitts%201954.pdf
e) Extending Fitts' Law to Two-Dimensional Tasks MacKenzie1 and William Buxton - 1992: http://www.billbuxton.com/fitts92.html
f) Celine Coutrix Report:
g) https://gricad-gitlab.univ-grenoble-alpes.fr/coutrixc/m2r_pointingxp/-/blob/main/journal.md?ref_type=heads