

# P15-Fitts' with a Twist: An Exploration of Scale Effects using a New Experimental Paradigm.

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Fitts' law is well known empirical regularity of human movements that predicts the movement time of a target pointing task from the task's geometrical features,  $D$  and  $W$ . We investigate the role of Scale in a Fitts' type pointing task, where a change in Scale may occur at the level of movement (Motor Scale), perception (Visual Scale) or both. For this experiment we utilize a new experimental paradigm, the Time/Error trade-off paradigm.

**Keywords:** Fitts' law, Scale, Time/Error trade-off paradigm.

## INTRODUCTION

Fitts' law is a classical theme of research within the fields of human movement science and human computer interaction (HCI). The law states that the time it takes a human to point at a target of width  $W$ , located at distance  $D$  is linearly related to the logarithm of their ratios, or more specifically the task's *Index of Difficulty* ( $ID = \log_2(2D/W)$ ). Operationally this means that for every level of  $ID$  in a given task there is a corresponding level of average movement time that is scale invariant. However, in his seminal 1954 paper, Fitts' himself asserted that this was only true "within a range". The limits of this range have though not received much attention in the Fitts' law literature.

The goal of our ongoing project is to investigate the effects of scale in a Fitts' type pointing task. We decided to decompose scale into visual and motor and vary one, both or neither of them in a series of four experiments. Alongside this work we have developed a new experimental paradigm for Fitts' law experimentation, the Time/Error trade-off paradigm (Guiard et al. in press). The paradigm, which originates from resource allocation theory, operates under the basic assumption of a min-min trade-off between average movement time ( $\mu_T$ ) and relative variable error ( $RVE = \sigma_A/\mu_A$ ). Rather than specifying target distance and tolerance  $W$  while asking participants to minimize movement time, we only specify  $D$  and manipulate the balance between time-minimizing effort and error-minimizing effort using a set of 5 instructions. We hypothesize that we will discover an optimal level of scale that may be different for the motor and visual components. Understanding how the principles of aimed pointing performance change alongside scale may, for example, be useful when designing interfaces of small devices such as mobile phones.

## METHODS

In all four experiments we use a Wacom Intuos3 digitizing tablet, connected to a PC. A stylus is used to interact with the tablet and instantaneous feedback of its position is displayed on a screen with a black crosshair cursor. The screen also shows the experimental tasks, with two red lines that indicate the start position and the target. The task is not shown on the tablet and participants are instructed to perform the task by looking at the screen, not the tablet.

For each experimental condition, participants perform either 2 (5 in exp.1) blocks of 15 discrete sliding movements on the tablet. The independent variables are Instruction and Scale. In all four experiments we use the same set of five instructions: 1) max speed, 2) speed emphasis, 3) speed/accuracy balance 4) accuracy emphasis and 5) max accuracy. The scale condition is different for all four experiments.

We split scale into motor (movement on tablet) and visual (movement on screen) and manipulate it by 1) changing the distance between the two targets (150 mm, 75 mm, 37.5 mm, 18.75 mm and 9.375 mm) and 2) by changing the control-display gain. CD gain describes how the amplitude of a movement performed on the tablet is mapped onto the screen ( $CD\ gain = \frac{Tablet}{Screen} = \frac{1}{1}$  when 1mm on tablet equals to 1 mm on screen).

In experiment 1, both motor and visual scales were held constant ( $CD = 1$ ) and so was the task, at 150 mm. In experiment 2, motor scale was held constant while visual scale changed. Thus, participants had every time to perform a 150 mm movement on the tablet, while the size of the task on the screen varied ( $CD \text{ gain} = 150/150, 150/75, 150/37.5, 150/18.75, 150/9.375$ ). In experiment 3, the roles will be reversed, that is, the task displayed on the screen is fixed at 150 mm while participants will have to perform varying sizes of movements to complete it ( $CD \text{ gain} = 150/150, 75/150, 37.5/150, 18.75/150, 9.375/150$ ). In experiment 4,  $CD$  gain will be constant but the size of the task will be varied. Now, we have completed experiments 1 and 2. Data from experiment 4 is being processed and experiment 3 is underway.

## RESULTS

In experiment 1, we saw that movement time increased almost linearly as the emphasis on accuracy increased while the decrease in relative variable error, RVE, was non-linear (far right symbols, Figure 1). We received close to identical results in the  $150/150$  scale condition of exp. 2 as exp. 1 and the same general order in all other scale conditions, indicating that participants were in all cases able to conform to the speed-accuracy instructions. Participants were in general faster in the smallest scale condition than in the larger but at the cost of a larger relative variable error.

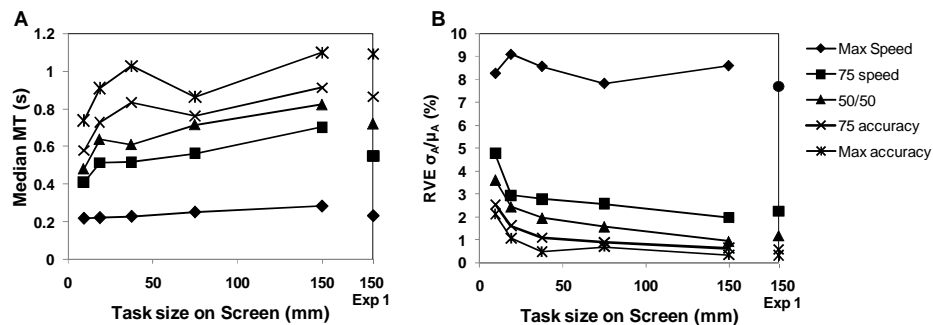


Figure 1: A. Median movement time and B. average relative variable error as a function of the size of the task on the screen for the five types of instructions in experiments 1 (far right symbols) and 2

Using the data of experiment 1 we calculated for each participant the *convex hull* (hypothetical optimal performance) of their minimization effort and discovered that while participants deployed different strategies of resource allocation, a coefficient indicating the size of their resource-pool remained constant. These results provide support to the resource-allocation approach to Fitts' law and the utility of the Time/Error trade-off paradigm.

## CONCLUSION

Currently we have concluded experiment 1 and 2. We are currently analyzing the data of experiment 4 while experiment 3 is pending. While results are rather incomplete at the moment we are certain that the data collected in all four experiments will yield us a complete picture of the effects of scale in Fitts' law research as well as serve as a test for the usability of the Time/Error trade-off paradigm.

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