Fitts Law 实验

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1. 通过anova分析A和W对于点击时间得影响是否在统计上显著 (analyze whether the impact of A and W on the click time is statiscally significant through anova)
2. 模拟Fitts Law,汇报你和得符合度（R^2值），比较两种device的a和b，尝试给予物理解释 (best fit fitts law, report the fit degree (R^2) , compare the a and b of the two devices, and try to give a physical explanation)
3. 鼠标、触摸板和手机三个平台，三选二，至少需要8个被试 (three platforms, mouse, touchpad, and mobile phone, choose 2 out of 3, at least 8 subjects)
4. 每种A和W上的数据点求平均后再拟合 (the data points on each A and W are averaged and then fitted)
5. 制作点击任务，不做拖拽任务 (do only click tasks, not drag tasks)

Fits Law

> A predictive model of human movement primarily used in human computer interaction and ergonomics. This scientific law predicts taht 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. Fitts law is used to model the actof pointing,either by phsycailly touching an object with a hand or finger, or virtually, by pointing to an object on a computer monitor using a pointing device.

There are many version's of the Fitt's Law, but the most commonly used equation to represent it is Sharon's Theorem, which is as follows:

$$T = B \log_2 (A/W + 1) + A$$

where the variables represent

A = intercept
B = slope
A = Amplitude
W = Width

Experimental Design

The goal of this experiment is to determine the residual values R^2 of the best fit line for Fitt's Law Test results among different devices.

The experimental settings and devices that are used are as follows:

Computer: Lenovo Thinkbook 14s

- Screen Diagonal: 14" -> 35.56 cm
- Screen Width: 12.21" -> 31.0134 cm
- Screen Height: 6.85" -> 17.399 cm

Mobile: IPhone 11 Pro

- Screen Diagonal 5.8" -> 14.732 cm
- Screen Height: 5.67" -> 14.4018 cm
- Screen Width 2.81" -> 7.1374 cm

Repitition: 19

Target Width: 0.25, 0.50, 0.75 cm

Target Distance: 2, 3, 4 cm

Participants

There will be 8 subjects

Participants	Gender	Age
周凯兴	男	21
刘志恒	男	20
李天勤	男	20
Kieren	男	21
周思祎	女	21
Adele	女	21
郑相姬	女	21
李蓉	女	21

Results

Mouse and Laptop

1、Error Rate:

There are a total of 19 repetitions * 3 (A values) * 3 (W values) * 8 (participants) = 1368 data points.

| Participants	Error Count
周凯兴	7/171
刘志恒	14/171
李天勤	6/171
Kieren	10/171
周思祎	2/171
Adele	8/171
郑相姬	40/171
李蓉	10/171

Of those data points, there is a total of 97 failed cases, thus, the error on the mouse test is 97/1368 or 7.0906%

2、Regression Analysis

Per Subject:.

| $log_2(A/W+1)$	李天勤	李志恒	周凯兴	郑相姬	周思祎	Adele	Kieren	李蓉
1.87444289	481.5789	477.5789	517.8947	568.474	585.8421	637.6842	556.2105	610.375
2.32192802	508.9474	628.4211	556.1843	600.5263	644.2532	672.263	530.1053	639.1579
2.66295742	566.8421	661.079	600.123	644.253	652.9474	696.9211	579.7895	657.6316
2.80735492	637.1053	706.4211	663.5789	700.4211	752.5789	736.8947	628.0526	693.4474
3.169925	697.6316	839.3422	738.5789	779.3948	855.7632	816.6842	657.8421	816.8158
3.70043972	771.3684	802.9474	762.2895	833.7895	965.3684	883.4747	819.1053	948.5789
4.08746284	813.9474	900.842	827	890.7895	1038.105	1001.789	845.1579	1028

Results Per Person, the Y axis representing the average time in ms, while the X axis represents the difficulty
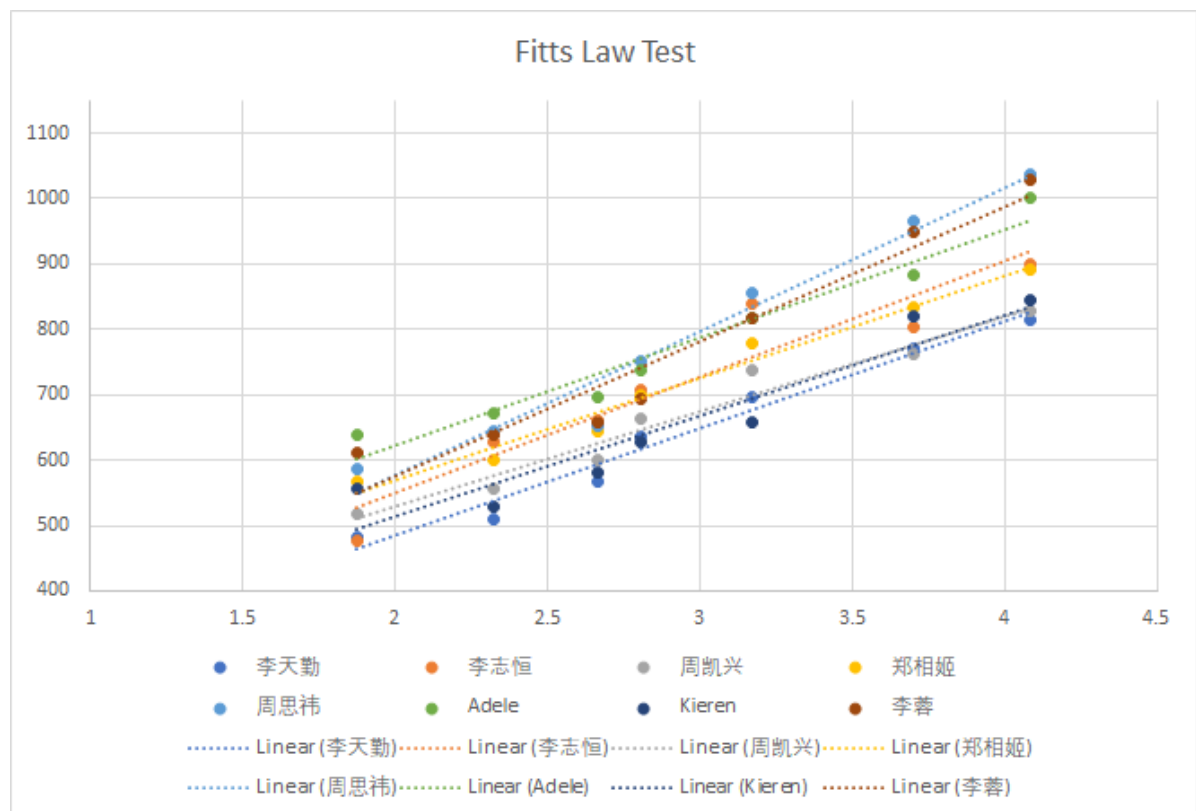
For each A/W values, calculate $log_2(A/W+1)$ and the average time it takes to hit the target.

A/W	$log_2(A/W+1)$	Time (ms）
2.666	1.87444289	554.4548
4	2.32192802	597.4823
5.3333	2.66295742	632.4483
6	2.80735492	689.8125
8	3.169925	775.2566
12	3.70043972	848.3653
16	4.08746284	918.2039

The scatter plot with the best fit line can be shown below:

Fitts Law Test for Mouse
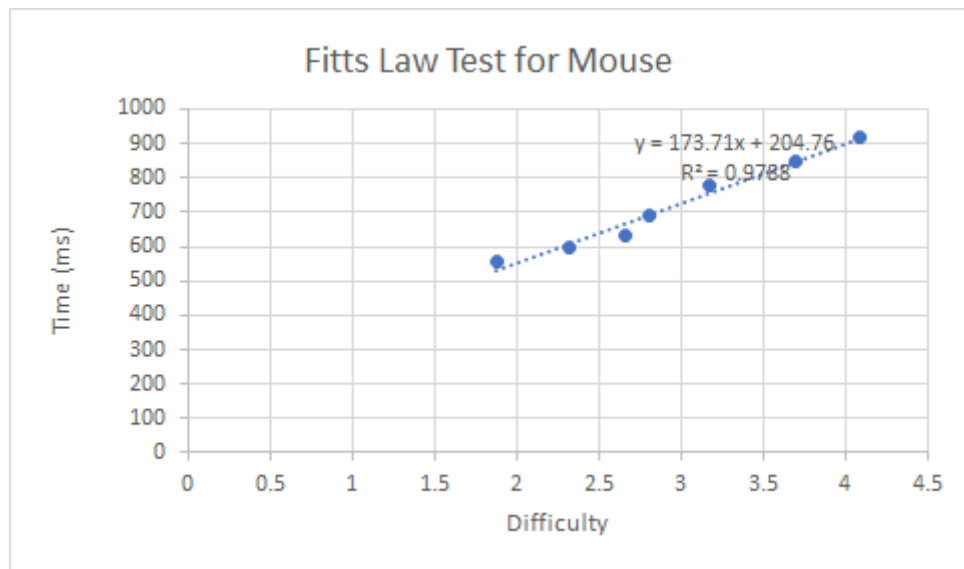
From the graph, we find that:

A = 204.76

B = 173.71

R^2 = 0.9785

The results from the linear regression show that the value of R^2 is around 93 percent. The points generally follow the Fitts Law equation but the only 2 are really touching/on the line. This result is generally bad for statisical test, but I will later explain possible errors for our data.

Mobile Touch

Since the process is the same as above, I will only show the important information

1、Error Rate:

Out of all the data points, 265 of those points were failed cases. Thus, the error rate on the mobile test is 19.37%。

2、Regression Analysis

For each A/W values, calculate $log_2(A/W + 1)$ and the average time it takes to hit the target.

A/W	$log_2(A/W + 1)$	Time (ms)
2.666	1.87444289	311.322
4	2.32192802	360.96
5.3333	2.66295742	376.986
6	2.80735492	408
8	3.169925	453.978
12	3.70043972	513.898
16	4.08746284	541.99

The data is shown below
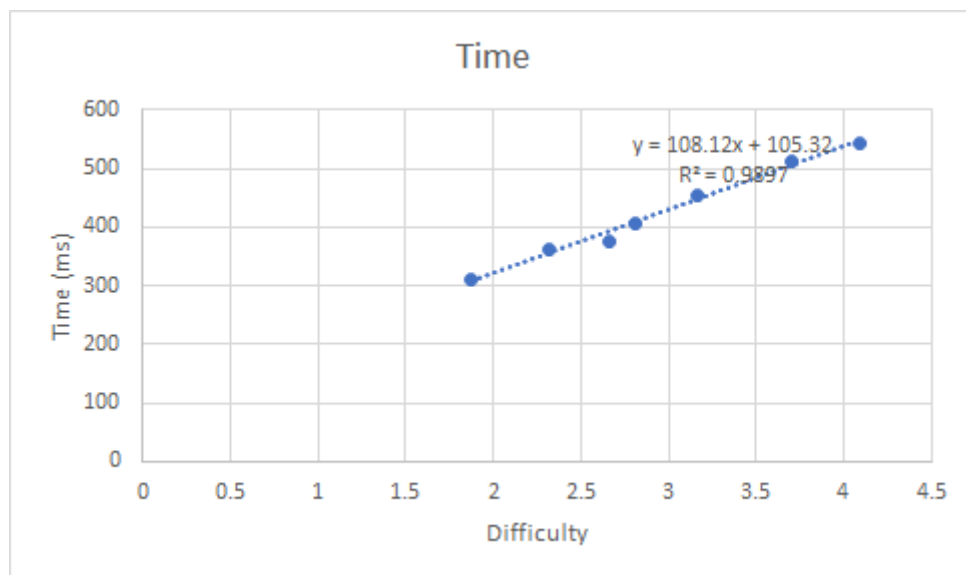
From the graph we get,

A = 105.32

B = 108.12

R^2 = 0.9897

The results from the linear regression treadline show that the Fitt's Law is relatively predictive when applied to mobile screens. This result is higher than the mouse and laptop test.

ANOVA Analysis

Analyze whether the impact of A and W on the click time is statiscally significant through ANOVA

The Effects of Distance (A) on target selection time

Summary

Groups	Average	Varience
A = 2	656.8082	59868.74
A = 3	725.863	56693.98
A = 4	758.4178	64073.27

ANOVA

Source of Varience	SS	df	MS	f	P-value	Fcrit
Between Groups	7861071.2	2	393053.6	6.527829	0.00161	3.016458
Within Groups	26192217	435	60211.99			
Total	26978325	437				

The Effects of Width (W) on target selection time

Summary

Groups	Average	Variance
W = .25	904.8923	93327.29
W = 0.5	759.938	68156.92
W = 0.75	702.4215	63885.09

ANOVA

Source of Varience	SS	df	MS	f	P-value	Fcrit
Between Groups	2982688	2	1491344	19.852	5.92E-09	3.017836
Within Groups	30650224	408	75123.1			
Total	33632912	410				

As seen from the above table, the p-value is $5.92 * 10^{-9}$, which is less than the significance threshold 0.05. This means that the target selection time is significantly affected by the size, or width W, of the target from the starting position to the target position. Also, we can can tell from the mean value that the target slection time is negatively correlated with W.

The Effect of Method (mouse or mobile) on target selection time

Summary

Groups	Average	Variance
mouse	762.85906	58964.23
mobile	450.328947	17436.5136

ANOVA

Source of Varience	SS	df	MS	f	P-value	Fcrit
Between Groups	7349319.01	1	7349319.01	193.443659	2.9511E-34	3.87274718
Within Groups	11359619.6	299	37992.0388			
Total	18708938.6	300				

As seen from the above table, the p-value is $2.9511 * 10^{-34}$, which is less than the significance threshold 0.05. Theis means that the target slection time is influenced by the target selection method. It takes more time to select targets on a computer by mouse than on a mobile phone through touchscreen.

总结

Comparing the R^2 regression of the two pointer types, mouse and computer versus mobile, the participants performed slightly better on the mobile test. This is probably because of familiarity, users were more comfortable using an iphone rather than the mouse I had supplied them to use (MX Master 3). A few of the participants normally did not use mouses and thus could wasn't always consistent, since it was also their first time performing the test. The mobile test was taking after the computer test, thus it was more familiar since they had better sense of what was happening. As the participants in the test did not take it in a controlled environment, there may be errors due to distractions such as noise.

We can also see the mobile test had significantly more errors than the mouse and laptop test. This is generally because of differing finger sizes. The lines on the mobile test were smaller than the width of the finger for all the participants, thus there would be more error even if the user pressed in the intended location. The tests were quicker because it is easier to move a finger than a mouse across a table.