Fitts' Law and Mobile Screen Device Size

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Literature Summary (Appendix A)

Ergonomics
Ergonomics refers to optimising product to design for human use. Characteristics such as height and body proportions are taken into consideration.

Correlations exist between users' hand size, the size of the input device they are using, and resultant perceived usability. It has been suggested that device size follows a `Goldilocks' phenomenon where it is possible for input size to be too small, too big, or just right based on user hand size \cite{Jain2012}. In addition to this, factors such as user dexterity can affect the overall input accuracy and user satisfaction that users have when using smartphones to input data \cite{ozkan2015effects}. It has also been noted that when accommodating for users with larger hands more sizeable buttons should be used\cite{Jain2012}. Based on this, it is important to consider overall input size as a factor when designing touch interfaces.

Along with hand size, there is also a connection between the posture of the user and perceived usability. Depending on the device and position that is being utilised performance may vary with every device having its own benefits and drawbacks\cite{Bachynskyi2015}. Surprisingly it has been observed that there are no noticeable differences in performance depending on if the user is standing or sitting whilst performing their task\cite{Berrigan2006}. Due to the differences in performance depending on the posture of a user when using a device is another very important factor to be regarded throughout the design.

Studies have also shown the effects of a user being hindered by carrying other items or are walking \cite{Ng}. It has been shown that being encumbered and walking can have a negative affect when using a mobile device with certain gestures being more strenuous to perform than others. Further research \cite{Crossan2008}has shown that there is added difficulty when a user is walking with a mobile device as opposed to standing or sitting still and that when a user is walking larger button sizes produce less errors \cite{Conradi2015} \cite{Kane2008}. As many mobile devices are used whilst the user is in motion, this is another element to be regarded throughout the study.

If the user has a preference for one handed utilisation of their device this can also have an impact on the usability of the device and its applications. Studies have shown that the target size has a direct impact on the effectiveness of one handed use against a two handed approach with larger targets proving to grant a greater success rate \cite{Park2010} \cite{Park2008}. Along with this, when only a thumb is used this can limit where on the screen can be touched. These areas are known as thumb zones and greatly constraint where the user can reach on their mobile device. It has been shown however that to allow for users to have full control of their device an optimal size should be found to allow for the user to have the most efficient performance \cite{Parhi2006}. Whether or not the user is utilising their dominant hand or not also affects the speed and accuracy\cite{Perry2008}. Based on many users preferring to use one hand on mobile devices these factors and their impact should be observed closely.

Additionally the orientation and posture of the users hands can also have an impact on performance with users who use their index fingers, as opposed to thumbs, have been shown to carry out tasks far more efficiently\cite{AHolzinger2003}. In addition to this it has been shown that, a vertical, two-handed grip also drastically improves the users performance in both terms of speed and efficiency \cite{Trudeau2016}. Due to the far reaching significance of how the user holds the device this is an area that will need to be examined closely.

Mobile Device and Target Size/Type

The size of the mobile device has a direct impact on the users performance. Experiments have shown that there is a link between the difficulty of a task and the size of the screen\cite{Gundelsweiler2007}. Further studies have

shown in addition to the size of the screen the information structure can also add to the perceived difficulty of tasks on touchscreen devices\cite{Chae2004}. As users will use varying sizes of mobile devices it is important to factor differences in performance based on what size of device they are using throughout the experiment.

Different types of mobile devices vary greatly in terms of what they are being used for. Smartphones and tablets have been shown to be used for different purposes with smartphones being used primarily for communication means and with tablets more for entertainment with the latter rarely leaving the house \cite{Muiller2015}. This is further emphasised with a decrease in accuracy when tablets are used when the user is mobile \cite{Hayes2014} \cite{Popova-Dlugosch2013}. Due to these findings it is important to consider the impact of whether the device in use is a smartphone or tablet and if the device in question is being used on the go.

Prior studies have shown that when using bendable mobile devices users reported that devices that were easiest to bend allowed for the most efficient for position control \cite{Burstyn2016}. However it was observed that devices which retain consistent level of bend will not affect user performance.

Variations on the device being used can also greatly impact the users performance. The wider the device in question gets the greater the level of difficulties that the user will experience. The error rate is also shown to increase if the bottom bezel is taken away [\cite{juanpablohourcadenatashabullockrest2018}]. An increase in smartphone width has also shown to cause users more discomfort when the phone is being grasped, especially on users with smaller hands[\cite{song2016}]. This is another factor that can significantly affect the experiment as the dimensions of each device can impact each users performance differently.

Target size is another important factor for consideration. When one-handed thumb input is used it has been shown that as the target size grows there is an increase in speed, however once the target expands to a certain size there will be no noticeable difference in error rates, thus indicating an optimal button size of 9.6mm for single tapping tasks[\cite{bederson2006}]. This is further supported with button sizes of 10mm producing the highest success rate in other one-handed thumb input tasks [\cite{emurian1995}]. Based on this research, it has been shown that the optimal button size when one-handed thumb input is being utilised will be have to be roughly 10mm and will need to be considered throughout the experiment.

In the original Fitts' Law task two long rectangles were parallel to one another with the participant expected to go back and forth between these two targets, research that has into target shapes has therefore been conducted and has found the impact the shape of a target can have on performance. It has been shown that targets that take the shape of a circle will perform take significantly longer than shapes such as a rectangle or a square[\cite{hoffmann2007}]. How the user decides to approach these shapes can also have an impact on performance as diagonal approaches will take longer than horizontal or vertical approaches[\cite{emurian1995}]. These qualities of the target shapes and interactions will need to be considered.

Many users will vary with how close they are to the screen, this distance can greatly impact how the users performance. Studies have shown that participants will have a preference for ease of use when they are closer and more so speed and accuracy will begin to decrease if they are too far away[\cite{bullockrest2012}].

User Satisfaction/ Performance

One of the main goals of this study is to help improve user satisfaction. There has been a lot of research into mobile devices and user satisfaction.

When Fitts' Law was first devised various physical pointing devices were used\cite{Fitts1954}. In more recent years however touchscreen devices have become more prominent. Large amounts of users have expressed that they find using touchscreens far more easier than using traditional pointing devices\cite{Holzinger2003}. However despite studies having shown that users in general found touchscreens easier it has been noted that when selecting smaller targets more conventional means such as cursors were preferred\cite{Sears1991}. As the devices that are utilised throughout this experiment will be exclusively touchscreen this impact on the users' preferences will be noted.

The delay when using a mobile device can have a large impact on the users performance. If the latency of a device is high enough this can cause for the performance of the user to decrease. Furthermore it has been shown that the size of targets can also have an impact on the users performance to a greater extent when combined with latency\cite{Jota2013}. Along with latency, jitter when using a device can also greatly impact the user performance by causing an increase in the amount of errors that occur \cite{Pavlovych2009}. To allow for the experiment to obtain the most accurate data possible it will need to run smoothly and avoid any of these noted issues that can have a large impact on the user performance.

Fitts' Law indicates there to be a certain speed-accuracy trade-off in pointing tasks. For a task to be performed with high accuracy it will typically take a much longer time than a task with low accuracy \cite{Zhai2004}. Studies have also shown that within Fitts' Law throughput is independent of the speed accuracy trade-off \cite{MacKenzie2008}.

The level of previous experience the user has with a device has been shown to be positively related to their performance when using technology, however older users have been shown to have a reduced performance when using technology\cite{Langdon2007}. In addition to this older users have been observed to take longer in a Fitts' Law type pointing tasks\cite{Murata2005} \cite{Findlater2013}. Further research into the sex of participants in studies has shown that females are faster than males in Fitts' Law type tasks \cite{Brogmus1991}. For the purposes of this experiment the level of prior experience, the user's age and sex will all have to be considered.

The orientation of the mobile device, vertical or horizontal, has been shown to have a direct impact on the users performance. Different gestures have been shown to be performed differently depending on the devices positioning\cite{Pedersen2012}. Vertical surfaces have been shown to be physically challenging than horizontal having an impact on the users performance. Further looking into orientation it has been shown that users perform much greater when movement is orientated from right to left\cite{Nguyen2014}. The users' preference to the device orientation will need to be considered based off this information.

When the amount of space available on a mobile device has been restrained users have reported being more satisfied with their experience and have also been shown to perform better when they are not overloaded with information\cite{joannamcgrenere2008}. Further research into spacing between targets has shown that buttons with zero spacing between will have higher accuracy, but however there will be a noticeable decrease in speed as the user will spend considerable more time searching for information if the spacing is too large \cite{kiff2007}. In order for participants to get to perform under ideal conditions for this experiment optimal spacing between targets will need to be considered.

The satisfaction the size of a mobile device has on its users can be further analysed by perceived adoption rates. The larger the device that was used, the higher the the user will smartphone adoption rate shall be \cite{shyamsundar2014}. This can be attributed to large screens allowing users to feel more in control of the device at hand whilst also creating a greater sense of control.

Research Questions

- How does Fitts' Law change when mobile device size is taken into consideration?
- How does the task load of carrying out a Fitts' law task alter dependant on mobile device size?

Tasks that are planned for the upcoming months

Task	Level of unknowns	Time (1 - 5)	Justification
Set up an SQL database and Zeno webspace	Low	1	Will only require asking for permission
Get devices for experiment	Low	1	This will only require seeing what devices are available in the QMB
Create database model	Low	2	Will require me to take time to think about the project as a whole and the database structure
Create study method design	Low	1	Will require me to take time to think about the project as a whole and how I want to conduct the study
Create requirements spec	Low	2	I will need to think about the various different requirements needed throughout the study
Create a functional website	Medium	3	I am very familiar with creating websites, however it might still be somewhat lengthy process
Create a user friendly UI for the website	Low	2	I am familiar with both CSS and bootstrap and I am therefore confident that this task will not take a long time
Ensure that the content on the website is functional	Low	3	It is important the Fitts' Law task is incorporated seamlessly into the website
Create a Fitts' Law type task	High	5	There are a lot of factors to be considered when creating this program and the potential for the most amount of learning curves at this stage
Have task measure user accuracy	High	5	I am unsure of how I will carry this task out, therefore making it difficult to estimate
Have task measure the time user takes selecting targets	Medium	3	I feel somewhat confident in carrying out this task, however incorporating this into the other tasks on this list may make it more difficult
Have task get x, y coordinates of targets	Medium	3	Whilst I am currently unsure of how exactly I will do this task, I imagine that if I struggle there will be online resources to help me
Ensure the data from the tasks is sent to the database	Medium	3	It is important that this data is sent to the database so it can be accessed and analysed in the future, ensuring that this happens has a lot of factors that could affect it however
Create tasks to complete	Medium	3	Once the program is completed it will be easier to know what tasks the participants will need to do, however at this stage I am uncertain
Recruit users for study	Low	1	This will only require me to send emails to my coursemates
Have participants complete given tasks	Medium	3	As these tasks are are currently undecided the complexity and time needed for them is difficult to estimate
Analyse Data	High	5	This requires me to find to look at all the data that has been gathered throughout the experiment and could take time to find any correlations within this data
Get conclusions from data	High	3	This requires correlations that have been discovered to be explained and explain how this can be used for future research

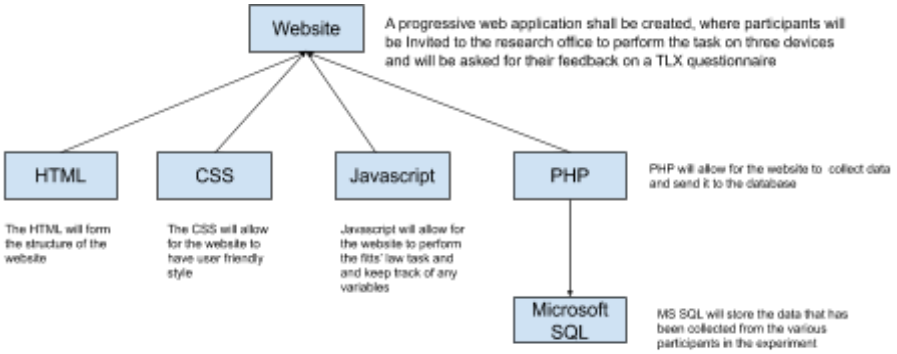
Complete final report	High	7	The report will require all of the above and will most likely be a very lengthy task

Possible challenges that may be faced

- Recording the distance between two points on the screen - This may be a challenge due to the varying sizes of each different device
- Recording the point where the user hit - ensuring that if a location is a hit or miss needs to be accurate and will also need to be recorded
- Determining what device the was used - If the data in the database does not have a corresponding device this could mean that any data collected becomes irrelevant
- Analysing the data that has been recorded and finding any connections and what these connections will mean - This has the potential to be a challenge as it will require for me to find links within the data gathered, work out how these links relate to the study and how they can be used in future research
- Ensuring that the data gathered is accurate - The time stamps used and the accuracy that is measured will need to be precise
- Gathering conclusions from the data - Finding out what the links in the data mean and how they can be used in future research could be challenging
- Measuring the accuracy - I will need to decide how I want to measure the accuracy, if it will either be a hit or a miss or if there will be different levels of accuracy.

Methodology

The project will take a agile-waterfall hybrid approach where I shall meet with my advisor, Michael Crabb every two weeks to update on the progress on the project.

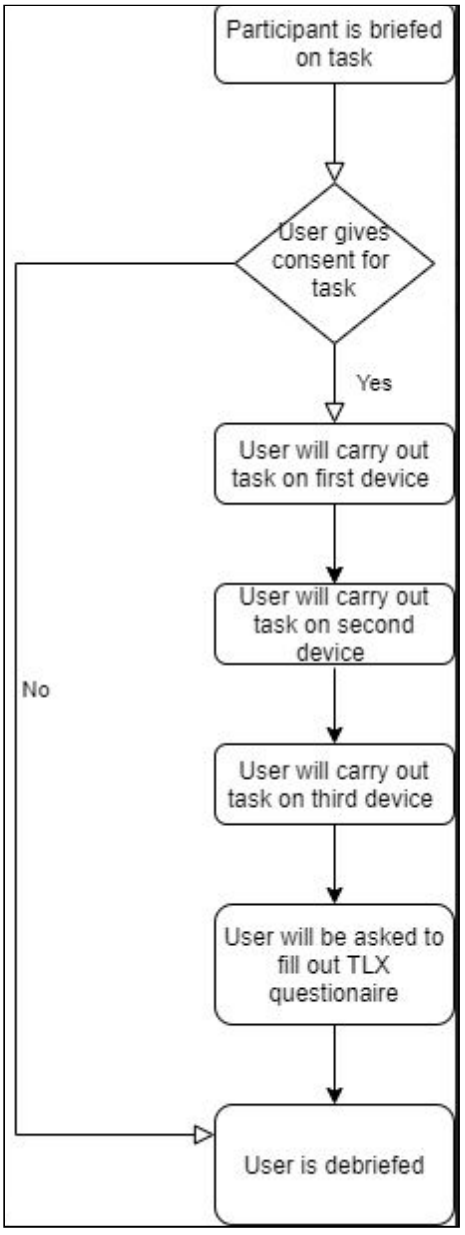


Intended Users

The users will be course mates who are under the age of 30 as previous studies have found the correlations of Fitts' Law type tasks and older users, however the likely increased level of skill these users have will need to be considered throughout the experiment

Predicted Grade

I feel confident in implementing the majority of this project, however there are some areas within the Database and effectively analysing the data given that may cause some issues. For these reasons I feel that I am comfortable in achieving a B grade.



Appendix

A - Literature Review

B - Gantt Chart

Gantt Chart (Appendix B)

	Sprint 1(w/c 3/2)	Sprint 2(w/c 17/2)	Sprint 3(w/c 2/3)	Sprint 4(w/c 16/3)	Sprint 5(w/c 30/3)	Sprint 6(w/c 13/4)	Sprint 7(w/c 27/4)
Set up an SQL database and Zeno webspace							
Get devices for experiment							
Create database model							
Create study design method							
Create requirement spec							
Create a functional website							
Create a user friendly UI for the website							
Ensure that the content on the website is functional							
Create a Fitts' Law type task							
Have task measure user accuracy							
Have task measure the time user takes selecting targets							
Have task get x, y coordinates of targets							
Ensure the data from the tasks is sent to the database							
Create tasks to complete							
Recruit users for study							
Have participants complete given tasks							
Analyse Data							
Get conclusions from data							
Complete final report							