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Investigating the Human Factors of Targeting

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Introduction

Targeting and selection of entities on a screen is the most fundamental task for users to complete on modern computers. Where with the use of a mouse as a common device to allow for the user to have two degrees of freedom to select a target on a screen. This investigation set out to understand the human factors of targeting (selecting) a 1D target with an everyday mouse.

The significance of this study is that it will allow designers to gain an understanding of what influences users selections of targets. By means of understanding exactly how the variation of target sizes and target distance from the initial mouse position may affect the targeting accuracy of the user. With this knowledge, a designer can influence their plans in order to make interfaces easier to use, or conversely, make targets much harder to select if desired. This is beneficial in order to create designs for user interfaces which are both easy to use (low level of errors) and have the usage as desired by the designers.

Method

The system created forms an experiment environment that a user interacts with in order to gather data about a user's targeting performance. This is done by presenting to the user a window where they are presented with a single vertical bar to select by simply clicking the white target against the grey background. A number of cues are implemented to help with the selection of the target. As when the bar is hovered over, the user is given a visual cue by means of the bar changing colour to orange. When the bar is not hovered over the target returns to white. Additionally, three distinct audio cues have been implemented to provide feedback to the user. A soft click like noise is played each time the mouse enters the target, in addition to the visual colour cue. A louder click-like noise is played when the user has successfully selected the target. Finally, a soft beep noise is played when a misclick of the target occurs.

During the experiment, users are presented with vertical bars where the aim is to select the bar present as accurately and quickly as possible. Once successfully selected a new bar is presented in a random position in alternating directions from the previous mouse position. This single task forms one trial and a block of trials consists of ten trials. With each block the user is offered a break for however long they deem necessary. They can then continue and the experiment is complete for one user once ten blocks are completed, forming a total of 100 trials.

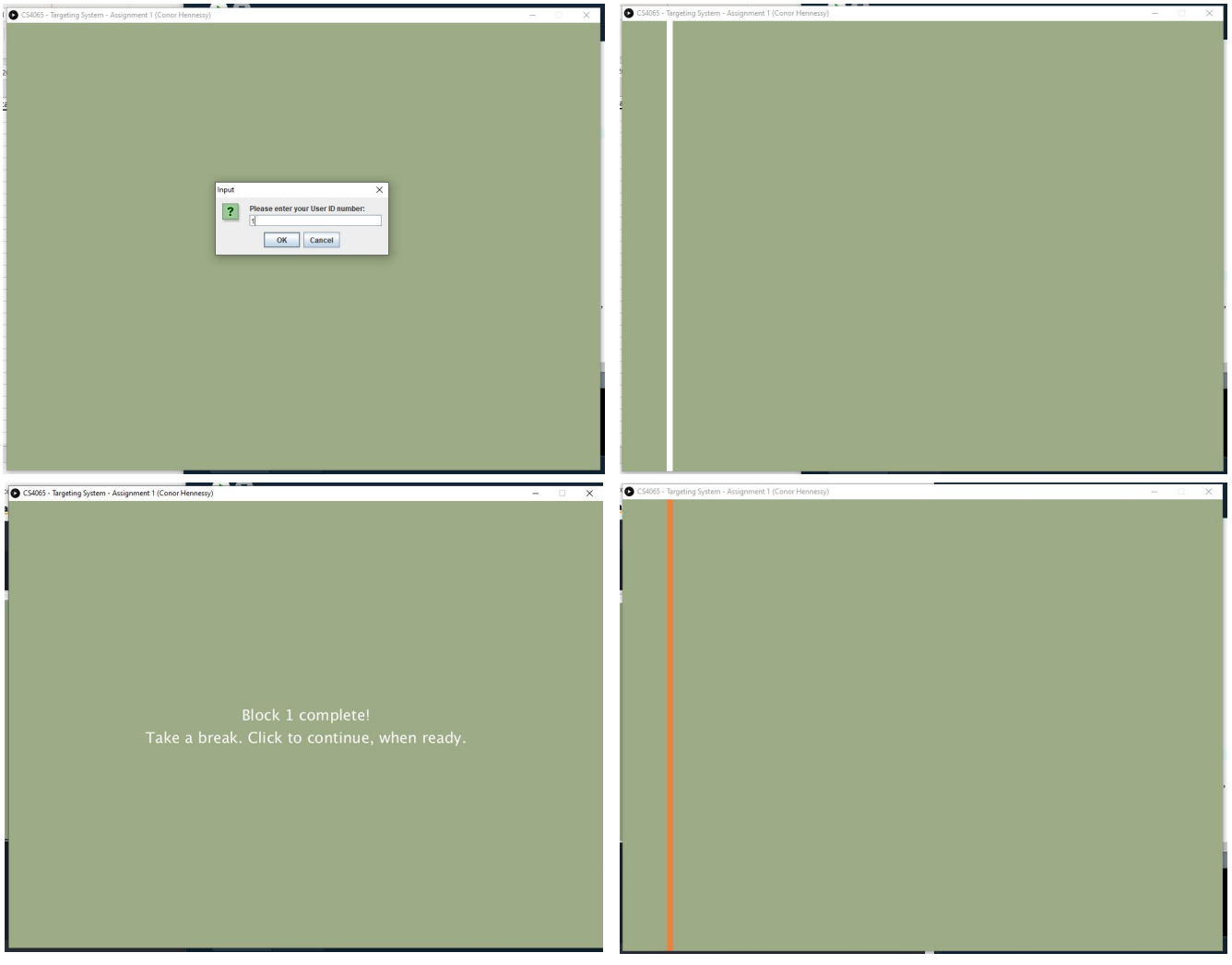
With each successful trail (selection of one bar) the system records a number of attributes. This includes the width (in pixels) of the presented bar target; the distance

(in pixels) between the cursor and the centre of the target; the time from the appearance of the bar to successful selection; the number of erroneous clicks before the successful selection. This is all recorded for each individual trial separately and is recorded against their anonymous user ID, the current trial number and block completed.

In order to gather the data for this experiment, I recruited six willing volunteers to complete the required 100 trials and recorded the given experiment results in a table. In order to gain interest and get people to complete the experiment, I offered chocolate for the completion of the experiment. No other incentives or bribes influenced the performance of the users.

With the collected data I was able to collate each user's data into a single table, as presented in figure one of the appendix of this report. With this I was able to form graphs and able to interpolate the trends with each attribute comparison. This allowed me to complete further analysis to understand what exactly makes targeting more or less difficult.

Figures 1 - 4 (From top left, Clockwise): 1; Screenshot of the initial launch, requesting the user to enter their ID. 2; Screenshot of a single trial, as a target appears with a random width & location. Appearing in an alternating direction from the mouse position. 3; Demonstrates the change in colour as the user hovers over the target. When the mouse enters this bar sound is played too 4; Demonstrates the break given between blocks. Where the user clicks to resume



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Results

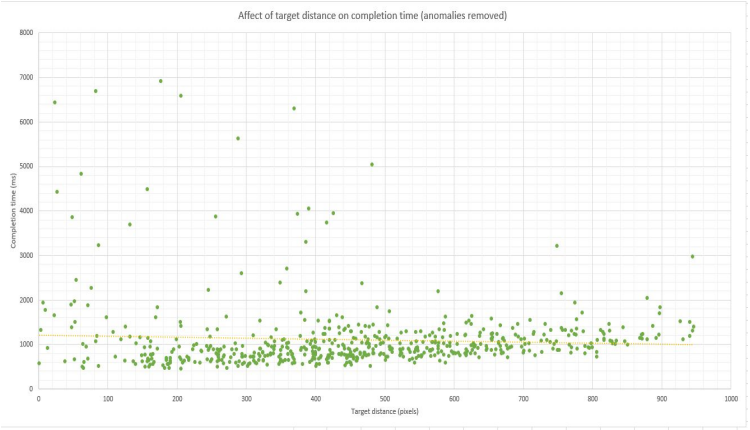
With the compiled results I have discovered a number of findings on the factors which affect targeting. It is important to state that these factors have varying magnitudes of effect on the human factors of targeting. The factors which were changed in order to understand their effects were the size of the target and the distance of the target from the users, both of which were entirely randomised. The results detail these random values and the corresponding completion time and error count for each trail. With this date, I have been able to understand the factors which affect targeting speed and accuracy.

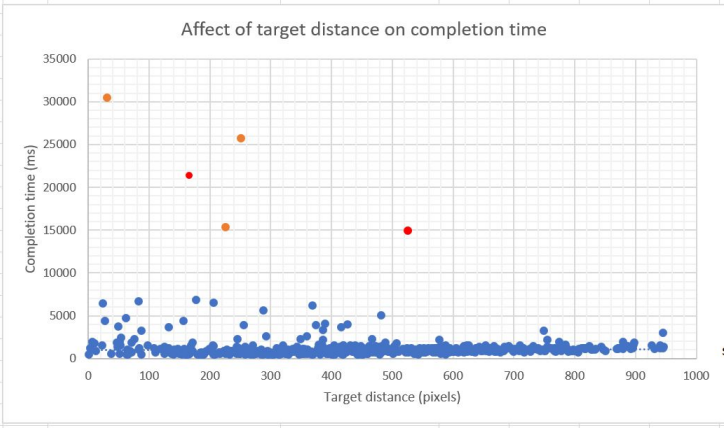
With this experiment there are some anomalous results for the elapsed time results, it is important to discuss this here rather than in the reflection as it has an impact on the evaluation of the results. I have deemed it necessary to remove these results from the evaluation and charts which include the elapsed time values. The results I have deemed anomalous all have a time recorded greater than or equal to 14500ms. All these values lie far out of the general range of recorded time which are all less than or equal to 7000ms. It is important to note that the 5 anomalous results recorded were the first trials of different blocks. Where two of the five anomalous times recorded were two independent user's first trial in their first block and the remaining three anomalies recorded were first trials in a block other than the first-ever block. One of these three anomalies were by a user who's the first-ever trial which was also anomalous. The remaining two of these 3 anomalies were by a user who did not have an anomalous first trial.
These anomalous values all occurred at the start of a block, where the participants either required clarification on what to do on their first-ever trial or were distracted on their first trial of a block - by means of asking myself a question, moving the mousepad or similar.
For the charts below the series of results are all shown in blue on the various charts. However, the anomalies are shown in a different colour for clarification. Where the red values are anomalies recorded on a participant first-ever trial (first trial, first block). Then the orange values are anonymously recorded on the first trial of a block which is not their first-ever trial (first trial, non-first block). I will present both the graphs with and without the anomalies for comparison. However, I have only drawn conclusions from the graphs with the anomalies omitted.

I found that the distance of how far away the target is from the user's mouse at appearance is a factor which has a minor positive relationship to the time to select the target. This was as expected result as you would expect that the further a target is from the user's current position, the longer it would take to select it. However, the relationship is very minor as shown by the trend line in figure 5 below. Figure 6 shows the same relationship with anomalies present.

Additionally, the factor of how far the target is from the user mouse has a minor positive relationship to the number of errors as shown in Figure 7 with the line of best fit and trend displayed. The fact that this trend is very minor can be explained by the fact that only a few errors present in the whole experiment; where 89% of all trials are in fact error-free (533 of 600 trials). To add to, for trails where an error did occur the range of the number of errors is very small, ranging from one to three. The combination of a lack of trials with errors and a limited range in error values means that this trend is not very significant at all, however, a negative correlation is present.

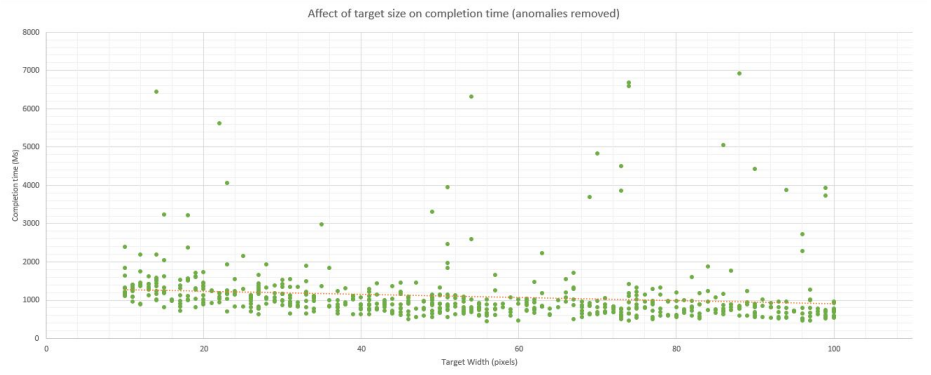
Figure 5 & 6 (Left to right):5; displays the effect of distance on completion time. 6; effect of target distance on completion time with anomalies present.

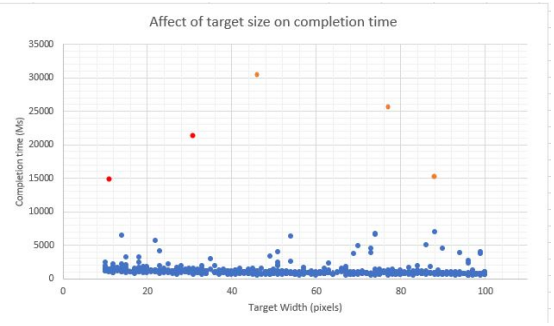




Other than the distance of the target from the user, the size of the target itself is the other factor which affects the human factors of targeting. The target size has a negative correlation on the completion time of trials, as shown in Figure 8, where the target width increases the completion time decreases to a minor extent.
Figure 9 shows this relationship with the anomalous data present with the colour coding as previously specified. This trend is as expected as a larger target inherently can be assumed to be easier to click.

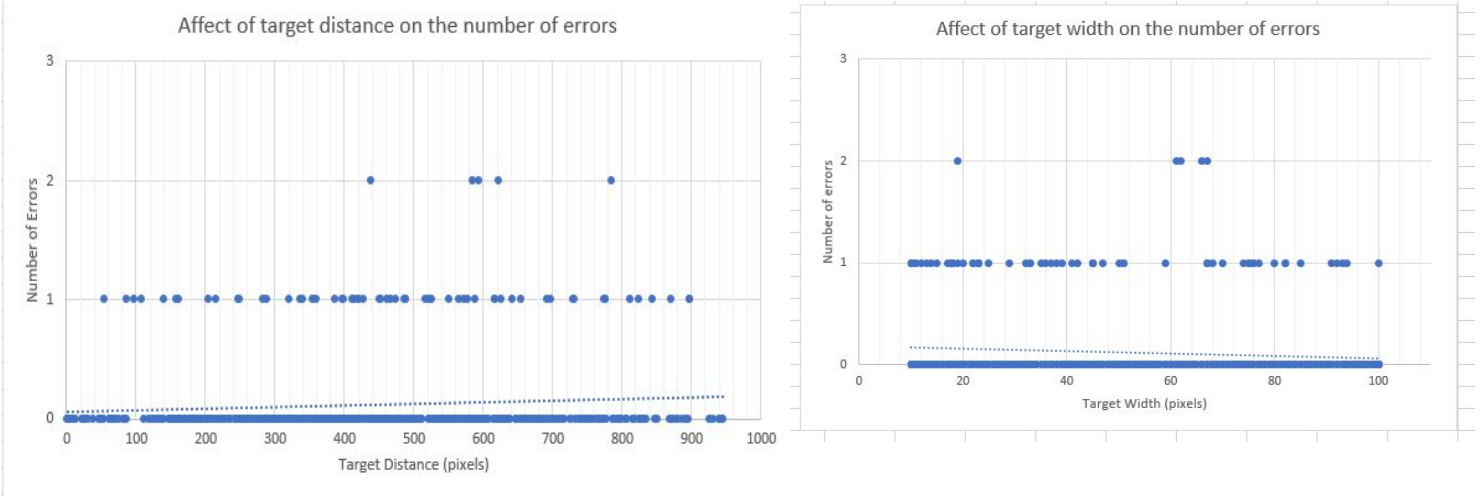
Figure 8 & 9 (Left to right); 8; displays the effect of target size on the completion time of trials. 9; displays the same relationship with anomalies present.





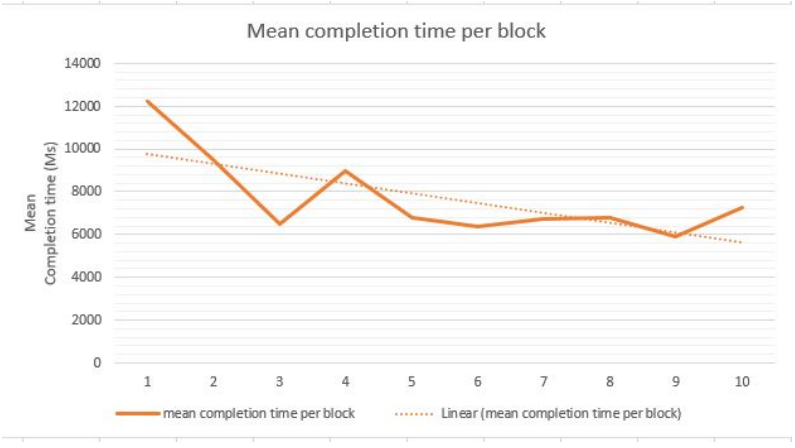
Additionally, the effect of target width on the number of errors has an inverse correlation, however minor. This is displayed in figure 10 however the trend is so minor that it is not really significant.

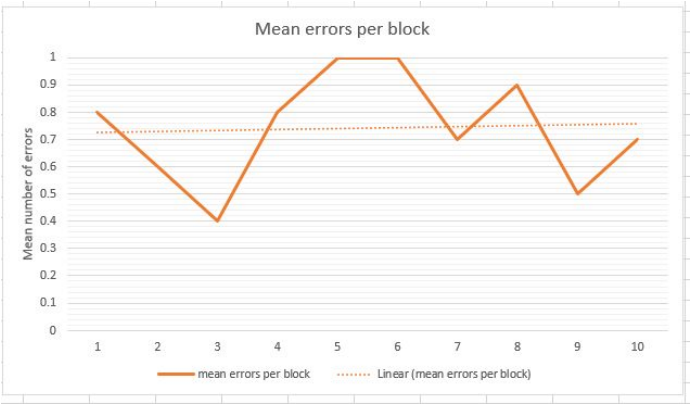
Figure 10 (Below); displays the effect of target distance & target width on the number of errors per trial.



Finally, with the complete set of data, I have been able to gather the mean recorded values for each block, allowing for an understanding of the overall trend in targeting speed and accuracy as the experiment progresses.
Overall it can be seen that an inverse correlation is present for the time to completion as the experiment progresses, with an increase in block number. As shown in figure 11. This can be explained by the user becoming more experience after being subjected to more trials and so their reactions become more rapid and rhythmic. Especially as they learn within the first two trials that target alternate from left to right.
On the other hand, the mean errors per block have no significant relationship overtime throughout the experiment, as shown in Figure 11. Where it can be seen that the relationship is minimal. There is not a reduction in the mean number of errors as one may have expected with the user becoming more experienced.

Figure 11, 12 (Left to right); 11; Displays the mean completion time per block. 12; displays the mean number of errors per block.





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Overall the results show that a closer and larger target has a positive effect on both the accuracy and speed of target selection. However, the change in accuracy is minimal and the target size had a greater positive effect than the distance of the target.

Predictive Equation

For an approximation of predicting the targeting time based on the size and distance of the target presented to the user.

Let *d* be the distance (in pixels) of the target to the mouse at the time of appearance.
Let *s* be the width (in pixels) of the target displayed.

> **TargetingTime = 0.8*d* - 3*s* + *5*00**

Validity of the equation

With some limited testing of this equation, it gave results which matched the trend line found on the chartshowever the accuracy is quite low. With a variety of results, it was quite hard to form this equation.

For an approximation of predicting the error count based on the size and distance of the target presented to the user.

> **Not possible**

Validity of the equation

I have deemed it not possible to determine the number of errors for a specific trial based on the size or location of a target, as seen in figure 5 and 7 the number of errors alternates between one or no errors for the majority of trials no matter the size or distance of the target. As previously stated the effect of size or distance on errors is not significant enough to determine an equation

Reflection on Results

With the analysis of the data complete and previous explanation of the results, I have been able to form a number of conclusions on what factors affect targeting and to what extent. Where some results have a distinct effect on targeting time and/or the number of errors. Overall the results show that a closer and larger target has a positive effect on both the accuracy and speed of target selection. However, the change in accuracy is minimal and the target size had a greater effect than the distance of the target.

It is important to remember that some results can be regarded as anomalous as previously discussed and thoroughly explained in the results section of this report. Please see the results section of this report. It would have been beneficial to have a 'practice' block for the participants first few goes in order to clarify what to do and prevent these anomalies. No anomalies were present for the errors counts recorded.

The majority of times to target selection range from 400 to 2000ms however it can be seen in the charts that there are a number of recorded trials which have a far greater completion time. Ranging all the way up to 7000ms. While it is not entirely clear why these results have occurred, these results occurred when the target was under 500 pixels from the user. Further analysis and reasoning on these trials would be needed to be completed to gain a further understanding.

On reflection on the target size data, I was expecting the especially small targets (size 10 to 30 pixels in size) to have a far greater number of errors and far greater times to completion. As these targets are far harder to select and thus I would have expected for this to have affected targeting speed and accuracy far greater. Repeating this experiment were the smaller sizes are more regular wold be an interesting experiment to complete in order to gather more data points on these values.

Overall I believe a larger study with a greater number of trials would allow for a better understanding of the trends in the factors which affect target selection. As the trends present in the data (as shown in the charts) are minor. With more data points it may be possible to understand these trends to a far greater extent.

Implication of design of interfaces and future

Finally, with regards to the design of a user interface, I believe designers should consider both the size and location of a target when it comes to setting out a user interface. Where they should prioritise the size of the target over the location or distance from the user's mouse. As size has shown to have a greater effect on completion time as shown in figure 8.

With this advice designers still should consider a logical structure for the targets when multiple targets are present. This experiment did not explore how to structure multiple targets and so further experiments which examine this would be useful for influencing user design.

Overall I am slightly confident in the results I found as I believe a far greater sample size would improve the analysis of the results in order to clarify the full trends and extent of factors on human targeting. Furthermore, I would definitely recommend a 'practice stage to the experiment in order to reduce anonymous data, in order for the user to be clear on what is expected of a trial.