Evaluating web accessibility for visually impaired users

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***Abstract*— Accessibility is still as important as ever when producing applications that will be accessible to users with visual impairments, as well as the average population. The context of this project is to assess the levels of usability across different user control methods to compare and contrast the level of accessibility of the two methods. The aim is to investigate the effectiveness of web accessibility for users with visual impairments. This project established this by testing both desktop and tablet platforms for the best method of user input for usability of common UI interactions. The method used in this project was a prototype application that required participants to complete five separate simple types of UI interactions, across both platform input methods, mouse and touch, simulating three user sight conditions Normal, Glaucoma and Macular Degeneration. The results compare the standard forms of desktop mouse accessibility environments with new modern touch-screen environments. The results from the 2-3 ANOVA showed that over all three sight conditions the desktop mouse input had the lowest completion times compared with tablet touch-screen input for the five UI interactions. This study concludes that new modern touch-screen devices that are growing in popularity with older generations who may not be the best choice for usability for users who may or may not live with a long term visual impairment.**

Keywords—web accessibility; usability; simulation; user testing; touch; mouse.

I. Introduction

A. *Internet usage in the older populations*

The use of tablet devices has increased in recent years. [1] Statista forecasted that from 2015 to 2017 they expected the total shipments of tablet devices to exceed the total shipments of both desktop and laptop computers combined for the next four years. Cisco forecasted by the end of 2014 the number of mobile-connected devices would exceed the total population of the world [2]. They also foresaw that by the end of 2016 tablet devices would exceed 15% of the global mobile data traffic [2].

The amount of adults that now have both fixed and mobile connected broadband has increased by 2% since March 2013 to March 2014. The average amount of time spent per month browsing the Internet has also seen an increase of 5 hours since 2013 [3]. Ofcom highlighted that younger and older generations tend to use their time on the Internet to accomplish different tasks [4]. The age group of 16-24 tend to spend on average 24 hours each week on the Internet. Younger generations are also more likely to multi task and undertake up to nine or more activities online weekly compared to older generations [4]. This is the opposite to older generations aged 55 and over who spend their time and money on online shopping compared to the 16% of younger generations who said they liked the anonymity of online shopping [4]. A survey completed by a 1000 users found that 59.2% of people aged 55 and over said that the reason why they shop online was down to the fact they like the products being delivered to their homes [5].

B. *Rise of Technology usage in the older populations*

The rise of such mobile devices has played a contributing factor to the increase of older populations accessing the Internet. Tablet devices have alone contributed to the rise of older populations aged 65 and over using these devices to access the Internet [4].When it comes to technology and older generations it is important to be aware that the risk of disabilities increases with age. This means that it is possible that the older populations may find it difficult to some degree to access or even use web applications with ease. Despite the concerns of usability of modern touch-screen devices a preliminary survey [6] in 2011 found that even though senior citizens are nervous about new technologies, they still show a strong desire and interest in the latest touchscreen-based smartphones based around the joy of creating gestures on their screen.

By the end of 2014 11.1 million of the UK population was contributed to people 65 and over [7]. The Royal National Institute of Blind People in 2015 attributed Macular Degeneration and Glaucoma as being the two most common medical conditions to contribute to sight loss in adults aged 75 and over [8].

C. *Aims and Objectives*

The aim of this project is to investigate the effectiveness of web accessibility for users with visual limitations across desktop and tablet devices. This project will establish what device platform is superior in terms of being the most usable for on-screen UI interactions but also which device user input approach is the more accessible platform for users with visual limitations - mouse or touch - in terms of delivering the best direct user control over the UI interactions. To achieve this one prototype will be developed. Tests will then be conducted on both Desktop and Tablet device and on three sight conditions; Normal, Macular Degeneration and Glaucoma. The results will be analysed and compared against each other to find which input platform is the superior in terms of performance.

II. Literature Review

A. Touch-screen usability

With the growing amount of tablet PC applications there is going to be an increase in different user profiles accessing them. This brings to the surface the problems with overall performance of the tablet device and even possibly full rejection of the new technologies. This is because these applications' interfaces fail to consider the personal traits, needs and limitations of users with disabilities and the effects of both physical environment and technological barriers [9]. Research in 2008 [10] found that newer touch screen devices like smartphones do not provide any of sort of tangible difference between the controls and display space of the surface, unlike that found in standard button mobile telephones whose operations can be easily learned through touch [10]. Changes such as these to user input have proven to be problematic for users with visual impairments [10], who find it difficult to learnt to adapt quickly to the new method of direct on-screen interaction. A study was completed in 2011 using a tablet device that was held in landscape orientation by users holding the tablet device with both hands at all times. Found that only a percentage of the surface area of the device remains accessible for the placement of UI widgets depends on the digit length of the individuals [11].

An addition to tabletop study in 2009 [12] carried out a comparison against touch and mouse to determine which was the more superior method in completing certain tasks. The study [12] looked at the simple Fitt's Reciprocal Tapping Task to carry out a threefold experiment that evaluated the performance rate of the two user interaction input types - direct touch using a finger and using a mouse. The experiments evaluated the performance rate of a simple target acquisition task, the difference in movement time and the error rates. For the throughput results the touch interaction method was the more superior compared to mouse. However the error rates component of the tests demonstrated the complete opposite to the previous tests. Direct touch ranked the highest overall for error rates. These findings were contributed to the fact that using touch on smaller targets was more difficult for users to complete with their finger and this could be contributed to the dimensions of the participants' fingers [12]. The final component examined in the study related to the movement time which differed significantly between the two input types; overall the touch interaction input throughout the tasks was fastest compared to the mouse.

B. Simulation and Automatic usabilitity user evaluation

The subject of user simulation is an approach for user testing that can enable developers, designers and companies to complete a user evaluation of a web application without needing to find specific persons that meet the accessibility testing criteria. A study in 2014 [13] highlights that the simulation approach has been used for a while for user testing; the technique has helped to provide developers, designers and companies with a better understanding of how their application can possibly be perceived by users with visual impairments. The study also highlighted that the main issue in that developers themselves cannot either understand or grasp the possible difficulties users with disabilities could experience with their applications [13].

The benefits from simulation software and hardware for user usability outweighs the benefits from automated accessibility evaluation that is used alone to evaluate web application usability. It is possible to complete an automated evaluation without ever requiring or inputting any form of human judgement as these tools only require the source code of applications to check for the compliance of web accessibility guidelines and current standards. The strong focus on the compliance of those guidelines and standards means these tools are not actually aiming to improve the users' experience on applications [14].

III. Methodology

To complete the user testing aspect for the Glaucoma and Macular Degeneration simulation goggles were used to simulate the effects of limitations associated with the conditions. The Vine visual impairment North-East simulation package goggle kit was used and goggles number 3 and 4 were selected to represent the following visual impairments for data collection.

Glaucoma – Goggles 3 represented the effect of loss in half of the visual field in each eye; in this case it was left side hemianopia.

Macular Degeneration – Goggles 4 represented loss to visual acuity, which left the participants with approximately 6/18 vision. This vision loss is just below the driving standard.

A. Participants

18 participants took part in the study and no participant suffered from any sight problems that could not be corrected be either spectacles or contacts. For participants who wore or used contacts to correct their vision were asked to use them throughout this study so every participant could start at the same vision baseline. Participants with spectacles simply placed the simulation goggles directly over their own glasses throughout the testing.

B. Application

The prototype web application contained five common types of UI on-screen interactions; sortable, selectable, draggable, droppable and resizable. The prototype was displayed over two individual computer platforms. In the study the platforms related to the Samsung Galaxy tab2 10.1 with the screen dimensions of 1280x800 pixels, and an HP desktop computer with the screen resolution of 1600x900 pixels.

Because the actual experiment had to be completed in a controlled manner in order to collect accurate data the following two equations had to be taken into account to ensure all participants experienced the exact same experiment experience as each other. The Shannon Fitt's Law equation related to the distance of rapid movement to the target and the ratio between the distance to the target and the width of the target. The Shannon equation related to the equation of level of index of difficulty of a Human Computer Interaction. To relate this aspect to this experiment the Index of Difficulty for each individual UI interaction had to be identical results across both platform screens. The second required equation was associated to the distance each participant had to sit from the platform screen whilst at eye level. For this the visual angle degree equation calculated that participants sat a distance of 70cm from the desktop screen and 31cm from the tablet screen.

C. *Interaction Counterblanace*

The counterbalance sequenced order highlights the order in which the UI interactions were counterbalanced in a Latin square sequence.

TABLE I

App Order	**Application Interactions Order**				
A	Sortable	Selectable	Droppable	Resizable	Draggable
B	Draggable	Sortable	Selectable	Droppable	Resizable
C	Resizable	Draggable	Sortable	Selectable	Droppable
D	Droppable	Resizable	Draggable	Sortable	Selectable
E	Selectable	Droppable	Resizable	Draggable	Sortable

The next Latin square sequence is the most significant sequence as it relates to how the 2 platforms and the 3 sight conditions should be counterbalanced. Due to these counterbalanced sequences no outside factor or inside factors had an adverse outcome to the data collection.

TABLE II.

Platform 2 x 3 Conditions Order Sequence					
Desktop Normal	Tablet Glaucoma	Desktop MD	Tablet Normal	Desktop Glaucoma	Tablet MD
Tablet MD	Desktop Normal	Tablet Glaucoma	Desktop MD	Tablet Normal	Desktop Glaucoma
Desktop Glaucoma	Tablet MD	Desktop Normal	Tablet Glaucoma	Desktop MD	Tablet Normal
Tablet Normal	Desktop Glaucoma	Tablet MD	Desktop Normal	Tablet Glaucoma	Desktop MD
Desktop MD	Tablet Normal	Desktop Glaucoma	Tablet MD	Desktop Normal	Tablet Glaucoma
Tablet Glaucoma	Desktop MD	Tablet Normal	Desktop Glaucoma	Tablet MD	Desktop Normal

[a] MD stands for Macular Degeneration.

D. *Testing the Prototype*

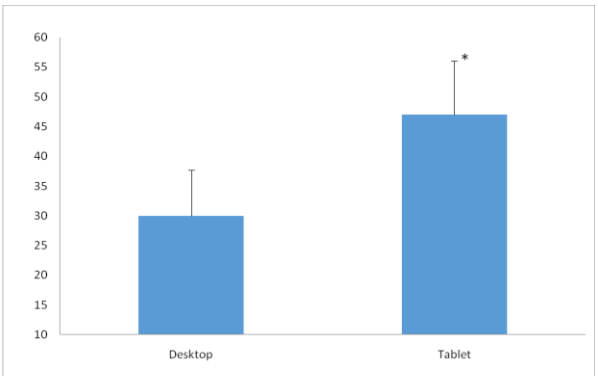
The prototype was tested so that a detailed comparison could be made to see how the platforms and sight conditions compared in terms of performance. The prototype was testing the following interaction task completion time. For the graphs, each of the completion times for each five individual interactions were added together to give each participant a final total time to use for the comparison.

IV. Results

A. *Platforms Comparison*

Fig. 1 showed that overall the average completion times were a lot slower for participants on the tablet touch-screen platform than the desktop mouse platform. The means of total application UI interactions completion time across both platforms for the three different sight conditions were desktop 30 ± 8 seconds and tablet 47 ± 9 seconds. The results showed that * is significant difference at ($P<0.001$).

Fig.1 Means of Platform overall completion times comparison.



B. *Conditions Comparison*

Fig. 2 showed that the total means of application UI interaction average completion time for Glaucoma desktop was 39 ± 26, and tablet was 57 ± 24 seconds. Macular Degeneration was desktop 27 ± 11, and tablet was 43 ± 19 seconds. The results showed that * is a significant difference at ($P<0.005$). Glaucoma was significantly slower than Macular Degeneration across both platforms.

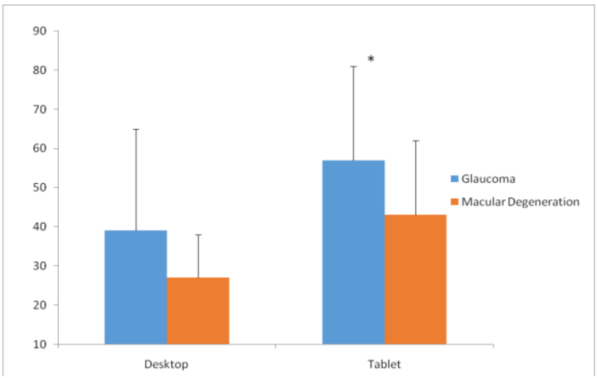


Fig. 2 Means of Glaucoma and Macular Degeneration overall completion times comparison.

Fig. 3 means of total application interaction average completion time across all three user sight conditions and Platforms is * significant at ($P<0.01$). The final overall average completion time for Normal on Desktop 25 ± 10 and Tablet 41 ± 23 seconds, Glaucoma on Desktop was at 39 ± 26, and Tablet was 57 ± 24 seconds, and finally, Macular Degeneration on Desktop was 27 ± 11 and Tablet 43 ±19 seconds. The overall significant effect of eye sight conditions is at ($P<0.001$).

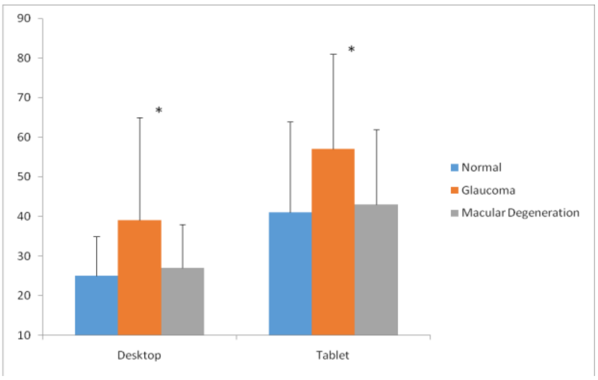


Fig. 3 Final means of overall completion times of all three sight conditions comparison.

V. DISCUSSION

The research in this project highlighted that despite the overwhelming growth and popularly [1, 4] of the newer touch devices for accessing the Internet there is still very little research done to determine the usability of these devices.

This little research does mean that there is still a large gap in the field of touch usability that still needs to be researched into. A study completed only last year in 2014 brought the problem forward of overall performance of tablet devices and, even more, the possible rejection of new technologies is still a possibility. These problems are because these applications' interfaces are failing to consider the personal traits, needs and limitations of users with disabilities and the effects of both physical environment and technological barriers [9].

The findings from this project only confirmed the concerns and worries highlighted from the 2014 study [9]. None of the three user sight conditions performance rate was quicker on the touch device. It is possible that touch devices still have a long way to go before users are really comfortable with newer technologies.

VI. CONCLUSION

In terms of web accessibility usability the overall results from the project highlighted that in terms of usability of UI interactions for users with visual impairments, desktop mouse input is the superior input of choice. The results highlighted that despite the growth of modern touch devices in older generations [4], these platforms inputs may very well not be the best method for users to control these types of interactions, for older users with visual impairments. This study also highlighted that throughout the experiment that not only is desktop mouse input the more superior platform for users with visual impairments, but the same conclusion can be seen for normal sighted users also.

A. Future work

Possible future work could be to take the findings for this study and to investigate further mouse and touch usability comparison across more in-depth web applications. It is also possible to cross over the comparison research to research into the effects mobility conditions could have on the usability of touch and mouse devices.

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