Feedback on Touch Screen User Interfaces

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Design

Industrial Design

Department of Art and Design
University of Alberta

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A case study using the Mobili-T health device to improve the user experience

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Thesis Project

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Abstract

This paper presents a study on feedback on touch screen user interfaces devices and how it impacts the use of the device by an individual. This paper looks at how the feedback may help or hinder the usability of a product. There is a focus in the paper on health care devices with touch screen user interfaces. Secondary research, such as journal articles, and primary research in the form of questionnaires and user interaction with a touch screen device make up the data collected for the paper. The main types of feedback studied are visual, auditory and haptic feedback. Four combinations of these feedback are the main focus of the study; these are visual only, visual and auditory, visual and haptic, and visual, auditory and haptic. Twenty participants volunteered to be in the study by filling out two questionnaires and doing a task on a touch screen device. Data was collected and analyzed to determine which combination of feedback would be most helpful for users in the use of touch screen user interface devices for a health care application. Results showed that feedback was helpful in the tasks done by the participants and most preferred only two types of feedback at a time over just one or all three types together. The results of this paper would help to improve the design and use of feedback in touch screen devices with health care applications.

Introduction

The proliferation of touch screens user interfaces in most consumer products has created a vast ecosystem of devices with divergent user interfaces. From cell phones to self-check-out devices at the grocery store, touch screens devices are now part of modern life (BusinessWire 2008). The number of devices along with various user interfaces has created confusion for many consumers of these devices. There exists a vast difference in the ways in which many of these devices function, especially in terms of the user interface and how they respond to user interaction. There are a multitude of ways of interacting with the devices and the feedback received by users on the devices differs significantly across the various interface platforms. "The demands and expectations of diverse users have grown faster than the quality of products." (Shneiderman 2003, 1).

This paper investigates the impact that feedback plays on a touch screen user interface and how the feedback can improve or possibly hinder the usability of the product. Feedback can be as basic as a visual cue that indicates to the user that something has occurred. It can also be auditory, such as the sound of a bell. Finally, feedback can be haptic, such as a vibration on the device. Haptic feedback can be more elaborate than a simple vibration; it can vary with intensity and frequency. Essentially, feedback is information the user receives when interacting with a device at a relevant time during that interaction.

It is important that all terms be defined in order to prevent confusion as to what is being discussed. A *touch screen* is a screen on a computer device where the user interacts with it using touch, either by hand or a hand held article such as a stylus pen. A *user interface* is a visual representation on a computer screen that may be portrayed by icons and visual representations of items such as files and documents. *Feedback* refers to any type of response that a device provides when a user interacts with it. This response can take the form of visuals, sounds or sensations with our hands or fingers that the user receives from the device. Feedback is essentially experienced by three of our five senses, sight, sound and touch. For example, turning on a television set by pressing the on/off button will give a distinct clicking sound as the button is pressed, a feeling of the button moving as it is being pressed by the user's finger and finally the light on to the button changing colour to green to indicate the television is now on. *Feedback* in the context of a touch screen user interface is some form of confirmation to the user resulting from an action that the user has taken on the interface. This confirmation can be a change in an icon position to a sound indicating that an action has taken place.

This study will also look at how certain feedback can be used in quality of life products and integrated with daily life to improve the lives of its users. The iRSM Mobili-T swallowing application will be used as a case study for this paper. Some of the findings from this study may have solutions for the swallowing application and may also have uses for other similar applications. Feedback on touch screen user interfaces will be researched and looked at as a major factor in an overall systematic way and identify aspects of it that will fit with the iRSM project. The study will focus on visual elements for the feedback on the design solutions and ways to utilize them in order to find how participants will be affected and be motivated by them. The study will use very basic sounds and haptic feedback during the study. Much more complex sounds and vibrations are currently beyond scope of the study but it is hoped that future research will look into them in much more detail.

For the swallowing therapy application, the information being sent from the patient to the device helps the translation of that information for the user in order to help them improve their swallowing ability. What ways can the correct feedback be represented and what would work best for the patient? How to represent the information as positive feedback that will connect with the user of the device? The case study of the swallowing therapy application will have as its goal the improvement of daily living for the patient, higher quality of life and possibly improve some social aspects of the patients' lives.

Mobili-T Case Study

The goal of the Mobili-T project is to design a mobile swallowing therapy device for patients with dysphagia, i.e. swallowing impairments. Currently, patients must come into a clinic to do their swallowing therapy. They are connected to a surface electromyography (sEMG) machine via an adhesive pad on their chin (Constantinescu et al. 2014). As the patient does the swallowing therapy, the clinician observes the results and assists the patient with their therapy.

The Mobili-T project is currently investigating ways to reduce the complexity of the necessary equipment to just a portable device such as a touch screen tablet and the adhesive pad on the chin for the swallowing muscle measurements. It is hoped that the patient will eventually be able to do the swallowing therapy in the privacy of their own home. (Appendix J).

The feedback that the patient receives via the touch screen tablet as they do the therapy is yet to be determined. It is hoped that from the research and results of this paper will lead to possible design solutions that may be useful and possibly adopted by the Mobili-T project.

Research Plan

My research plan is to study the feedback that a user receives from an application that is used on a touch screen user interface which helps the user complete health related tasks. The importance of the feedback and the improvements of the task will consist of gathering data from information recorded from the sessions during which the user completes a particular task and analyzing those results. From this data, the information that is collected will help answer my research question. I am studying feedback that users receives from an application (app) on a touch screen user interface (UI) because I want to find out how feedback helps the user improve his or her ability to do the task in order to understand the role of feedback so that the feedback received from touch screen user interfaces can be improved.

Throughout the research, I will look at different kinds of feedback that might be useful for users. The research will try to focus on meaningful feedback and on individual improvement. That is, the feedback that will assists the user not only in doing tasks on the touch screen device, but have the greatest positive impact and will hopefully motivate users to continue with any health related tasks.

My research plan will also to look into research that has studied different types of feedback on touch screen user interfaces in the general population. Some of my own primary research will be conducted in the form of a questionnaire to participants in the study. Hopefully this will allow a better understanding of how feedback can assist users with touch screen devices. Other research will touch upon other general health related applications and to see how they may apply to this particular case.

Question

The main question for this paper is as follows:

Does the feedback that the user receives from an application on a touch screen user interface improve the usability of the device?

The question for the iRSM Mobili-T project case study can be stated as follows:

Does the feedback that the patient receives from an application on a touch screen user interface improve the patient's ability to swallow?

Hypothetical Answer

A hypothetical answer to the main question may be that feedback will improve the usability of the touch screen interface device, especially when there is multi-modal feedback. A possible hypothetical answer to the question for the case study could be that feedback does improve the patient's ability to swallow using an app on a touch screen user but only when the patient uses it consistently and correctly and if the UI has been well designed. It is also important to point out that different types of feedback may have different results with different users.

Limitations

My research will be limited to the feedback that the user will receive. It will not include any feedback between any system component that does not include the user. For example, feedback from the app to any data server will be excluded from the research. The research will also focus only on the interaction and feedback of the user with the app, touch screen and user interface. It will not include any feedback or interaction with clinicians or patients. The focus of the research will look at the feedback during the task in the study and will investigate the different types of feedback and combinations of feedback.

The research will also try to focus on individual improvement and the possibility that different types of feedback may work differently for various individuals. Overall, the paper will focus on users and the feedback that they receive while doing the task in the study.

Users with physical limitations such as low vision or poor hearing will be excluded. This will help to limit the research to feedback that includes visual feedback either by itself or in combination with another type of feedback. Since touch-screen user interfaces are visual by nature it makes more sense to have visual feedback as a constant. Haptic-only or auditory-only or haptic and auditory together are not useful for this project. There may be a slight exception to this limitation in which the user may close their eyes or look away from the screen briefly.

Terminology

Touch Screen User Interface

For this research paper, the definition of a touch screen user interface is the rectangular area on a device which uses finger touching or tapping or a stylus for input on the screen. Today, touch screens are ubiquitous and most people have some basic experience with them. Examples include smart phones such as the iPhone or Samsung Galaxy, tablets such as the iPad and even the devices used in self-checkout lanes in grocery stores and bank ATMs. According to Lee et al., "touch screen user interfaces have a one-to-one relationship between the control and display, and often no additional training is necessary for their efficient use." (2009, 129). Their ease of use and low learning curve are part of the reason why touch screens are so ubiquitous.

“Predictable and controllable user interfaces seem strongly preferred.” (Shneiderman 2003, 2).

One notable downside of touch screen user interfaces is the lack of physical keyboards and button that have been part of most electronic devices. "Although the keyboards used on touchscreen devices are based on the original physical mobile keyboards, one important feature is lost: the buttons cannot provide the tactile response that physical buttons do when touched or clicked." (Hoggan et al. 2008, 1573). Users have become accustomed to feeling the placement of keys and buttons on devices. "One of the key features lost in a touchscreen keyboard is feeling the edges of the keys." (Hoggan et al. 2008, 1575). Despite the lack of physical keyboard, the popularity of touch screen devices continues to grow. “Shipments in 2007 of touch screen-based mobile devices increased 91% over 2006, and ABI Research forecasts that revenue from the global touch screen market for mobile phones and other handheld devices … will reach $5 billion in 2009”. (BusinessWire 2008).

Visual Feedback

Visual feedback includes anything that would be seen on the screen of the device that occurs after the user interacts with the touch screen. This can include pictures, text or even abstract shapes. The user interface consists of visual elements that the user will see and interact with to do various tasks. The user interacts with these elements using their fingers or a stylus. Examples of visual feedback can be as simple as a change in the colour of a button to indicate that is has been touched by the user. More complex examples of visual feedback can be an application starting and changing the screen or a text box indicating an error or confirmation of a task. Visual feedback is the primary component in the research due to the fact that touch screen user interfaces are primarily visual.

Auditory Feedback

Auditory feedback is about sound. Sounds can include voice, beeps and various other types of audio. Finding the most relevant and useful auditory feedback for the swallowing application therapy will be part of the research. The audio feedback can be played using the built in speakers on a device or headphones for more privacy and a more personal experience. Auditory feedback can be as simple as a clicking sound when the user is inputting data into a phone via the touch screen keyboard. Another example can be the sounds made during a game on a tablet or a sound made when there is an error or a task is completed.

Haptic / Tactile Feedback

Haptic and tactile feedback is a type of feedback that deals with touch. For the purposes of this study, it will be limited to simple vibrations. Some research will be conducted on more advanced types of haptic and tactile feedback and their possible applications to this study. Haptic feedback is something that is not used as much as it requires extra hardware and complexity for touch screen devices. An example of haptic feedback is the vibration felt on a phone when the user receives a text message or a phone call if the phone is on silent. Many games on mobile phones give haptic feedback during game play to give the user a feeling of being more engaged with the game.

Multi-modal Feedback

Multi-modal feedback is a combination of more than one type of feedback. It may include any combination of two types of feedback or even all three together. The combination that might work best for users while doing the health related task will be investigated. It may be possible that one combination may work better for some and another combination may work better for others. One possible solution could be to allow the user to use the combination that works best for them. An example of multi-modal feedback could be a game on a phone that has sounds and vibrations. This would include feedback that uses visuals, sounds and haptic together.

Process Summary

There are a number of design processes that may be used to arrive at results or a conclusion for the main topic of this paper. As such, it is necessary to take into consideration which process will be most useful and helpful for the particular case study. Various different design processes are able to achieve the desired goal and the process selected is best suited for this paper's purpose. The design process to be used for this paper consists of the following: background research, analysis and synthesis, primary research, evaluation, discussion, and design recommendations.

Background research

The research to be undertaken for this paper will consist primarily of two main types of background research. These will be literature review and secondary research. The literature review will "distill information from published sources" (Martin and Hanington 2012, 112). This will allow the study to get an overview of other papers' results with respect to how feedback is viewed and studied by others. The secondary research will consist of scholarly articles that discuss feedback on touch screen user interfaces. Much of the research will look at multi-modal feedback and see what, if any benefits there might be in using multi-modal feedback. The research will take a look at other health devices that may have some relevance for the swallowing therapy case study. The background research together with the primary research will be analyzed in order to produce useful and innovative design solutions.

Analysis and synthesis

The analysis and synthesis section will analyze the background research and see how some of the results from the research can be applied to this study to find possible design solutions that can be useful in motivating users in using health apps on touch screen devices and as well as for the Mobili-T project and similar future projects.

Primary research

The primary research consists of an initial questionnaire, a simple task that is done by participants in a simulated app on a touch screen device and a follow-up questionnaire. The results will be analyzed and used together with the secondary research to create design solutions.

Evaluation

This section will evaluate the results from the questionnaire done by the participants. The raw data will be evaluated to better understand what the results might mean for this study.

Discussion

In this section, the results of the study will be discussed and to see what insights the results may offer. It is hoped that these insights will be useful for possible design recommendations.

Design Recommendations

This section will discuss the design recommendations that will focus on individual improvement on tasks done by users on touch screen devices. It will look to see how to represent the feedback that will connect best with participants.

It is a process of constant refinement as new information is uncovered. New research or insights may cause some of the analysis or evaluation to be refined within the process. The discovery of new data and information will not conclude with this paper, as this is a topic that can be researched and studied much more. It is hoped that the Mobili-T project will apply and continue the ideas that will be proposed in this paper. The design process of this paper will focus primarily on feedback to assist health related applications with the primary and background research as support for the main topic of the paper.

Background Research

The research in this paper includes primary and secondary research. The primary research will consist of participants interacting with a touch screen device by completing a task on it and answering two questionnaires. The secondary research will consist of scholarly articles and books in support of the main topic of this paper. This research will focus on the types of feedback and their combinations. The main focus will be on visual feedback and a combination of visual with the other two types of feedback, as well as research on all three types of feedback together.

For the iRSM Mobili-T project case study, the emphasis is to discover how feedback may assist patients in learning and retaining the swallowing manoeuvres to be able and to keep a regular schedule for the swallowing therapy. As such, some of the research will consist of studying other types of therapies and their feedback to see how it can be applied in this particular case.

Much of the preliminary research indicates that some form of feedback on a touch-screen user-interface has a positive effect on the user which assists them with the tasks on the device. The following sections will elaborate more on the research for the types of feedback and their application for this project. It will look at the three types of feedback, their combinations and how it can relate or apply to this paper.

Health Devices and Feedback

One important segment of touch screen devices that may greatly benefit from proper use of feedback are health care devices and health care apps. In this regard, to get users to use the devices to improve their health, regardless of what are the particulars that they need to improve on, motivation for the behavior change is fundamental. "Behavioral change theory posits that behavioral change (e.g., using learned memory strategies in daily life) is most likely to occur when the cost–benefit analysis of the new behavior is positive, the person is able to form and articulate intended behavioral change, has positive experiences with the intended behavior, and is satisfied with the outcome of the behavior" (Seelye et al. 2012, 30). To learn a new behavior that will be done with regularity, "According to learning theory, a new behavior should be learned during an acquisition phase, applied to daily life in an application phase, and practiced so as to make it habitual and routine" (Seelye et al. 2012, 30).

From this, it is important that the user recognizes the benefits of the behavior with the device to improve whatever health aspect is needed to improve. According to Seelye et al., "behavioral change is most likely to occur when the cost–benefit analysis of using support is positive and the user is satisfied with the outcome." (2012, 37). The feedback that the user would receive while doing the task or exercise with the touch screen device can improve or diminish their motivation and satisfaction with the device and the results. "For example, large print and buttons, nonglare surfaces, simple steps, and verbal prompts that are in the appropriate vocal range, tone, wording, and preferred gender would be most effective." (Seelye et al. 2012, 41).

The range of users that may utilize a touch screen device for health purposes is potentially very large. It may be necessary to limit the range of users for specific devices otherwise it might be very difficult to design a solution that will work best for all. As Gregor et al. mention:

> "In contrast the young, fit, male "typical user" is assumed to have abilities which are broadly similar for everybody, and crucially these abilities are perceived to remain static over time. Not only is this view wrong, in that is does not take account of the wide diversity of abilities among traditional users, but it also ignores the fact that for all users, abilities are dynamic over time. Both the abilities and the rate at which they change also vary between individuals and between cultures, and these variations can be very much more pronounced for older users." (2001, 152).

With this knowledge, allowing devices for health applications to be able to be customized for various user groups would be of great benefit for users.

Many users who may use such devices may be older aged users and within this demographics the difference between users are also large. ""Older people" encompass an incredibly diverse group of users, and even small subsets of this group tend to have a greater diversity of functionality than is found in groups of younger people." (Gregor et al. 2001, 152). Assisting older users with the use of the device is imperative for the improvement of their health and to continue their motivation to use the device. Proper feedback is something that may be the difference that would increase use and determination. Other issues need to be taken into account for older users. "In addition to vision and memory problems, many older people lack confidence in using IT systems, and it is important that we take this into account in the design process." (Gregor et al. 2001, 154).

One of the most important issues regarding the use of touch screen devices for health issues is the necessity of continued and regular use by the user. Without this, no improvement in the design of the interface or device will help the user in utilizing the device to improve their health. “Patient adherence to a treatment regimen is an important factor in improving health outcomes, but simply tracking patient activity does not ensure, or even motivate, adherence.” (Constantinescu et al. 2014, 433). This is one very important aspect for the feedback that can have great potential. That is, being able to motivate the user to continue utilizing the device and thus improve their health.

Feedback

The three basic types of feedback are visual feedback, auditory feedback and haptic / tactile feedback. Combinations of these three main types of feedback are commonly known as multi-modal feedback. These combinations along with their short hand notations are visual and auditory (V + A), visual and haptic (V + H), haptic and auditory (H + A) and finally all three together, visual, auditory and haptic (V + A + H). Each individual type of feedback and their combinations will be discussed in the following sections.

Visual

Visual feedback on a touch-screen user interface is assumed to be standard for visual display devices. There are rare devices that have very little if any visual feedback. Though the lack of visual feedback is clearly a problem, the bigger problem is devices with incorrect or even un-helpful visual feedback. The feedback may be too subtle, or get in the way of the users’ next task, or block information on the screen.

According to Nishino et al., there are various drawbacks to only visual feedback. These include users having to watch the screen continuously to see if the task or operation completes, users "may sometimes lack confidence in accurately touching a target icon displayed in the screen and correctly launching a desired program”, it may be difficult to see the screen outside due to sun glare and the “most serious problem is that the touch panel interface is totally useless for the users who have visual impairments.” (2012, 1055).

Timely and correct visual feedback for users should be the norm for all touch screen devices. For a wide-variety of devices, this unfortunately is not the norm. As Lin and Wu conclude, “designers need to reduce response complexity and to be much more cautious with the use of visual feedback.” (2013, 817). Using touch screens have the effect of reducing accuracy due to the lack of tactile feedback that a user would get when using a physical keyboard (Lin and Wu 2013, 820). As such, the user must continuously look at the screen especially if they are unfamiliar with the device.

Auditory

The use of audio only for touch screens is a special case, usually reserved only for users who are visually impaired. This is rarely used as Nishino et al. indicate that using audio only for the rendering of items on the screen is extremely difficult for the visually impaired user (2012, 1055). As such, audio only feedback is not part of the main research for this paper as is it assumed that the users have no visual impairments. Though it is possible that the visual feedback is not seen by the user due to their closing their eyes for a brief moment or looking away from the display. In such case, audio may become the only feedback for the user.

Haptic

Same as auditory feedback, haptic only feedback is considered only as a special case reserved for users who are visually impaired. In Nishino et al.'s "research, large tablets are used and their results show that their methods are useful when there is no visual and auditory feedback." (Nishino et al. 2012, 1068). The research done on haptic only feedback mostly deals only with users who are visually impaired and as stated above for auditory feedback, it is assumed that the users for this paper's study have no visual impairments. Same as for auditory feedback above, there may be cases where the visual feedback is not seen by the user due to their closing their eyes or looking away from the screen briefly.

Though there is some research being conducted on haptic only feedback for touch screen interfaces. In one of them, users "can identify physical object's features such as shape and texture by examining the object surface with his/her hand." (Nishino et al. 2012, 1059). Nishino et al. indicate that "haptization also provides visually-impaired persons with an effective method for recognizing and utilizing digital data with the touch-based interaction all by themselves." (Nishino et al. 2012, 1055). Their results were very positive for the use of haptic sensations to help those with physical limitations and visually impaired users navigate the web on a tablet (Nishino et al. 2012, 1071).

Multi-modal

Multi-modal feedback seems to be the most promising according to the preliminary literature review. Two meta-studies (Burke et al., Prewett et al.) seem to indicate that the use of multi-modal feedback significantly improves users' abilities to complete tasks in various environments (Causo et al. 2012, 430). The question remains as to which combination will assist the users in their tasks more effectively. According to "Wicken's Multiple Resource Theory (MRT), information delivered using multiple modalities (i.e., visual and tactile) could be more effective than communicating the same information through a single modality." (Prewett et al. 2006, 333).

Too much information on modern visual display devices can overload users and "has the potential to result in extremely high cognitive workload, which subsequently reduces situational awareness and lowers the quality of performance." (Prewett et al. 2006, 333). As such, the purpose of multi-modal feedback is to reduce the workload for the user and provide benefits for overloaded users (Prewett et al. 2006, 334).

This information overload can be reduced.

> "A promising conceptual framework for the information overload problem is available via Wickens' Multiple Resource Theory (MRT). MRT proposes that different cognitive resources exist for the processing of different modalities of stimuli (e.g., visual, audio, or tactile information). When a large amount of information is presented solely through one modality, cognitive overload becomes problematic and can negatively impact performance. When task feedback is administered using multiple modalities instead of a single modality, multiple cognitive systems are able to process different chunks of information. This mitigates the decrement in performance due to information overload." (Prewett et al. 2006, 333).

Despite some drawbacks of multi-modal feedback such as overload for the user, there are benefits for certain user groups. One particular user group that may benefit from multi-modal feedback is older aged adults. As Lee et al. explains:

> "Multimodal feedback might provide even larger benefits to older adults who are often unfamiliar with recent developments in electronic devices, and may be suffering from the age-related degeneration of both cognitive and motor processes. Therefore, the beneficial effects associated with the use of multimodal feedback might be expected to be larger for older adults in perceptually and/or cognitively demanding situations." (2009, 128).

The main focus for the background research will be on multi-modal feedback as it seems to have the most potential for this paper's topic. The next sections will look at the various combinations of multi-modal feedback.

Visual + Haptic

A meta-analysis done by Prewett et al. indicates that visual and tactile feedback assists users more than visual feedback only. Visual and tactile feedback can reduce reaction time and increase performance of users (2006, 333).

For pen-based interfaces the results are that “for both the 1D and 2D pointing tasks show that tactile plus visual feedback can improve accuracy and audio is not efficient to give user feedback in tracking state.” (Sun and Ren 2011). As well, Ren and Well’s results “showed tactile plus visual feedback was the best feedback among these multimodal feedback in tracking state.” (2011, 735) and can improve user’s performance.

This combination of feedback is able to assist those with physical limitations and elderly users by “enabling them to explore their desired information with the vibration effects as clues.” (Nishino et al. 2012, 1056).

According to Prewett et al., the benefits of visual and haptic feedback “are better realized under conditions of higher cognitive load.” (2006, 336). They conclude that "results indicate that VT feedback provides significant advantages over simple visual feedback". (2006, 337).

Visual and haptic feedback has some limitations with respect to the information that the user is able to infer from them. The user is more efficient with this combination but the haptic feedback cannot assist the user with decision making. The user needs the visual component in combination with the haptic feedback (Prewett et al. 2006, 337).

This combination of feedback appears to be much better in assisting users in their tasks than simply visual only when the tasks are of a high workload. It strongly assists users in increasing their performance by reducing the cognitive load that the user experiences (Prewett et al. 2006, 337).

Prewett et al. suggests that visual and haptic feedback should be implemented in pilot testing before wide scale implementation as there may be unique scenarios where users do not receive any benefits. This includes when the user is inexperienced with tactile feedback (2006, 338).

One place where touch screens are becoming very prevalent is in the dash of automobiles. This is especially true for luxury vehicles where the touch screen replaces standard buttons such as heating, cooling and radio controls. Pitts et al. did a study comparing visual only feedback and visual and haptic feedback. They tested by delaying or removing visual feedback which increased the workload for the user. By introducing haptic feedback, the effect was offset. When visual feedback was degraded, “haptic feedback was able to compensate for the information loss” (Pitts et al. 2012, 15). Their test users’ task completion time was reduced with haptic feedback and performance while driving had no effect on feedback type.

Their users' own subjective task experience was improved by haptic feedback and "reduced perceived task difficulty." (Pitts et al. 2012, 7). Pitts et al.'s study also found secondary effects for the users. The users reported an improved user experience, more pleasure using the device, easier to use, and greater confidence when using the touch screen interface device in their study (Pitts et al. 2012, 15).

A study by Causo et al. appears to indicate that the combination of visual and haptic feedback is better than visual by itself. Their study focuses on a health related aspect, arm posture correction. " Results show that the series visuotactile mode enables faster and more accurate arm posture correction compared to the other modes that uses tactile feedback." (Causo et al. 2012, 430). The results from Causo et al.'s study have allowed work to begin "in designing rehab modules that use tactile feedback in actual stroke rehabilitation." (2012, 437).

Another study by Hoggan et al. "showed that the addition of tactile feedback to the touchscreen significantly improved fingerbased text entry, bringing it close to the performance of a real physical keyboard." (Hoggan et al. 2008, 1573). As the lack of a physical keyboard is a possible downside for many users, the study results by Hoggan et al. "suggest that manufacturers should use tactile feedback in their touchscreen devices to regain some of the feeling lost when interacting on a touchscreen with a finger." (2008, 1573). By adding tactile feedback, many problems caused by a lack of physical keyboard can be overcome (Hoggan et al. 2008, 1577). Adding tactile feedback help with some aspects of typing but is not able to replicate completely a real physical keyboard (Hoggan et al. 2008, 1578). But the results indicate that tactile feedback has "some significant advantages for touchscreen devices." (Hoggan et al. 2008, 1578).

Users produced fewer errors with text entry when using devices with tactile feedback than devices without tactile feedback. The results strongly suggested that tactile feedback should be added to touch screen phones to improve user performance (Hoggan et al. 2008, 1579). The addition of tactile feedback can increase the performance of touchscreen keyboards to almost the level of physical keyboards (Hoggan et al. 2008, 1582). "It has been demonstrated that tactile feedback can benefit touchscreen interaction in both stationary situations and more varying, realistic mobile situations." (Hoggan et al. 2008, 1582).

Hoggan et al. concludes that "The results of our studies suggest that manufacturers should include tactile feedback in new touchscreen devices. There were no drawbacks from including it, only benefits." (2008, 1582) and their "results strongly suggest that using either the builtin vibrotactile actuator already present in most mobile devices or more specialised actuators to produce tactile feedback can improve the usability of touchscreen keyboards." (2008, 1582).

The research on visual and haptic feedback strongly indicates that it can have a positive effect on tasks done by a user on a touch screen device. Research into the other feedback combinations will aid in getting more information as to how visual and haptic feedback compares with other combinations.

Auditory + Haptic

A number of research papers done on auditory and haptic feedback, though not on a touch screen interface, indicates some positive results for the use of audio and haptic feedback. A study by Huang et al. shows that providing audio feedback with haptic feedback helped users perform their tasks for the experiment much faster than when only haptic feedback was provided. Even though this study was geared towards users with little to no vision, it does show the importance of a secondary feedback for users (2012, 267). As stated previously for auditory and haptic feedback, it seems that this combination is focused on users who are visually impaired. For this study, users are assumed to have good vision and so this combination will not be used for this study.

Visual + Auditory

This combination of feedback is being used in many touch screen devices and is very common. It is used in most everyday touch screen devices such as those used in self-check-out registers, ATMs and especially in games. It is a widely used combination of feedback due to the fact that most modern touch screen devices are able to produce sound either by built in speakers or the use of headphones.

There are studies that have shown that there are advantages to adding auditory feedback to touch screen devices. A paper by Schuck shows that the "the addition of auditory feedback has a significant effect upon typing performance in the use of touchscreen input devices. Speed of response was shortened with the addition of auditory feedback." (1994, 61). Schuck's study did indicate that even though errors in the input did not improve, "[w]here speed is important, however, auditory feedback does significantly improve performance." (1994, 61).

The results from Schuck's paper do show that there is a definitive advantage in adding auditory feedback together with visual feedback. Schuck writes, "While error rates were not affected by the feedback, the addition of auditory feedback to a typing task did improve typing speeds under all tested conditions. This indicates that the addition of auditory feedback to touchscreen input devices provides a measurable benefit and should be considered, where possible." (1994, 59).

In addition to typing on touch screens, visual and auditory feedback has various advantages for older adults. A study done by Lee et al. discusses multimodal feedback and in particular visual and auditory feedback. As indicated by the study, "crossmodal feedback involving auditory stimuli resulted in the older adults responding more efficiently."(Lee et al. 2009, 133). The results from their study also "suggest that crossmodal auditory stimulation has a pronounced effect on participant's performance of a touch screen task." (Lee et al. 2009, 133).

Adding auditory feedback to a touch screen device, especially for older adults, increases the effectiveness of successfully completing a task on the device.

> The "results demonstrate the effectiveness of multimodal feedback presented via a touch screen and the importance of auditory information as a form of crossmodal stimulation in the task that seemingly only involves the visual and tactile modalities, for older adults" (Lee et al. 2009, 134).

To summarize, Lee et al.'s results "demonstrate that the presentation of multimodal feedback with auditory signals via a touch screen device results in enhanced performance and subjective benefits for older adults." (2009, 128).

As indicated by the research, visual and auditory feedback has definite benefits, especially for older adults. As common as this combination of feedback might be, there exists the possibility for improvement. This will be one of the combinations that will be studied for this paper.

Visual + Auditory + Haptic

Various papers have been published which point to greater success in improving usability of touch screen user interfaces for users. Most of this research has focused on the use of phones with experiments testing single feedback vs. multi-modal feedback. This research lends support to this paper's premise that multi-modal feedback will enhance the usability of touch screen user interfaces. "In particular, bimodal audiovisual and/or trimodal audio-visual-tactile feedback led to more efficient mobile phone performance than either unimodal visual and/or bimodal visuotactile feedback". (Lee et al. 2009, 133).

This particular paper's results are very promising with regard to efficiency when doing specific tasks on a touch screen. Lee et al.'s outcomes showed that "results of the analysis of the behavioral data therefore demonstrate that participants were able to perform the mobile phone task more efficiently when they were given bi- or trimodal sensory feedback including auditory stimulation than when they were provided only with unimodal visual feedback or with bimodal visuotactile feedback." (2009, 133).

In relating the results from the Lee et al. paper to the goal of helping users with health related tasks, there is much that can be used to support the idea that multi-feedback will be very beneficial for users. "These results demonstrate that multimodal feedback (i.e., feedback that includes the stimulation of two or more of an interface operator´s senses) can have a beneficial effect on subjective measures of difficulty, as well as on the more objective measures of participants' behavioural performance." (Lee et al. 2009, 134). As well, their "results clearly show that both objective and subjective measures of older users' performance were enhanced by the presentation of bi- and trimodal (as opposed to unimodal) feedback including auditory stimulation." (Lee et al. 2009, 134).

One potential downside is overwhelming the user with too much information at once. "Too many active feedback channel, especially if the feedback needs interpretation, may confuse users so putting the feedback in series could minimize confusion. On the other hand, putting the feedback in parallel i.e., provide feedback simultaneously, may tax user's attention." (Causo et al. 2012, 437). The design of the feedback for the device will need to take into account when too much or too little feedback is detrimental for the operation of the task needed to be completed.

In reviewing some of the research, the results from the papers seem to indicate that multi-modal feedback has the strongest positive impact for users. Which combination of feedback will work best may depend on the user's own personal experience and preferences.

The main focus of research for the types of feedback are visual, visual + auditory, visual + haptic, and visual + haptic + auditory. Auditory only, haptic only and auditory + haptic will be excluded as it is assumed that the users for the study will have no major visual impairment.

Analysis and Synthesis

In looking at the research, many of the conclusions and results in the papers and studies that were examined strongly indicate that some form of feedback is very helpful for the user. Feedback does seem to enhance the users' experience and task completion in the use of touch screen devices. Currently, many devices have some form of feedback yet do not seem to utilize it effectively. It is the goal of this study to discern information together with the secondary research and questionnaires that will prove valuable to determine which path to follow for possible design solutions.

The next step would be find a way to apply the conclusions from the research to inform the development of the primary research in order to arrive at potential general design solutions and as well beneficial design solutions for the Mobili-T project. Current research simply indicates that feedback is useful, but how to apply it for this paper's case study is something that needs to be investigated. Some issues that need to be taken into account for the Mobili-T project include:

- Patient needs
- Personalization

- Ease of use
- Progress indication
- Simple to understand

The results of the primary research will also need to be taken into account for the design solutions for the Mobili-T project. It is hoped that together with both research results, the design solutions will be useful, practical and viable for the Mobili-T project in order to better support patients for their swallowing therapy.

Designing a general feedback solution that can be implemented across different devices and that is usable for diverse tasks may be complicated and yet might possibly work if properly implemented. The question is to determine how to use the information gathered from the questionnaires and primary research together with the background research.

The background research tended to look at the types of feedback more or less independently of each other. General design solutions would need to utilize feedback in conjunction with each other in order to improve the usability of the touch screen device for the user. The results from the primary research will also be taken into account for any general design solutions.

The overall results from the background research strongly indicate that feedback of all types is helpful for the user to complete tasks on touch screen devices. The design solutions, for the Mobili-T project and for general use, will make use of the conclusions from the background and primary research to better help patients and user in general respectively.

Primary Research

The primary research consists of two questionnaires and a simple task that is done by the participants in a simulated app on a touch screen device. There results will then be analyzed and used with the secondary research to create design proposals.

The main design of the tests involved participants using a touch screen device and observing feedback while doing a particular task. The feedback will be visual, auditory and haptic. The feedback combinations discussed earlier in the paper will be used. The participant will let the researcher know whether the feedback was successful or not via a second questionnaire right after using the device.

The results will give indication if the feedback aided the participants to complete the task on the device. This will allow the researcher to know if the feedback improved the participants' use of the device.

Questionnaires

There are two questionnaires for this study. One will be given to the participant at the beginning of the study and the second will be given after the task has been completed. The questions in the first questionnaire are about the participant's experience with feedback on various types of touch screen user interface devices. The questions in the second questionnaire are to get their personal opinions and experiences regarding the task done in the second part of the study. These two questionnaires are where the data for the primary research will come from for this paper. Both questionnaires are reproduced in the Appendices.

Prototyping

For the task portion of the study, a simulated app will be used on an iPad tablet touch screen device. The participant will use the device as directed by the principal investigator. As they use the device, they will receive some feedback. The simulated app will be created using Microsoft PowerPoint and run on the iPad version of PowerPoint. Since the iPad does not have haptic feedback, it will be simulated by attaching a small vibrating disk motor on the back. This will be controlled by the principal investigator to simulate the haptic feedback as needed during the study (Figure 1).

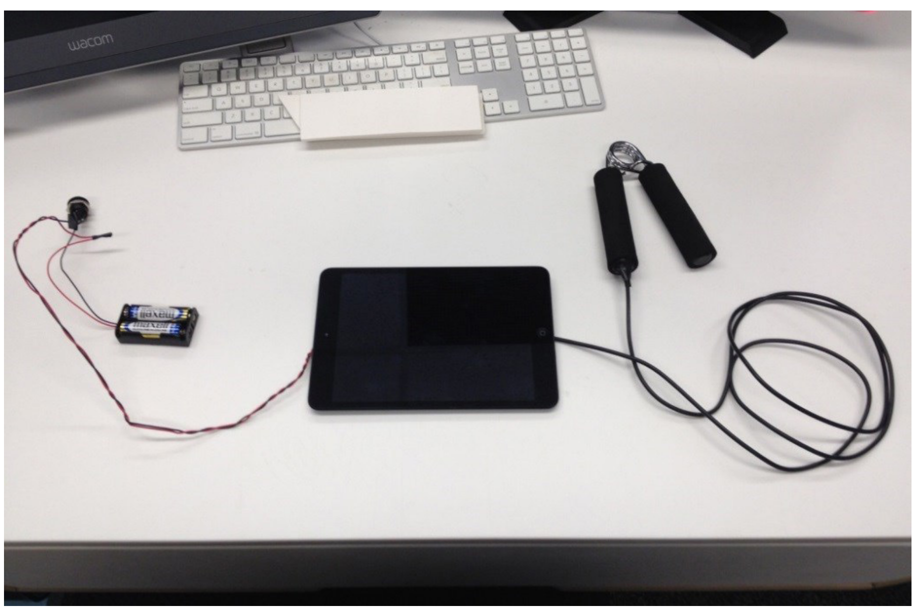

Figure 1: Device with hand grip, iPad and vibrating disk motor attached to the back

Study Outline

The study consists of three parts:

1. Answering a simple 5 – 10 minute questionnaire
2. Doing a task on a touch screen user interface device
3. Answering a second 5 – 10 minute follow-up questionnaire

Part 1 – Questionnaire 1

The type of questions in the first questionnaire are about the participant's experience with feedback on various types of touch screen user interface devices.

Part 2 – Task

This part consists of the participant doing a task with a touch screen user interface device. They will be asked to do a simple task and observe the feedback on the device.

The three types of feedback are: visual (V), auditory (A) and haptic (H). The feedback is meant to assist the participant to complete the task correctly.

The task consists of using a hand grip and doing two types of exercises. The first exercise is holding closed the hand grip for a length of time while observing the iPad (Figure 2). The second exercise is opening and closing the hand grip a number of times and observing the iPad (Figure 3). Each participant will do the task for four sessions. They will receive four combinations of feedback during each session and the order in which they receive the combinations will be randomized for each participant. The feedback combinations for each session are the following:

1. V
2. V + A
3. V + H
4. V + A + H

Each type of feedback will be as simple as possible to allow the participant to focus on the task and not be distracted by the feedback. The purpose of the feedback to guide them while doing the task.

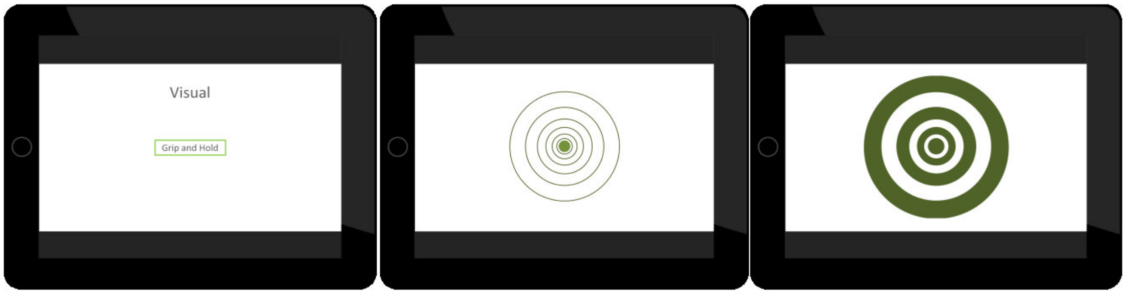

Figure 2: Example of Grip and Hold Exercise Images on iPad device

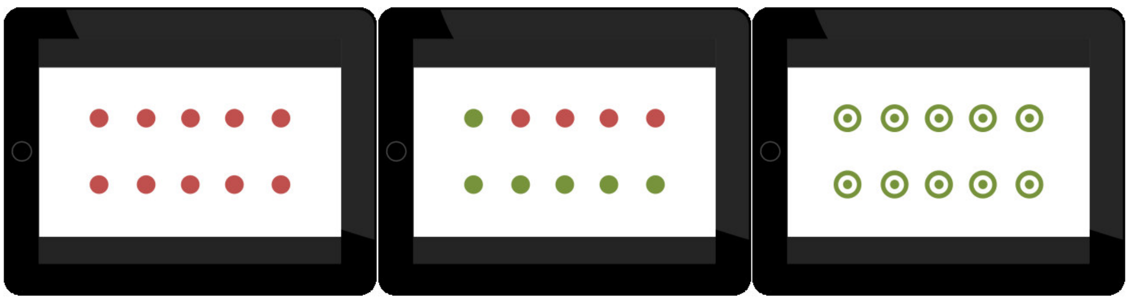

Figure 3: Example of Strength Exercise Images on iPad device

Feedback

Visual – The visual feedback will be displayed on the device's screen. It will display for each of the four sessions and be the same visuals each time.

Auditory – The touch screen device will emit sounds during the task. The sound will come from internal speakers in the device.

Haptic – The device itself will vibrate during the session via the small vibrating disk motor attached to the back and the participant will be holding the device in their hand or placed on their lap.

Steps

1. Participant will be given the device to hold in their hands or lap (Figure 4).
2. While holding and observing the device, participant will do the task and receive the first combination of feedback (any of 4) which is to assist with the exercise (Figure 5).
3. Participant may rest between each session.

4. Second session, another combination of feedback except the one done in 2.
5. Rest.
6. Third session, another combination of feedback except the one done in 2 or 4.
7. Rest.
8. Fourth session, final remaining combination of feedback (Figure 6).
9. Rest.
10. End of Part 2.

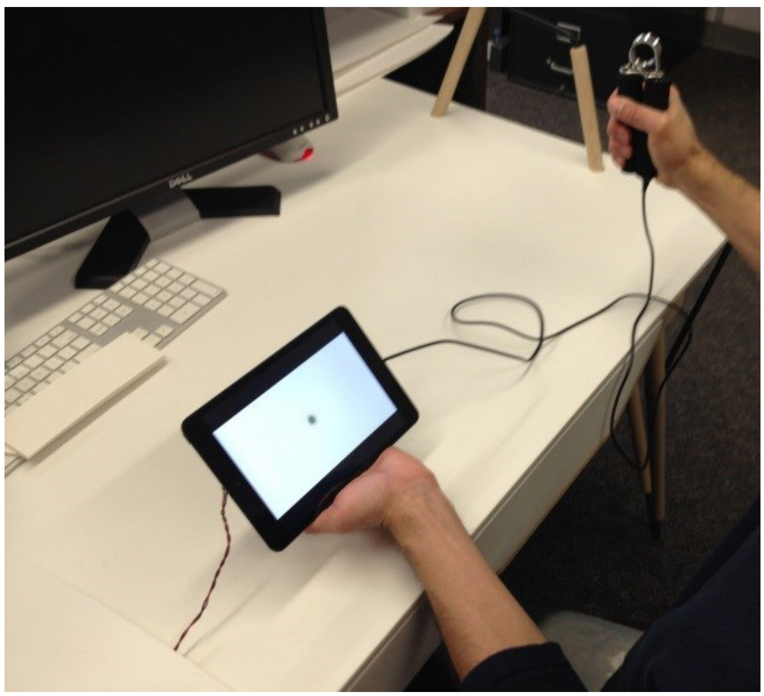

Figure 4: Participant starting the task

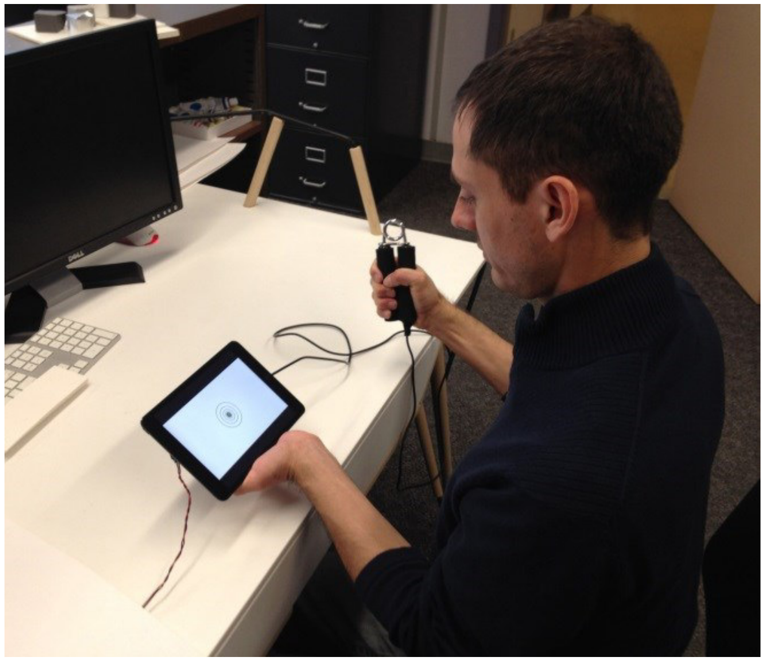

Figure 5: Participant doing the task

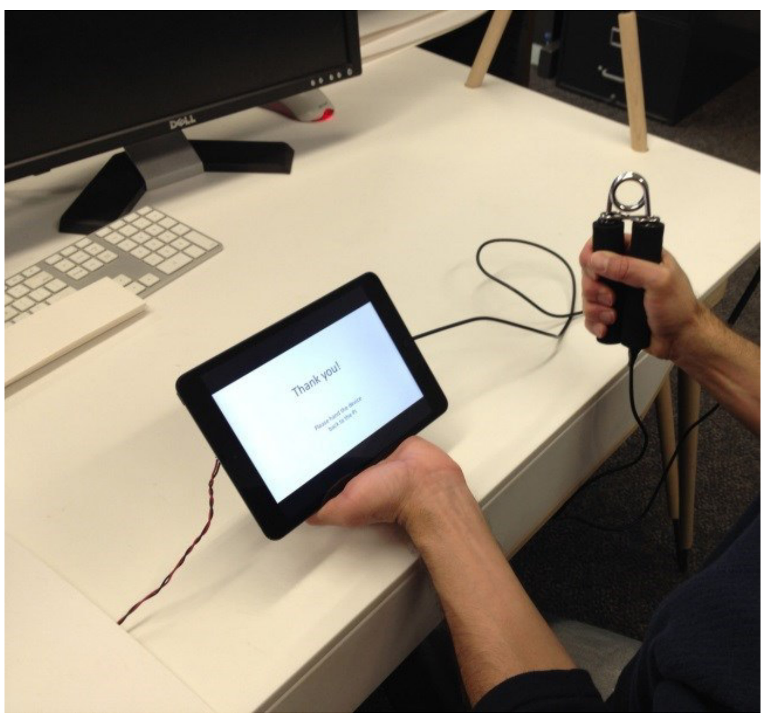

Figure 6: Participant finishing the task

Part 3 – Questionnaire 2

The questions in the follow-up questionnaire are to get their personal opinion and experience on the task done in part 2 of the study.

Summary

The primary research will consist of two questionnaires and a simple task to be done by the participants in a simulated app on a touch screen device. The feedback will be visual, auditory and haptic including the combinations discussed earlier. The results will let the researcher know if the feedback aided the participants in doing the task on the device. The results from this research are then to be analyzed and utilized in conjunction with the secondary research to produce design proposals.

Evaluation

The primary research that was done strongly indicates that feedback on touch screen user interfaces has not only a measurable and beneficial effect for the user to complete their tasks but the feedback has a subjective effect on the user as well. The comments given by the participants and the results from the questionnaire also seem to indicate this.

There were 20 participants, ten males and ten female between the ages of 19 and 64. Please note that all the spelling and grammar mistakes in the participants' quotes are their own.

Questionnaire 1

The results of the first questionnaire gave an insightful look into the participants' experiences with touch screen devices and feedback. One of the most noticeable results of the questionnaire was that all participants have had at least some experience with touch screen devices (Figure 7) and use them daily (Figure 8). Most were familiar with visual and auditory (Figure 9) but a fair number had not used devices or had experience with haptic feedback (Figure 10). A good number of participants had not used a device with all three types of feedback (Figure 11).

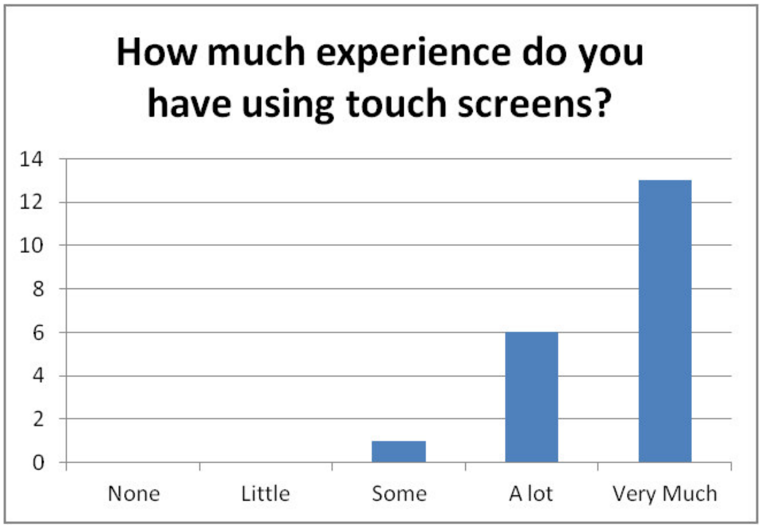

Figure 7: Participants' experience using touch screens

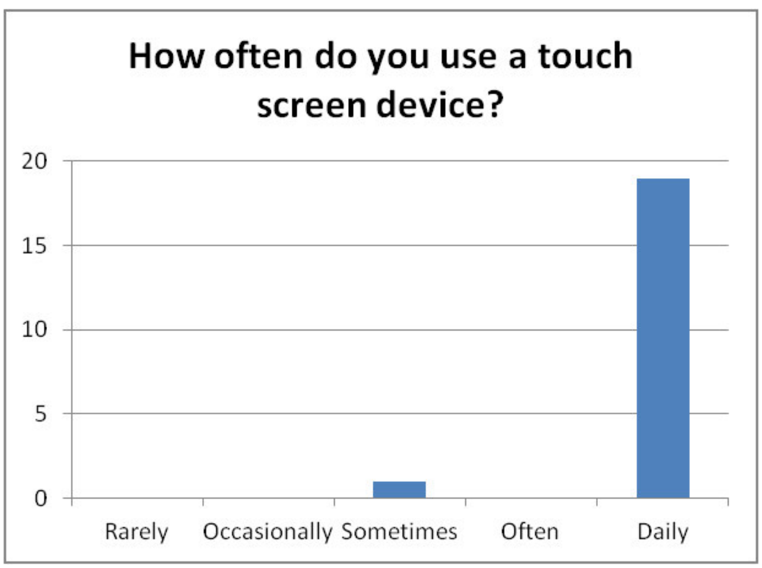

Figure 8: How often participants use a touch screen

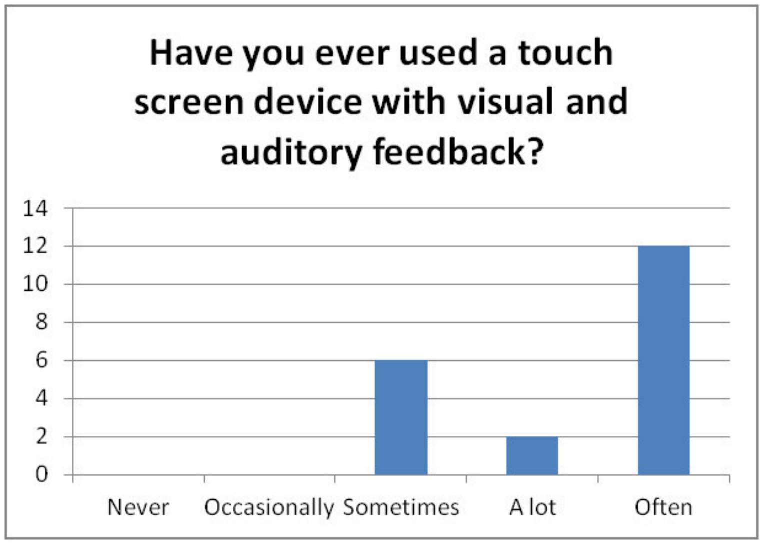

Figure 9: Has participant used a device with visual and auditory feedback

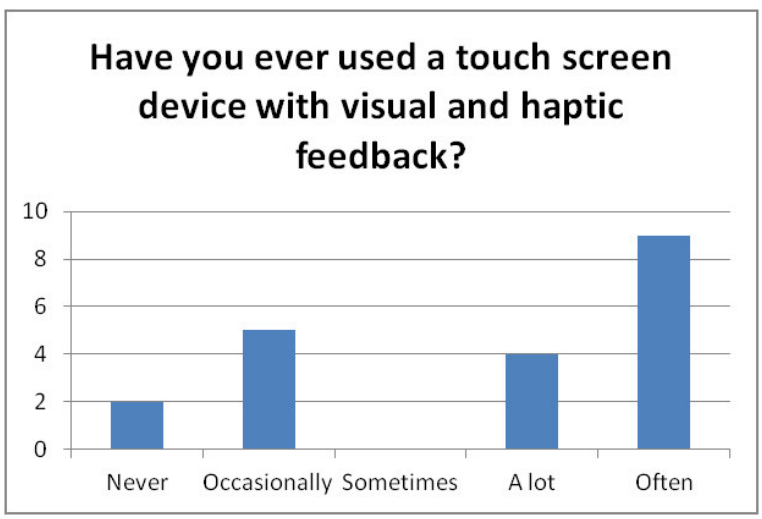

Figure 10: Has participant used a device with visual and haptic feedback

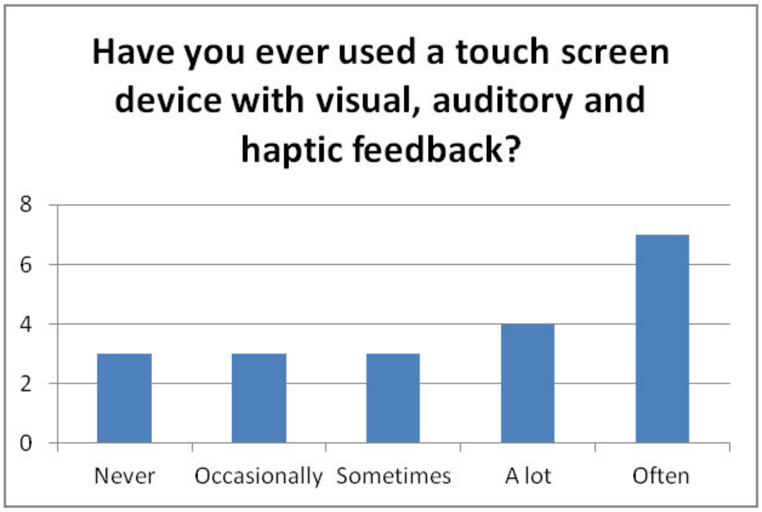

Figure 11: Has participant used a device with visual, auditory and haptic feedback

Much of the information written down by the participants in the questionnaire was varied and somewhat unique. When asked in question 5 to name a device with only visual feedback, many participants gave a whole range of answers. For example: computer screen monitor, iPhone, laptop, camera, watch, and EMG. This is in contrast to questions 9, 14 and 17 which asked about devices the participants had used with V + A, V + H, and V + A + respectively. The large majority of answers were smartphones (iPhones, Samsung Galaxy, etc.). This seems to indicate that for a large number of these participants, their primary experience with multi-modal devices are smartphones. (Appendix H).

Interesting responses given by the participants came from question 11 which asked "What kind of auditory feedback does the device provide?" with regards to a device which gave auditory feedback. The two main responses were "beeps" and "human voice" as the auditory feedback. It is worth noting that the auditory feedback for the devices used by the participants were as simple as a beep and as complex as a human voice with very little in between.

There was very little correlation between men and women with regard to the participants experience with the various types of feedback, as well as with regard to the participants' ages.

Looking at the ranking of the combinations of feedback (Figure 12), the most selected as "Least Helpful" was visual only, "Somewhat Helpful" was visual and auditory, "Helpful" was visual and haptic and "Most Helpful" was all three together. The combinations that were regarded as "Helpful" and "Most Helpful" both included haptic.

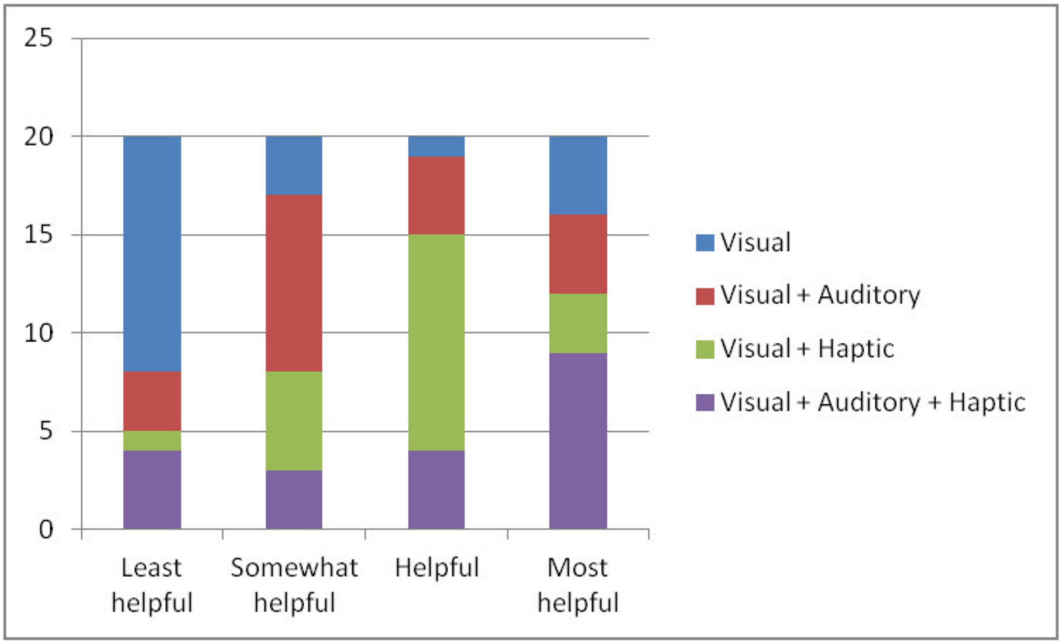

Figure 12: Ranking the combinations of feedback

Least Helpful

Some of the answers by the participants as to why visual by itself was considered the "Least Helpful" include the following:

"Not as much sensory input." (Participant 2).

"I'll say it's still helpful but not as impressive as other combination might provide." (Participant 8).

"Same reason as above, visual only interface doesn't give good user interface." (Participant 14).

"Visual feedback is essential but any singular type of feedback is limited in adaptability." (Participant 18).

"It would be difficult to multitask with only visuals, you would have to constantly look at it." (Participant 19).

The answers seem to indicate that visual by itself lacks information that might be helpful for the user.

Most Helpful

To contrast, the answers given by the participants to why V + A + H was the most helpful include the following:

"I think that by getting the most feedback as possible will apply to a wider audience. This would also help in more feedback to help others." (Participant 2).

"Has the most options." (Participant 5).

"Less room for error. The more signals put out, the higher the odds of them being received efficiently." (Participant 6).

"Its most helpful because it covers all the bases. Sometimes the vibration doesn't go off on my phone so having the visual light to back it up when I look at it helps. Same concepts applies for if I have it turned to sound." (Participant 9).

"If you need to be alerted to something on the device you are given more opportunities to notice." (Participant 16).

The general impression given by the participants seems to indicate that more information given by the device to the user is better.

Summary

The results of the first questionnaire gave an insightful look into the participants' experiences with touch screen devices. In demographics, there was very little correlation between feedback experience and age, and between men and women. All participants had some experience with touch screen devices and almost all use a touch screen device daily. Most had used a device with visual and auditory feedback but a few had never used one with some form of haptic feedback. Most of the participants rated visual only feedback as the "Least Useful" and all three types of feedback as the "Most Useful".

Questionnaire 2

The results of the second questionnaire provided some notable perspectives into the participants' opinions and experience regarding the different combinations of feedback in the study. The general trend in the answers given by the participants was that a combination of two feedbacks seemed to be ideal for many. Visual feedback by itself was always picked as at least "Mildly Helpful". The combination for all three types of feedback seemed to be considered by some of the participants as overwhelming and too distracting. Overall, the results seem to indicate that most participants preferred either just visual or a combination of two types of feedback, V + A feedback and V + H feedback.

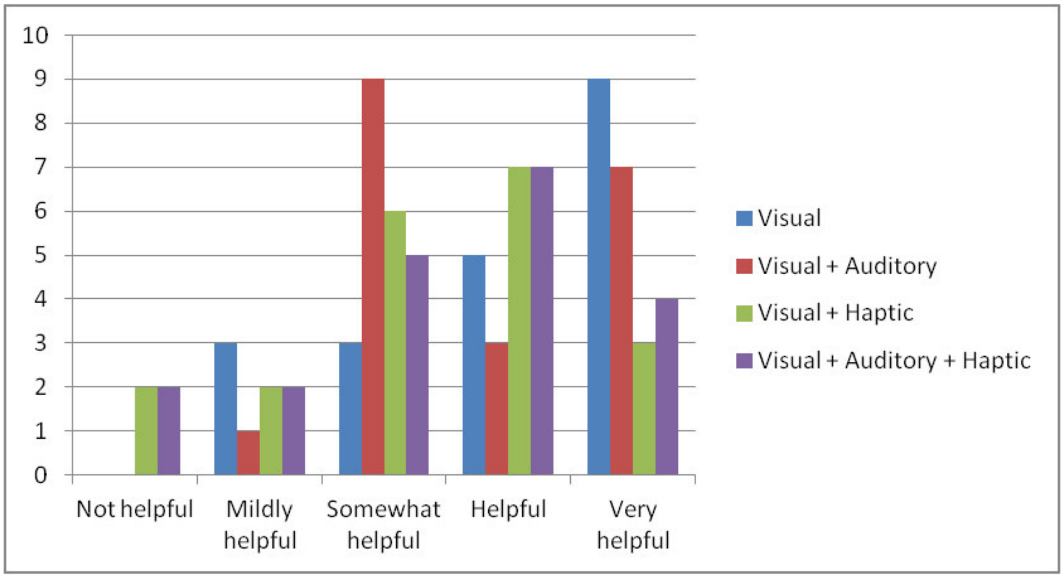

Figure 13: How helpful in completing the task with the combinations of feedback?

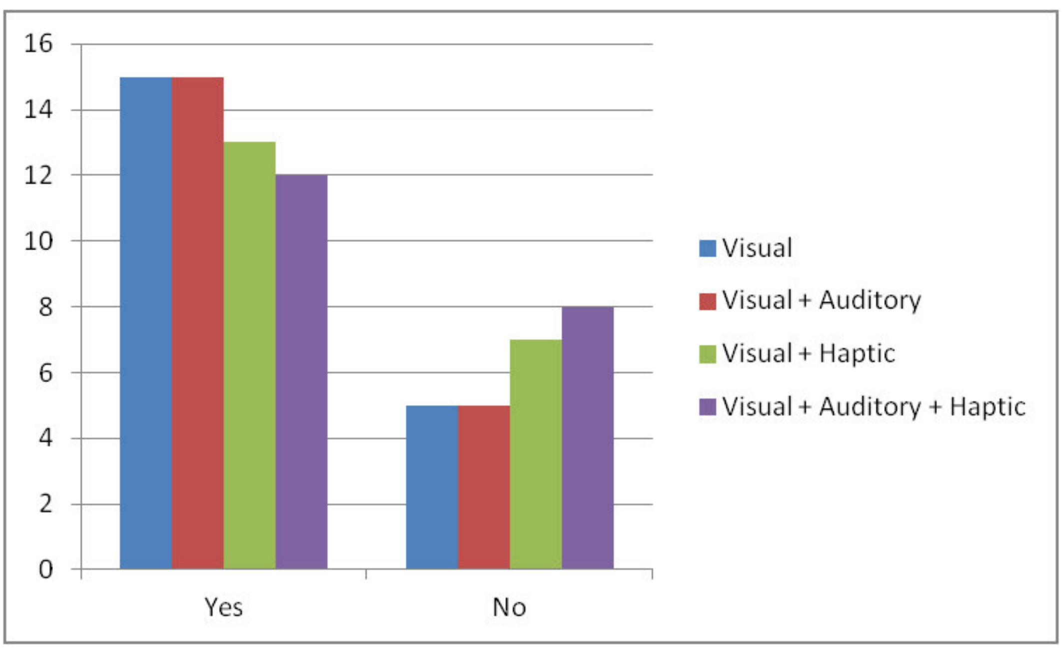

Figure 14: Did you feel that your performance of the task improved with the feedback?

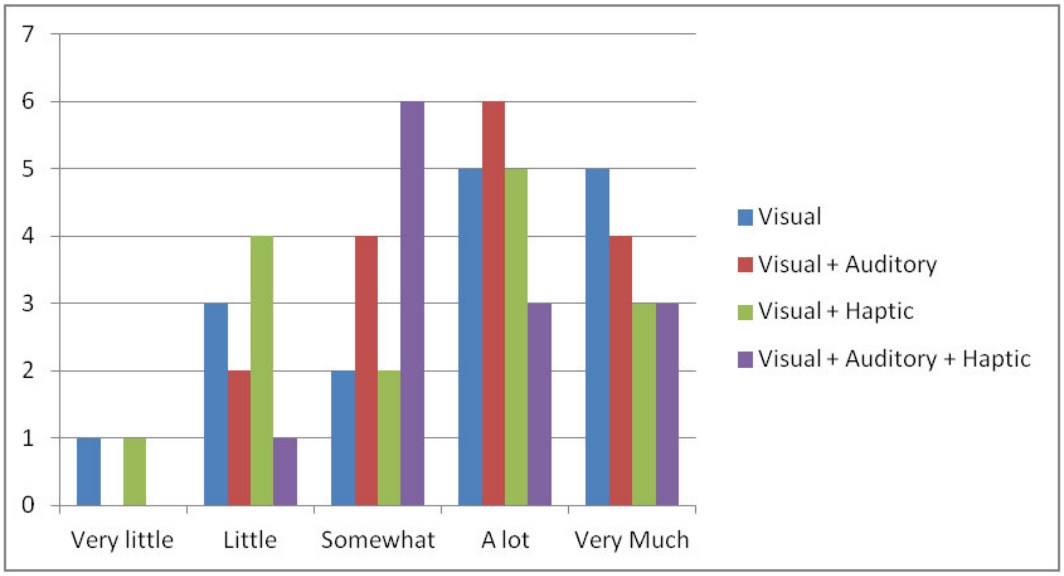

Figure 15: If yes, by how much?

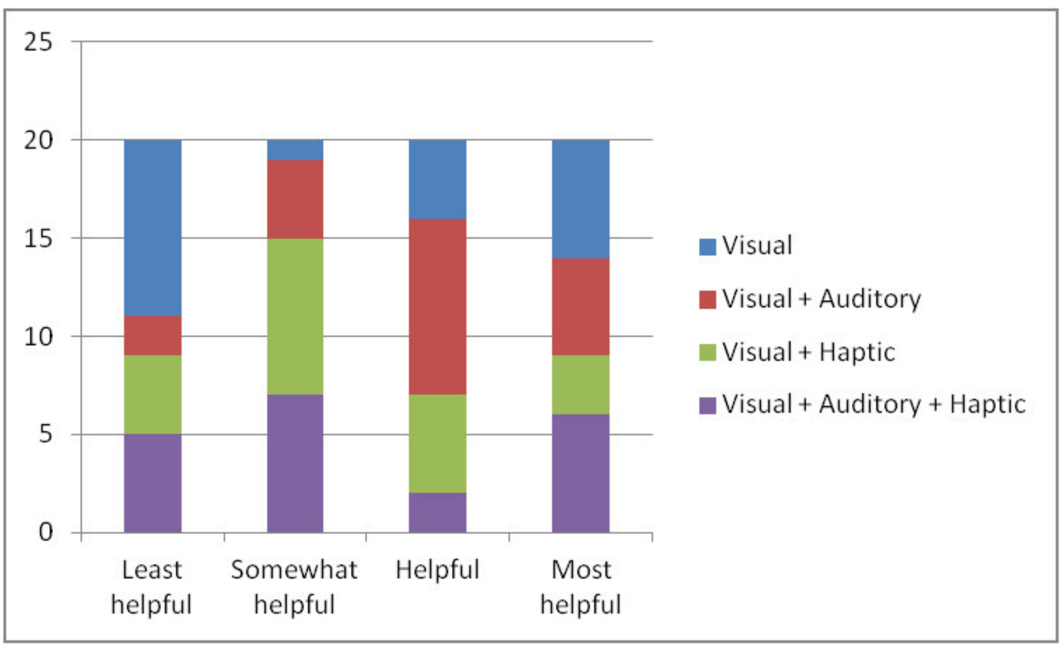

Figure 16: Ranking the combinations of feedback

Visual

A majority of participants considered visual feedback to be at least "Mildly Helpful" in completing the task and almost half selecting visual as "Very Helpful" (Figures 13 - 15). Most considered that the visual feedback improved their performance in completing the task (15/20 participants) and that it helped at least "Somewhat" or more. For the participants who did not think that the visual feedback helped in completing the task, some stated the following:

"I had to pay more attention to see if a "task" was being completed." (Participant 6).

"I got confused by the visual one time when doing the test. It works way better when it combines visual and haptic." (Participant 7).

"The visual feedback just seemed to time me, not motivate." (Participant 19).

There didn't seem to be a general consensus for the participants who thought that visual feedback helped in completing the task.

Visual + Auditory

The participants mostly considered V + A at least "Mildly Helpful" in completing the task with a good number selecting "Somewhat Helpful" and "Very Helpful" (Figures 13 - 15). The number was the same as visual only feedback that considered that V + A feedback improved their performance of the task (15/20 participants) and it helped at least "Somewhat" or better for most of the participants. For the participants who did not feel that V + A improved their performance, some of their reasons are as following:

"My attention was caught by the sound that I slightly forgot I have to squeeze the grips tightly." (Participant 8).

"I was still relying more the visual cue, the auditory didn't necessarily add to it." (Participant 10).

"The timing of the audio felt disconnected maybe it should follow after a full movement / task? Not during." (Participant 12).

"There was a delay in the auditory feedback that affect my rhythm of performing the task." (Participant 14).

The underlying feeling in their comments was that there seemed to be a disconnect between the audio and the visual and that caused problems to these participants.

Visual + Haptic

Most of the participants found V + H to be at least "Mildly Helpful" though a few participants did find V + H to be "Not Helpful" (Figures 13 - 15). A smaller number than before felt that V + H improved their performance of the task (13/20) and 6 thought that it helped "Little" or "Very Little" with the rest "Somewhat" or better. Some of the replies of the participants who did not feel that V + H improved their performance include the following:

"The buzzer was too forceful and distracting." (Participant 5).

"Same problem as the combination of visual and auditory, it's too disturbing for me." (Participant 8).

"I didn't feel any haptic feedback and the vibration was quite loud so it almost felt like a different auditory feedback." (Participant 10)

"Again, the timing felt off. The haptic feedback felt more like noise." (Participant 12).

"I heard the vibration rather than felt it at the grip, it would be more direct if I felt it at the grip." (Participant 13).

"I totally missed it! In my brain I think I just registered it as a sound because it was accompanied by a load buzz." (Participant 16).

The general consensus for these participants seems to be that the sound emitted by the vibrating disk motor used to simulate haptic feedback is too loud and was interpreted by these participants as sound instead of haptic feedback.

Visual + Auditory + Haptic

As above, most participants found this combination to be at least "Mildly Helpful" with a few as "Not Helpful" (Figures 13 - 15). This was the combination with the most participants indicating that it did not improve the performance of the task (8/20 participants) and for those that it did help, most indicated it helped improve at least a "Little" with most "Somewhat" or better. For participants who did not feel that this combination of feedback improved their performance of the task, some of the replies are as follows:

"I felt the haptic was redundant." (Participant 1).

"Too much going on." (Participant 5).

"Just too much". (Participant 8).

"The haptic vibration buzz overshadowed the auditory pop. Pretty much just relied on visual." (Participant 10).

"There were a lot of noises / senses to pay attention to, the task felt very distracting." (Participant 12).

"I have become used to the test procedure, the feedbacks did not help much." (Participant 14).

"I didn't really notice the auditory feedback until the last couple of dots, so it was mostly the same as visual + haptic." (Participant 19).

The overall response for these participants was that there was too much going on, too many noises and some of the feedback went unnoticed for some of these participants.

Overall Helpfulness

Looking at the ranking of the combinations of feedback (Figure 16), the most selected as "Least Helpful" was visual only, "Somewhat Helpful" was V + H and V + A + H, "Helpful" was V + A and "Most Helpful" was a tie between V and V + A + H.

Least Helpful

Some of the answers by the participants as to why visual by itself was considered the "Least Helpful" include the following:

"Because it was hard to follow." (Participant 4).

"Just visual feedback was too passive in comparison to others." (Participant 11).

"Not enough certainty." (Participant 13).

"Visual only feedback is not enough in user-interactivity of today's interface design." (Participant 14).

"I find it to be the most essential form of feedback, but alone it has failure potential due to a variety of circumstances (ex. distracted and look away from screen)." (Participant 18).

"Just visual didn't ever make me feel like I wanted to try harder, and it was easier to lose focus. The only signifier was color change for when the task was done. It was not as rewarding." (Participant 19).

The answers seem to indicate that visual by itself was not enough and did not really motivate these participants to complete the task.

Most Helpful

To contrast, the answers given by the participants to why visual only and V + A + H were the most helpful include the following:

Visual

"I really only paid attention to the visual. Auditory and haptic was largely ignored or even went unnoticed." (Participant 3).

"I can completely concentrate on one thing." (Participant 8).

"Clarity of input not mixed signals." (Participant 10).

"It seemed appropriate and simple. Feedback was fast and clear. No extra feedback necessary." (Participant 12).

V + A + H

"Felt like I was able to understand and have a more rhythmic pace." (Participant 2).

"More confirmations." (Participant 13).

"I can see, hear and feel." (Participant 15).

"Visual (for me) is the most important / dominant. But it was an enhancement having a more robust system." (Participant 18).

There is a clear contrast between the two combinations of feedback. The consensus for those who prefer visual only is that it is simple, clear and they can focus on only one thing. The general impression given by the participants who preferred V + A + H seems to be that more feedback was better due to having more confirmation. As well as seeming more robust i.e. more feedback was better in case one type of feedback was not noticed by the user.

Summary

A good number of the participants had some final thoughts and suggestions regarding the study. Many of their observations are useful to understand what users in general consider regarding the types of feedback. Some were generic comments with regards to feedback in general:

"Limiting the types of feedback to only what the user requires, too much conflicts with the ability to complete the task efficiently." (Participant 6).

"The feedback is best to be simulating real like experiences." (Participant 13).

Most other comments were about specific feedback, for examples as participant 19 stated "For something that requires physical effort, haptic feedback make the most sense because it is the closest to what I am experiencing". Other comments:

"Perhaps utilizing haptic and auditory responses opposite of each other as to not use them simultaneously." (Participant 4).

"Sounds could be more interesting. Sounds in "Hold" section should be different than other sessions." (Participant 7).

"Just visual is good if you are expecting full attention without any help. The change on the screen (clue) is just enough clue to know that you are moving forward. Visual + auditory and visual + haptic are alarming enough to grab attention and not allowing to sway. Visual + auditory + haptic is annoying till the point it confuses." (Participant 11).

"The exact timing of feedback seems important in connecting the task and feedback together, especially for audio and haptic." (Participant 12).

"Maybe a sound that is pleasing to indicate I have completed the task." (Participant 16).

"Haptic + auditory differentiation to indicate progress. I want the 10th rep to feel more significant than the 3rd. Increases motivation and is a satisfying reward to the exercise." (Participant 18).

"The visual as the only one told me how many more trials I still had left or how much longer I still had to go. The auditory feedback felt like a reward. The haptic almost let me know that the device was working and reading my muscle contraction. It was also a nice distraction from muscle fatigue. All 3 together worked as a strong reinforcer to keep help me contract for longer (like a feedback cheering squad)." (Participant 20).

These comments indicate the variety of the participants' experience with the study as well as how different the suggestions are to improve feedback for the study and touch screen devices in general.

The results from the second questionnaire shed light on the different feedback combinations in the study. The one combination that did not improve the performance for a large number of participants was V + A + H. Some of the participants felt overwhelmed by the feedback and found it too distracting. The combinations that improved the performance of the task the most were V and V + A, followed by V + H.

This result could be due to the fact that most participants had more experience with visual and auditory feedback over haptic feedback as seen in questionnaire 1. There could be other reasons as well which will be explored in the following section.

Discussion

As indicated in the previous section, there were large amounts of information gathered in the study. This section will look at the results and attempt to understand how they may be used for possible design solutions or recommendations.

Performance

It is important to note when the feedback did not assist the participant with the performance of the task. This information may provide more understanding into what doesn't work and potentially why it didn't help the participant with the task. Please note that all the spelling and grammar mistakes in the participants' quotes are their own.

Visual

Five participants felt that the visual feedback did not improve the performance of the task (Questionnaire 2, Question 2). Participant 19 stated "The visual feedback just seemed to time me, not motivate." Participant 7 preferred V + H, "I got confused by the visual one time when doing the test. It works way better when it combines visual and haptic."

V + A

Five participants did not feel that the visual and auditory feedback improved their performance of the task (Questionnaire 2, Question 6). Participant 10 noted "I was still relying more the visual cue, the auditory didn't necessarily add to it." Participant 14 stated "There was a delay in the auditory feedback that affect my rhythm of performing the task."

V + H

For visual and haptic feedback, seven participants did not feel that this combination of feedback improved their performance of the task (Questionnaire 2, Question 10). Two notable responses from these users are "The buzzer was too forceful and distracting." (Participant 5), and "Again, the timing felt off. The haptic feedback felt more like noise."

V + A + H

For this combination, eight participants felt that their performance of the task did not improve (Questionnaire 2, Question 14). The participants were much more direct in their answers, "Too much going on." (Participant 5), "There were a lot of noises / senses to pay attention to, the task felt very distracting." (Participant 12), and "The haptic vibration buzz overshadowed the auditory pop. Pretty much just relied on visual." (Participant 10).

It is notable that the number of participants whom did not feel that the feedback improved the performance of their task was only 5 in both visual only and visual and auditory. The number grew to 7 and 8 in visual and haptic and all three feedbacks together despite the fact that the order of the feedback combination was randomized for each participant. The participants' responses tended to indicate that "It was too distracting and overwhelming having that many types of feedback" (Participant 6), and there was "Way too much information to pay attention to" (Participant 12). Participant 14 did prefer visual and haptic, "Visual + haptic provides best feedback to the user. The more feedbacks provided are not always the best. Just enough feedbacks are better." This comment by participant 14 brings up a good point and is very useful for this study.

Summary

In evaluating the results of the questionnaire, especially the comments made by the participants with regards to the specific combinations of feedback two main results are notable. The first is that the data and comments strongly indicate that simply adding more feedback is not necessarily better. The combination with the three types of feedback was the least helpful. The second result is that when the haptic feedback is in the combination of feedback, the helpfulness of the feedback is reduced as well. Many of the participants themselves explained why this was. More study will be needed to understand how haptic feedback can be improved so haptic does not reduce the helpfulness of the tasks to be done.

Overall, the two most successful and helpful combinations for this study were visual only and visual and auditory feedback. It could be because these are the feedback that most people are familiar with. Haptic is new and rarely used for most users. The next section will look at design recommendations in how all types of feedback can be used to improve user performance of their tasks on touch screen devices.

Design Recommendations

In looking for design solutions, it is important to take into consideration the secondary research and the results from the study that was done for this paper. One of the main goals is for the participant to want to continue to use the device and be motivated through the use of proper feedback on the touch screen device. As the research indicates, feedback is an essential part of using a touch screen device and it assists with motivation for the user to continue its use. The study conducted also strongly indicates that feedback is essential in assisting and motivating the user during the task.

As helpful as feedback may be to the participants in the study, there was a difference in which combination worked best for each participant. In all of the solutions, visual feedback is the one mode of feedback that is constant. Visual feedback is necessary even if a user looks away for a moment or closes their eyes, as long as the user looks back or reopens their eyes, the visual feedback is relevant.

The status quo with regards to feedback on many devices seems to be that the types of feedback are independent of the others. Visual feedback displays to the user in the same way regardless whether haptic or auditory feedback is enabled or not. Auditory feedback will give the user the necessary feedback and visual feedback will not be affected in any way by the auditory feedback. In the same way, haptic feedback causes the device to vibrate when necessary and the visual and auditory (if enabled) will not be affected by it. There are few advantages over other potential solutions. It is simpler and does not require much design or programming by the device manufacturers. This system worked well when touch screen devices began to appear in the market but with newer technologies and more research, other solutions for feedback and user experience are necessary.

Based on the background research and primary research results, this paper offers three initial possible design recommendations for the Mobili-T project. They are described in the following sections.

As well, this paper offers two general design recommendations to improve the experience of users with touch screen devices. These are Interdependent Feedback and Feedback Intensity.

Mobili-T Design Recommendations

In the following sections, three design solutions are offered for the Mobili-T project to possibly assist patients with their swallowing therapy. Each solution is applied to two therapy components, one for a swallow hold and the second for multiple swallows. They are based on the primary research where the participants applied a force to the hand grip and held it closed for a certain amount of time and when they opened and closed the hand grip for a certain number of repetitions.

1. Reach the Target

The goal of this design is to reach the target at the far end of the screen. The patient does the swallowing exercises and as they do, the small circle at the left side of the screen moves across toward the goal. The goal of this design is to increase the concentration of the patient by focusing on the movement of the item on the screen.

For the swallow hold exercise, the circle moves in one continuous line while the patient holds the swallow. Once the goal is reached, the feedback will indicate to the patient that they may release holding the swallow. If the goal is not reached for whatever reason, the screen visuals will indicate to the patients the locations of their previous attempts. (Figure 17). The length of the swallow hold would be set by the clinician.

For the multiple swallow exercise, the patient will see a number of small goals to be reached before the main goal. Each swallow will move the small circle toward each small goal and finally to the final target. The number of goals/swallows would be set by the clinician. (Figure 18).

The auditory feedback for this design will work best if the patient is using stereo headphones. The audio will be simple beeps and tones for the initial design. The sound will begin on the left side and move towards the centre and the right as the swallowing therapy take place. This will assist the patient, if for whatever reason they close their eyes they still get feedback on their progress.

The haptic feedback in this case would be mild and continuous as the patient holds the swallow and the circle moves across the screen. When the final target is reached, the vibration will speed up and stop to indicate the exercise has finished. For the smaller goals in the multiple swallow exercise, as each small target is reached, the vibration will speed up slightly and then stop until the next swallow starts.

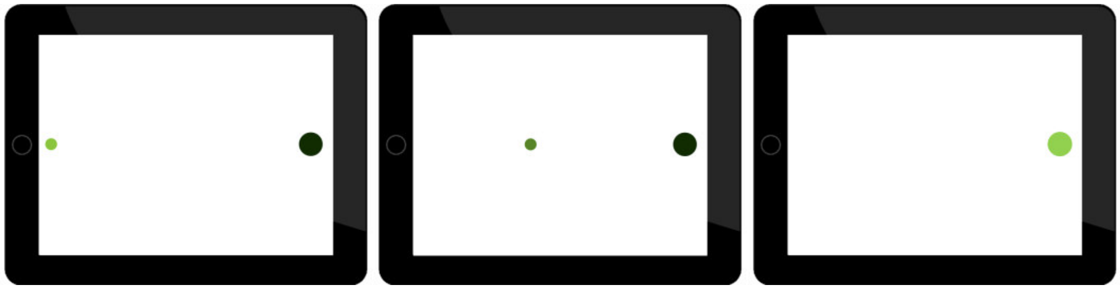

Figure 17: Reach the target - Swallow Hold

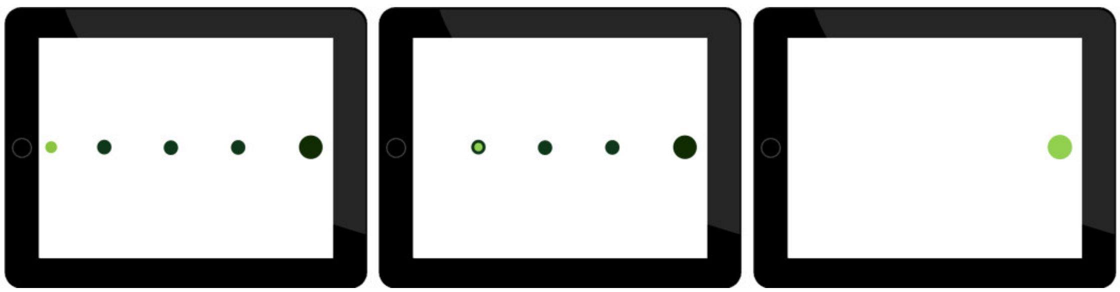

Figure 18: Reach the target - Multiple Swallows

2. Fill the Circle

For this design solution, the goal is to fill the circle on the screen. The patient performs the swallowing exercises and while they do the exercise, the circle on the screen is assembled on the screen. The aim for this design is for the patient to want to complete the therapy session in order fill up the image on screen.

While the patient does the swallow hold exercise, the circle is filled in a clock-wise direction. When the swallow hold exercise is successfully completed, the circle is fully displayed on the screen. In case the exercise is not completed successfully, visuals on the screen will indicate to the patient how far their previous attempts were. The length of the exercise can be set by the clinician. (Figure 19).

For the second exercise, the multiple swallows, on the screen there will be lines that indicate the number of swallows to be done to complete the circle. At each swallow that the patient performs, the circle will fill in a certain amount. For example, if there are three swallows to do, each swallow will fill the circle a third of the circle. The clinician would set the number of swallows. (Figure 20).

In this design, the auditory feedback that the patient will hear during the therapy will be a pentatonic scale of ascending musical notes. As the circle begins to fill, the sounds will be at a low note and slowly ascend in scale as the circle completes. When the circle is all filled in, the final note will sound and the audio will stop. The sound will be continuous for the swallow hold therapy and for the multiple swallows it will start and stop with each individual swallow.

The haptic feedback while the circle is filled would vibrate while the patient holds the swallow. When the circle is completely filled, the vibration will speed up and stop to indicate the swallow hold exercise has completed. For the multiple swallow exercise, the vibrations will occur in short bursts in conjunction with each swallow. For the final swallow, the vibration may speed up slightly as the final swallow ends and the circle is filled in.

Figure 19: Fill the circle - Swallow Hold

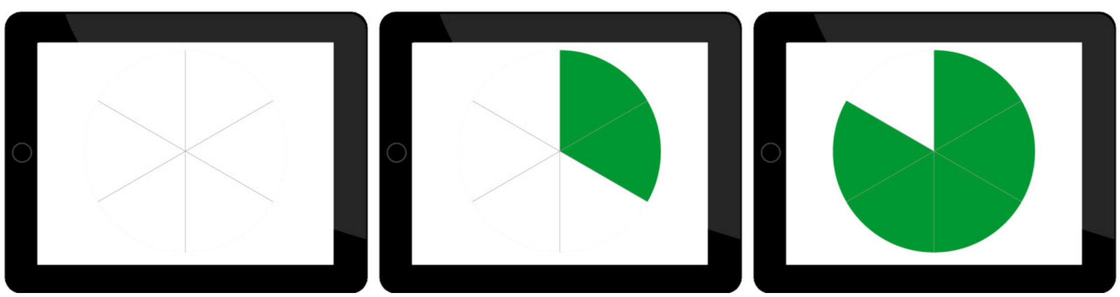

Figure 20: Fill the circle - Multiple Swallows

3. Sweep the Screen

In the third design solution, the goal of the patient while doing the exercises is to change the colour of the entire screen by sweeping a vertical bar across the screen. This design's purpose is to maximize concentration and to want to complete the therapy session as in the above two design solutions.

As the patient does the swallow hold exercise, the vertical bar will move in a left to right direction across the screen. As the bar moves while the swallow is being held, the colour will change. If for any reason, the exercise ends before the entire screen is a different color, there will visuals for the patient to let them know of their previous attempts. How long the patient needs to hold the swallow is set by the clinician.

As in the first design, the audio will be initially simple beeps and tones. The auditory feedback will work best when stereo headphones are used by the patient. During the swallowing therapy, the auditory feedback will start on the left side and move towards the centre and finally to the right. In case the patient closes their eyes, they will still be able to get feedback on their progress. (Figure 21).

For the multiple swallows exercise, the screen is divided into a number of sections by vertical bars indicating the number of swallows that need to be done. For each swallow completed, each section will change colour. For example, if the patient needs to complete four swallows, the screen is divided into four sections. Each swallow will sweep the bar to across each section and change that particular section's colour until the entire screen has changed colour. The number of swallows is set by the clinician. (Figure 22).

As the bar sweeps across the screen, the haptic feedback for the swallow hold exercise would vibrate mildly and continuously. As the bar nears the edge, the vibration would speed up slightly and stop to indicate to the patent that the exercise has completed. In the multiple swallows exercise, the vibration will occur during each swallow and stop when the swallow completes. It will continue in this fashion until the final swallow where it will speed up slightly.

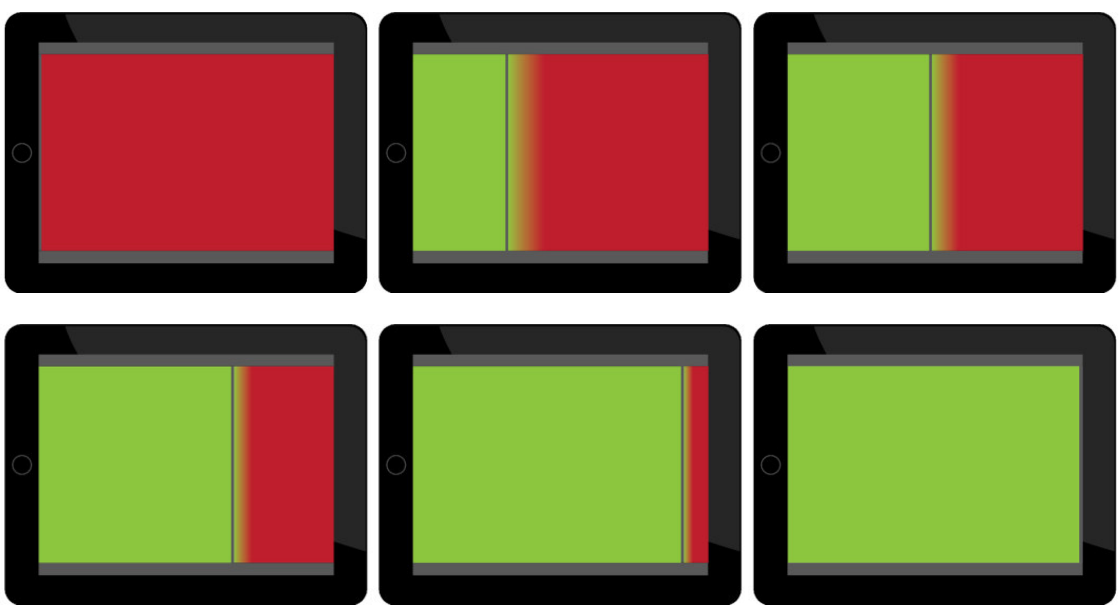

Figure 21: Sweep the screen - Swallow Hold

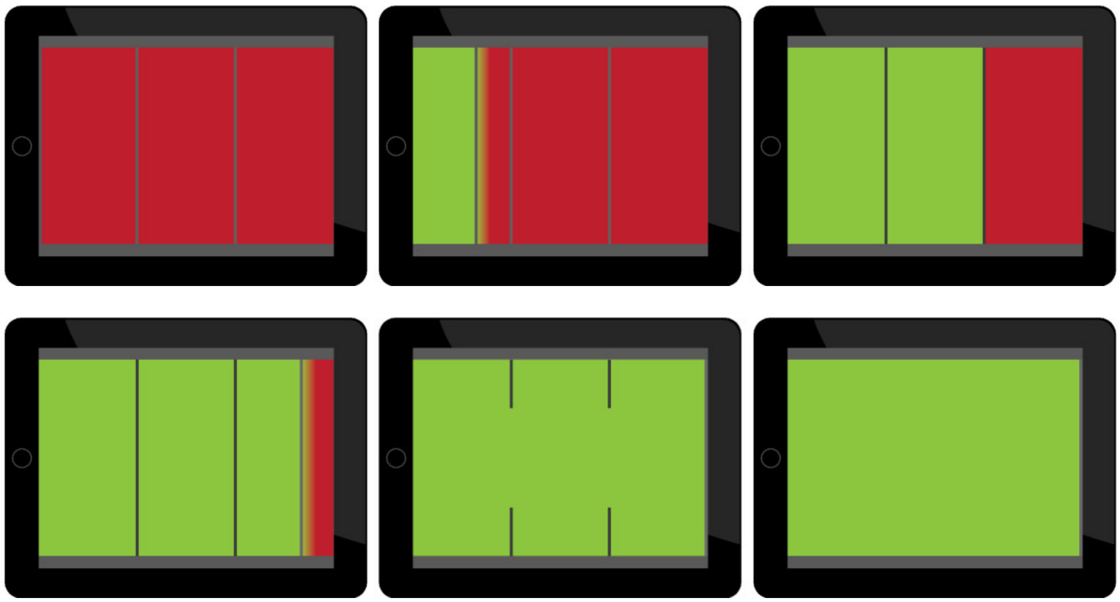

Figure 22: Sweep the screen - Multiple Swallows

In all of the above design solutions, the clinician will be able to adjust and customize the feedback to better benefit the patient in their therapy. The main goal of the designs is to better assist patients with their swallowing therapy. Further research will need to be done along with testing the designs with the Mobili-T project to improve the designs in the hopes that they will eventually be beneficial for the patients' swallowing therapy.

General Recommendations

1. Interdependent Feedback

In this design proposal, the feedback that the user receives during the task or exercise will be slightly different depending on the current combination of the feedback. Each feedback will be interdependent with the other feedback. Since visual feedback is the main feedback that will be available in all combinations, it will be the most dependent with respect to the other two types of feedback.

Visual Only

This is the simplest mode and as such, any visual feedback in this mode will be unaffected since there is no other feedback to affect it.

V + A

When auditory feedback is used, the visual elements in the screen can change colour and tone slightly in sync with the sound. The visual elements will return to their original colour and tone as soon as the sound completes. The changes will be subtle enough as to not distract the user but noticeable enough that they will be evident to the user.

V + H

In this combination of feedback, the visual elements on screen will slightly vibrate in sync with the actual physical vibration of the device. This will give the user the illusion that the physical vibration of the device has affected the visual elements in the screen. This will help to emphasize the haptic feedback and amplify its effect on the user when they are looking at the screen.

V + A + H

In this combination, all three types of feedback will affect each other. Visual elements will be interdependent on the auditory and haptic feedback as explained in the V + A and V + H combinations above. The visual elements will both vibrate and change colour in sync with the audio and the vibrations of the device. This will help emphasize to the user the feedback and assist them in completing any tasks with the device. An optional component of this design solution would be that auditory feedback and haptic feedback would also affect each other. The audio could sound slightly distorted to give the effect that the vibration has affected the auditory feedback. The haptic feedback could vibrate more in sync with the sound; again to give the effect that the auditory feedback has affected the haptic feedback. Both haptic and auditory affecting each or one affecting the other could be options for the user. Of course it can be overwhelming to some users and as such, they will always be able to choose which combinations of feedback they prefer.

2. Feedback Intensity

In this design proposal, to motivate the user to continue using the device, the feedback would become more intense as the exercise or task is being completed by the user. The device would track if the user started to slow down significantly toward the end of the task, and the feedback that the user receives would become more intense. The intensity of the feedback would be calibrated by the device to find the combination of feedback that would assist the user the most in completing the task.

Visual Only

When there is only visual feedback, the visual elements would become brighter and more intense as the user slows down with the task. As the user begins to return to doing the task at a normal speed or pace, the visual elements would return to their original brightness and intensity. The visual elements may even change colour or intensity slightly from what they were originally to indicate to the user that the task was completed successfully with the extra effort noted.

V + A

Along with the changes in the visual feedback indicated above, auditory feedback will also become more intense to motivate the user. The feedback can become slightly longer and louder in response to the user slowing down or seeming to lose interest in the task. As both the visual and auditory feedback become more intense and the user returns to the normal speed or pace, the feedback can return to normal or change slightly from what they were originally to indicate to the user that their extra effort in returning the normal pace and completing the task was noticed.

V + H

Along with the same changes for visual feedback indicated above, haptic feedback will increase in intensity to help motivate the user. The haptic feedback would vibrate a little longer with more intensity in response to the user seeming to lose interest or motivation in completing the task. Again, as indicated above, the visual and haptic feedback would return to normal as the user returns to the normal or previous pace of the task. When the feedback reduces its intensity as the user returns to a normal pace and completes the task, the feedback can change slightly to let the user know that the extra effort was noted in finishing the task.

V + A + H

This combination of feedback would be the same as the two combinations described above. All three types of feedback would increase in intensity to help motivate the user to complete the task. The same ideas would apply in this combination; one or a combination of the feedback or even all three could vary in their intensity. Again, as the user becomes more motivated and completes the task or just returns to a normal pace, the intensity of the feedback would return to normal. There could be slight difference in each of the feedbacks to confirm to the user of the extra effort in completing the task.

In both of the above possible design solutions, the user will be able to adjust and customize the feedback to his or her liking. The device or app would also note which variations of the feedback intensity or which interdependent feedback works the best to maximize the motivation for the user to complete the task.

Future Research

The background and primary research and results of this paper have generated possible ideas and opportunities for further research and study. Some ideas are for immediate short-term improvements and others are for long-term enhancements of feedback for touch screen devices.

Short-Term

In the short-term, the results from this research will hopefully be used to assist patients with swallowing therapy for the Mobili-T project. It is hoped that the clinicians will use these types of feedback when assisting patients with their swallowing therapy. For two of the design solutions for the Mobili-t project, “Reach the Target” and “Sweep the Screen”, where the visual and audio move left to right, it may be beneficial to use haptic pads. A haptic pad can be placed on each side where the patient sits to do their therapy and would place their hands on each pad. The patient would feel the vibrations move from left to right in sync with the visual elements.

Another short-term opportunity to apply the results in general, can be that app developers start to use the auditory and haptic capabilities of the devices on which they create apps. Many apps do not use the capabilities of their devices to their full potential and this one instance where their use can have an immediate and positive effect on the user. Of course, simply adding more feedback is not enough and this leads to looking at long-term ideas and further research.

Long-Term

The design solutions for the Mobili-T project are basic and somewhat simple but this is necessary to test them out to discover what patients prefer. They are currently at a very early stage and once some hands-on research has been done with patients and the designs, more complexity may be added to the solutions. For example, in the “Reach the Target” solution, the simple circle can become a basketball and each swallow is a bounce before going into the basketball net. Maybe it can be a beach ball that bounces along a beach. For the “Fill the Circle” solution, instead of a very simple circle, the image can become a pizza or a clock face. An idea for the “Sweep the Screen” solution can be that instead of a colour change, an image is revealed. Perhaps a picture of a landscape, family and friends or maybe a comic where an individual swallow reveals each panel in the comic. More complexity can be added to make the solutions more game-like and more enjoyable and interesting for the patient.

The use of basic shapes allows the substitution of the shapes with the more complex ideas mentioned above. One original possibility for the design solutions could have been to use numbers and letters instead of basic shapes and colours. This idea was not used for a few reasons. One reason was the need to find a good typeface that would have been easy to read for the patients. The main reason numbers and letters were not used was that they would not be easy to substitute with the more complex ideas mentioned above.

Research into sounds and audio is something that will need to be studied further. It is currently out of the scope of this project yet audio and sound research is something that is very important for the future success of the design solutions. For example, ideas used in sound therapy may have some insight into what type of audio feedback may be best for patients. Proper audio feedback may be able motivate and assist patients in addition to the visual components of the design solutions.

The general design solutions suggested in this paper can be implemented and studied to see if they do in fact improve the experience for users. Both design solutions involve some form of user specific calibration of the feedback. Getting the feedback to be customized and calibrated for specific users to motivate them and improve their experience with touch screen devices will require greater collaboration between software programmers, engineers and designers. Another idea for long-term improvement in the use of feedback is education for users to be more receptive to feedback. As more and more people use touch screen devices, some may be unfamiliar with feedback and may need to learn about it to improve their experience. How this is done remains up to future researchers. In the end, more research will be needed to better understand how feedback can be improved and personalized for individual users.

Conclusion

Touch screen devices have come a long way since their introduction and their popularity among consumers has grown significantly. These include consumer electronic touch screen devices such as smartphones, tablets, consoles in cars and various others. As well as non-consumers devices such as in ATMs, store checkouts and medical equipment. It is with these touch screen devices and many others in mind, that the goal of this paper and study is to improve the experience for users.

This study looked at three types of feedback in touch screen user interfaces. These were visual feedback, auditory feedback and haptic feedback and four combinations of these feedback (V, V+ A, V + H, V + A + H). This was done to better understand how users interact with the devices with respect to the feedback they receive and to improve the experience during the use of the device especially with respect to health care devices and health applications on the device itself.

The results of the questionnaires strongly indicate that multi-modal feedback had an overall positive effect on the task done by the users in the study. This indicates that proper multi-modal feedback can be used with other devices and health care applications to improve user motivation and participation. Much more research and study will be needed to further understand and improve how feedback can be better utilized in order to motivate the user to continue using the device, especially with respect with health care applications.

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List of Appendices

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1.1 Study Identification

*All questions marked by a red asterisk * are required fields. However, because the mandatory fields have been kept to a minimum, answering only the required fields may not be sufficient for the REB to review your application.*

Please answer all relevant questions that will reasonably help to describe your study or proposed research.

1.0 * **Short Study Title** *(restricted to 250 characters)*:
Feedback on Touch Screen User Interfaces

2.0 * **Complete Study Title** *(can be exactly the same as short title)*:

Understanding Feedback on Touch Screen User Interfaces - The interaction of feedback and the user experience with products on touch screen user interfaces

3.0 * **Select the appropriate Research Ethics Board (***Detailed descriptions are available by clicking the HELP link in the upper right hand corner of your screen***):**
REB 2

4.0 * **Is the proposed research:**
Unfunded

5.0
* **Name of Principal Investigator** *(at the University of Alberta, Covenant Health, or Alberta Health Services)*:
Juan Fajardo

6.0
Investigator's Supervisor *(required for applications from undergraduate students, graduate students, post-doctoral fellows and medical residents to Boards 1, 2, 3. HREB does not accept applications from student PIs)*

Robert Lederer

7.0 * **Type of research/study:**
Graduate Student - Thesis, Dissertation, Capping Project

8.0 **Study Coordinators or Research Assistants:** People listed here can edit this application and will receive all HERO notifications for the study:

Name	Employer

There are no items to display

9.0 **Co-Investigators:** People listed here can edit this application but do not receive HERO notifications unless they are added to the study email list:

Name	Employer

There are no items to display

10.0 **Study Team** *(Co-investigators, supervising team, other study team members):* People listed here cannot edit this application and do not receive HERO notifications:

Last Name	First Name	Organization	Role/Area of Responsibility	Phone	Email

There are no items to display

1.5 Conflict of Interest

1.0
* **Are any of the investigators or their immediate family receiving any personal remuneration (including investigator payments and recruitment incentives but excluding trainee remuneration or graduate student stipends) from the funding of this study that is not accounted for in the study budget?**
○ Yes ◉ **No**

Appendix A

If YES, explain:

2.0 * **Do any of investigators or their immediate family have any proprietary interests in the product under study or the outcome of the research including patents, trademarks, copyrights, and licensing agreements?**
Yes **No**

3.0 **Is there any compensation for this study that is affected by the study outcome?**
Yes **No**

4.0 **Do any of the investigators or their immediate family have equity interest in the sponsoring company? (This does not include Mutual Funds)**
Yes **No**

5.0 **Do any of the investigators or their immediate family receive payments of other sorts, from this sponsor (i.e. grants, compensation in the form of equipment or supplies, retainers for ongoing consultation and honoraria)?**
Yes **No**

6.0 **Are any of the investigators or their immediate family, members of the sponsor's Board of Directors, Scientific Advisory Panel or comparable body?**
Yes **No**

7.0 **Do you have any other relationship, financial or non-financial, that, if not disclosed, could be construed as a conflict of interest?**
Yes **No**

If YES, explain:

Important
If you answered YES to any of the questions above, you may be contacted by the REB for more information or asked to submit a Conflict of Interest Declaration.

1.6 Research Locations and Other Approval

1.0 * **List the locations of the proposed research, including recruitment activities. Provide name of institution or organization, town, or province as applicable**
The proposed research will take place at the University of Alberta in Edmonton. The recruitment will be conducted via email and sent to potential participants. The potential participants will reply to the email if they would like to participate or not. The participants will mostly be members of the Faculty of Art and Design.

2.0 * **Indicate if the study will use or access facilities, programmes, resources, staff, students, specimens, patients or their records, at any of the sites affiliated with the following** *(select all that apply):*
Not applicable

List all facilities or institutions as applicable:

3.0 **Multi-Institution Review**

* **3.1 Has this study already received approval from another REB?**
Yes **No**

4.0 **Does this study involve pandemic or similar emergency health research?**
Yes **No**

If YES, are you the lead investigator for this pandemic study?

Appendix A

Yes No

5.0 **If this application is closely linked to research previously approved by one of the University of Alberta REBs or has already received ethics approval from an external ethics review board*(s)*, provide the HERO study number, REB name or other identifying information. Attach any external REB application and approval letter in Section 7.1.11 – Other Documents.**

2.1 Study Objectives and Design

1.0 **Date that you expect to start working with human participants:**
5/18/2015

2.0 **Date that you expect to finish working with human participants, in other words, you will no longer be in contact with the research participants, including data verification and reporting back to the group or community:**
7/20/2015

3.0 * **Provide a lay summary of your proposed research suitable for the general public** *(restricted to 300 words)***. If the PI is not affiliated with the University of Alberta, Alberta Health Services or Covenant Health, please include institutional affiliation.**

The purpose of this research is to better understand and improve the feedback on touch screen user interfaces. The proliferation of touch screens user interfaces in most consumer products has created a vast ecosystem of devices with divergent user interfaces. From cell phones to self check out devices at the grocery store, touch screens devices are now part of modern life. The number of devices along with various user interfaces has created confusion for many consumers of these devices. There exists a vast difference in the ways in which many of these devices function especially in terms of the user interface and how they respond to user interaction. There is a multitude of ways of interacting with the devices and the feedback given to users by the devices differs significantly across the various platforms.

My study is the impact that feedback plays on a touch screen user interface and how the feedback can help or possibly hinder the usability of the product. Feedback can be as basic as a visual cue that indicates to the user that something has occurred. It can also be auditory, such as the sound of a bell. As well, it can be tactile feedback, a vibration on the device. It can even be more elaborate than a simple vibration. Essentially it is information the user receives when interacting with a device at a right time during that interaction.

This study will also look at how can certain feedback be used in quality of life products and integrated with daily life to improve the lives of its users.

4.0 * **Provide a description of your research proposal including study objectives, background, scope, methods, procedures, etc)** *(restricted to 1000 words)***. Footnotes and references are not required and best not included here. Research methods questions in Section 5 will prompt additional questions and information.**

Study Objectives: To understand and improve the user experience of user interfaces and their interaction with touch screen products. The main focus is to improve the experience for users and to apply it to quality of life products with touch screen interfaces. The study will look at three types of feedback on a touch screen device, visual, auditory and haptic feedback. The study will look at the combinations of the feedback which will all include visual feedback.

Background: The background of the research is rooted in studying the effects of feedback and its interaction with the user on touch screen user interfaces. The proliferation of touch screens user interfaces in most consumer products has created a vast ecosystem of devices with divergent user interfaces. The number of devices along with various user interfaces has created confusion for many consumers of these devices. There exists a vast difference in the ways in which many of these devices function especially in terms of the user interface and how they respond to user interaction. There is a multitude of ways of interacting with the devices and the feedback given to users by the devices differs

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significantly across the various platforms.

Scope: The research will look at mostly quality of life products with touch screen user interfaces. The number of participants will be between 5 and 10 people. The study will be limited to simple tasks on a touch screen device with basic feedback.

Methods: The methods of the research will consist of three parts.

1. Questionnaire - The study will begin with a quick 5 - 10 questionnaire given to the participant to gauge their experience with touchscreen user interfaces and types of feedback.

2. Interaction - After the questionnaire is finished, the participant will interact with a touch screen device and will be asked to perform a simple task on the device. As they perform the task, they will receive some form of feedback on whether they performed the task satisfactorily.

3. Post-interaction questionnaire - After they finish the tasks on the touch screen device, they will receive a quick 5 minute questionnaire to get their opinions on using the device and the different types of feedback they received.

Procedures: The potential participants will be contacted via email and asked to participate in the study. A time and date will be setup. The participant and the PI will meet at the designated place and time. The study will then be conducted as indicated above in the Methods section. After all the data has been gathered, the PI will analyze the data and results. Once that is complete, the final data and results will be used in the thesis paper.

Analysis: After the data has been gathered from the study, the data will be from the questionnaires will be analyzed in two main ways. The first will compare the results from the first and second questionnaire. It look look to see if there was any change in the participants reaction or opinions to feedback in general on touch screen devices. The second type analysis will be focused on the second questionnaire results. It will try to see if the feedback was helpful and more importantly, which type or combination of feedback was the most successful or helpful for the participant to complete the task. It is from these results that the paper will look at possible ways to apply it to improve user experiences with feedback on quality of life products with touch screen interfaces.

5.0 **Describe procedures, treatment, or activities that are above or in addition to standard practices in this study area** *(eg. extra medical or health-related procedures, curriculum enhancements, extra follow-up, etc)***:**

6.0 **If the proposed research is above minimal risk and is not funded via a competitive peer review grant or industry-sponsored clinical trial, the REB will require evidence of scientific review. Provide information about the review process and its results if appropriate.**

7.0 **For clinical research only, describe any sub-studies associated with this application.**

3.1 Risk Assessment

1.0 * **Provide your assessment of the risks that may be associated with this research:**
Minimal Risk - research in which the probability and magnitude of possible harms implied by participation is no greater than those encountered by participants in those aspects of their everyday life that relate to the research (TCPS2)

2.0 * **Select all that might apply:**

Description of Potential Physical Risks and Discomforts

No Participants might feel physical fatigue, e.g. sleep deprivation

No Participants might feel physical stress, e.g. cardiovascular stress tests

No Participants might sustain injury, infection, and intervention side-effects or complications

No The physical risks will be greater than those encountered by the participants in everyday life

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Potential Psychological, Emotional, Social and Other Risks and Discomforts

No	Participants might feel psychologically or emotionally stressed, demeaned, embarrassed, worried, anxious, scared or distressed, e.g. description of painful or traumatic events
Possibly	Participants might feel psychological or mental fatigue, e.g intense concentration required
No	Participants might experience cultural or social risk, e.g. loss of privacy or status or damage to reputation
No	Participants might be exposed to economic or legal risk, for instance non-anonymized workplace surveys
No	The risks will be greater than those encountered by the participants in everyday life

3.0 * **Provide details of the risks and discomforts associated with the research, for instance, health cognitive or emotional factors, socio-economic status or physiological or health conditions:**
There is minimal risk and discomfort for the participants. The only minor discomfort that the participant might feel would during the interaction portion of the study. The participant would need to concentrate to complete the task while receiving some form feedback on the device to assist with the task. As for the questionnaires, only simple questions will be asked in both questionnaires with no wrong answers.

4.0 * **Describe how you will manage and minimize risks and discomforts, as well as mitigate harm:**
To manage and minimize risks and discomfort:
- Describe and explain to the participants the study, outlining the benefits and possible discomforts and answer any questions
- Explain to the participant that the task in the interaction portion is only a simple task and that there is no penalty if it is done incorrectly.
- Let them know the study is completely voluntary and they may choose not to participate at any time without any penalty.

5.0 * **If your study has the potential to identify individuals that are upset, distressed, or disturbed, or individuals warranting medical attention, describe the arrangements made to try to assist these individuals. Explain if no arrangements have been made:**
Since the risks are minimal and the participant may only feel some minor discomfort during a portion of the study, no arrangement have been made.

3.2 Benefits Analysis

1.0 * **Describe any potential benefits of the proposed research to the participants. If there are no benefits, state this explicitly:**
There are no potential benefits for the participant.

2.0 * **Describe the scientific and/or scholarly benefits of the proposed research:**
The potential scientific or scholarly benefits of this research are to better understand and improve feedback on touch screen user interfaces. The main focus would be to improve the experience for users and to apply it to quality of life products with touch screen interfaces. The research could potentially be used by designers to improve the experience for users on touch screen devices and to use appropriate feedback for the best user experience with special regard to quality of life products.

3.0 **Benefits/Risks Analysis: Describe the relationship of benefits to risk of participation in the research:**
As there are no benefits for the participant and the risks are minimal, there is slightly more risk for the participant than benefits.

4.1 Participant Information

1.0 * **Who are you studying? Describe the population that will be included in this study.**
The participants for the study will be those between the ages of 40 - 60 years, both men and women.

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2.0 * **Describe the inclusion criteria for participants (e.g. age range, health status, gender, etc.). Justify the inclusion criteria (e.g. safety, uniformity, research methodology, statistical requirement, etc)**

The inclusion criteria for the study is participants for the study will be chosen to match the age range of people who would most likely use quality of life products and would also have some minimal experience with touch screen user interface devices. Both men and women will be included since both will have had experience with touch screen user interfaces and are both likely to use quality of life products.

3.0 **Describe and justify the exclusion criteria for participants:**

Participants with low vision or poor hearing will be excluded. Since the main task of the study requires a visual and an audio component, it will be necessary that the participant be able to see and hear the feedback without problems.

4.0

* **Will you be interacting with human subjects, will there be direct contact with human participants, for this study?**

(•) **Yes** ( ) No

Note: No means no direct contact with participants, chart reviews, secondary data, interaction, etc.

If NO, is this project a chart review or is a chart review part of this research project?

( ) Yes ( ) No

5.0

Participants

How many participants do you hope to recruit *(including controls, if applicable)*
10
Of these how many are controls, if applicable *(Possible answer: Half, Random, Unknown, or an estimate in numbers, etc).*
Not applicable
If this is a multi-site study, for instance a clinical trial, how many participants *(including controls, if applicable)* **are expected to be enrolled by all investigators at all sites in the entire study?**

6.0 **Justification for sample size:**
This study only needs a small sample size to get a good idea of how feedback may be used on touch screen user interfaces in relation to quality of life products.

7.0 **Does the research specifically target aboriginal groups or communities?**

( ) Yes (•) **No**

4.3 Recruit Potential Participants

1.0

Recruitment

* **1.1 Describe how you will identify potential participants (please be specific as to how you will find potentially eligible participants i.e. will you be screening AHS paper or electronic records, will you be looking at e-clinician, will you be asking staff from a particular area to let you know when a patient fits criteria, will you be sitting in the emergency department waiting room, etc.)**
The PI will get a list of faculty of the Art and Design Department and will email them requesting if they would be able and willing to participate in the study.

1.2 Once you have identified a list of potentially eligible participants, indicate how the potential participants' names will be passed on to the researchers AND how will the potential participants be approached about the research.
Any potential participant that replies will be contacted again via email to confirm they wish to participate. Arrangements will then be made for the PI and the participant to meet and discuss the study to inform the participant and answer any questions they may have.

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1.3 How will people obtain details about the research in order to make a decision about participating? Select all that apply:

Researchers will contact potential participants

1.4 If appropriate, provide the locations where recruitment will occur *(e.g schools, shopping malls, clinics, etc.)*
The recruitment will occur at the University of Alberta, Edmonton.

2.0

Pre-Existing Relationships

2.1 Will potential participants be recruited through pre-existing relationships with researchers *(e.g. Will an instructor recruit students from his classes, or a physician recruit patients from her practice? Other examples may be employees, acquaintances, own children or family members, etc)***?**

◉ **Yes** ○ No

2.2 If YES, identify the relationship between the researchers and participants that could compromise the freedom to decline *(e.g. professor-student)***. How will you ensure that there is no undue pressure on the potential participants to agree to the study?**
Most of the potential participants will be from the Faculty of Art and Design. The PI will have met some of them, either in class as a student or as a TA for their class. At this moment, the PI has no class with any faculty member and is not a TA for any faculty either. Any potential participant will be told that they are free to decline to participate in the study and there will be no pressure to take part in the study.

3.0 Outline any other means by which participants could be identified, should additional participants be needed *(e.g. response to advertising such as flyers, posters, ads in newspapers, websites, email, listservs; pre-existing records or existing registries; physician or community organization referrals; longitudinal study, etc)*
If there are not enough participants, then the PI will ask his supervisor for assistance in contacting other participants possibly through other faculties in the university.

4.0 Will your study involve any of the following *(select all that apply)***?**
None of the above

4.5 Informed Consent Determination

1.0

* **Describe who will provide informed consent for this study (select all that apply). Additional information on the informed consent process is available at: http://www.pre.ethics.gc.ca/eng/policy-politique/initiatives/tcps2-eptc2/chapter3-chapitre3/#toc03-intro**

All participants have capacity to give free and informed consent

Provide justification for requesting a Waiver of Consent (Minimal risk only, additional guidance available at: http://www.pre.ethics.gc.ca/eng/policy-politique/initiatives/tcps2-eptc2/chapter3-chapitre3/#toc03-1b

2.0

How is participant consent to be indicated and documented? Select all that apply:

Signed consent form

Except for "Signed consent form" use only, explain how the study information will be communicated and participant consent will be documented. Provide details for EACH of the option selected above:

3.0

Authorized Representative, Third Party Consent, Assent

3.1 Explain why participants lack capacity to give informed consent *(e.g. age, mental or physical condition, etc.).*

3.2 Will participants who lack capacity to give full informed consent be asked to give assent?

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Yes No

Provide details. IF applicable, attach a copy of assent form(s) in the Documentation section.

3.3 In cases where participants (re)gain capacity to give informed consent during the study, how will they be asked to provide consent on their own behalf?

4.0 **What assistance will be provided to participants, or those consenting on their behalf, who have special needs?** *(E.g. non-English speakers, visually impaired, etc)***:**

5.0 * **If at any time a participant wishes to withdraw, end, or modify their participation in the research or certain aspects of the research, describe how their participation would be ended or changed.**
A participant who wishes to withdraw from the study would need to contact the PI or his supervisor via the contact information given to them at the time of the study to have their data removed from the study.

6.0 **Describe the circumstances and limitations of data withdrawal from the study, including the last point at which it can be done:**
The participants data can be removed up July 1, 2015. Anytime before this date, their data will be removed per their request. After the date, it will not be possible since their data will most likely be part the thesis and published. The participants will be told exactly when this date will be during the study session.

7.0 **Will this study involve any group(s) where non-participants are present? For example, classroom research might involve groups which include participants and non-participants.**
Yes No

4.7 Group Research Documentation

1.0 * **How will you ensure that non-participants are not included in the study? How will you ensure that data from non-participants are not used in the study?**
Non-participants will not answer the questionnaires nor will they take part in the task portion of the study.

During the recruitment process, how will you guard against peer pressure influencing an individual's decision to participate or not?
Only those participants who reply the initial introductory email stating they are willing to participate will be contacted further. Anybody who replies stating they do not wish to participate will no longer be contacted again. Anyone who does not reply at all, may be contacted a second time in case they did not see the first email but only if there are not enough participants and they will not be contacted a third time if they do not reply.

2.0 **How will you provide appropriate activities for non-participants?**

3.0 **How will you address discomfort or disadvantage, if any, arising out of non-participation?**

5.1 Research Methods and Procedures

Some research methods prompt specific ethic issues. The methods listed below have additional questions associated with them in this application. If your research does not involve any of the methods listed below, ensure that your proposed research is adequately described in Section 2.0: Study Objectives and Design or attach documents in Section 7.0 if necessary.

1.0 * **This study will involve the following** *(select all that apply)*
The list only includes categories that trigger additional page(s) for an online application. For any other methods or procedures, please indicate and describe in your research proposal in the Study Summary, or provide in an attachment:
Surveys and Questionnaires (including internet surveys)

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Participatory Action Research

2.0 *** Is this study a Clinical trial? (Any investigation involving participants that evaluates the effects of one or more health-related interventions on health outcomes?**
Yes **No**

3.0 **If you are using any tests in this study diagnostically, indicate the member(s) of the study team who will administer the measures/instruments:**

Test Name	Test Administrator	Organization	Administrator's Qualification
There are no items to display			

4.0 **If any test results could be interpreted diagnostically, how will these be reported back to the participants?**

5.7 Interviews, Focus Groups, Surveys and Questionnaires

1.0 **Are any of the questions potentially of a sensitive nature?**
Yes **No**

If YES, provide details:

2.0 **If any data were released, could it reasonably place participants at risk of criminal or civil law suits?**
Yes **No**

If YES, provide the justification for including such information in the study:

3.0 **Will you be using audio/video recording equipment and/or other capture of sound or images for the study?**
Yes **No**

If YES, provide details:

6.1 Data Collection

1.0 *** Will the researcher or study team be able to identify any of the participants at any stage of the study?**
Yes No

2.0 **Will participants be recruited or their data be collected from Alberta Health Services or Covenant Health or data custodian as defined in the Alberta Health Information Act?**
Yes **No**

Important: Research involving health information must be reviewed by the Health Research Ethics Board.

3.0 **Primary/raw data collected will be** *(check all that apply)*:
Indirectly identifying information - the information can reasonably be expected to identify an individual through a combination of indirect identifers (eg date of birth, place of residence, photo or unique personal characteristics, etc)

4.0 **If this study involves secondary use of data, list all original sources:**

5.0 **In research where total anonymity and confidentiality is sought but cannot be guaranteed** *(eg. where participants talk in a group)* **how will confidentiality be achieved?**

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6.2 Data Identifiers

1.0

* **Personal Identifiers:** will you be collecting - at any time during the study, including recruitment - any of the following *(check all that apply)*:

Surname and First Name
Email Address
Age at time of data collection
Other

If OTHER, please describe:
Gender of participant is collected.

2.0

Will you be collecting - at any time of the study, including recruitment of participants - any of the following *(check all that apply)*:

There are no items to display

If OTHER, please describe:

3.0 * **If you are collecting any of the above, provide a comprehensive rationale to explain why it is necessary to collect this information:**
Surname and First Name / Email: This data will be used to contact and recruit potential participants for the study.
Age at time of data collection: This data will be collected during the first questionnaire and it is necessary to have the correct age range of people who will be most likely using quality of life products.
Gender: This data is collected in the first questionnaire and is used to see if there any differences between men and women's opinions or experiences with feedback on touch screen interface devices.

4.0 **If identifying information will be removed at some point, when and how will this be done?**
Identifying information will be removed during the analysis of the questionnaires after the study has concluded. As the data from the paper questionnaire is inputted into digital format, the age of participants will be grouped into age ranges. From then on, participants will be referred as "Participant 1, age range 50 - 55, participant 2, age range 56 - 60" etc.

5.0 * **Specify what identifiable information will be RETAINED once data collection is complete, and explain why retention is necessary. Include the retention of master lists that link participant identifiers with de-identified data:**
No identifiable information will be retained. The "Age at time of data collection" will be grouped into age ranges to prevent identification of individuals.

6.0 **If applicable, describe your plans to link the data in this study with data associated with other studies (e.g within a data repository) or with data belongong to another organization:**
Some of this data may be associated with a project called the Mobili-T project. This project is designing a device to assists patients who have difficulty swallowing. The device is a touch screen user interface which will have feedback to assist the user during swallowing exercises. Some of their data and the data collected from this study may used in my thesis as they both deal with feedback on touch screen user interfaces.

6.3 Data Confidentiality and Privacy

1.0 * **How will confidentiality of the data be maintained? Describe how the identity of participants will be protected both during and after research.**
The confidentiality of the participants will be respected at all times. No names will be used and the ages of the participants will be grouped into age ranges (eg. participants aged 51, 53, and 54 will be grouped into ages 50 - 55). Participants' data will be stored securely and will not be used outside of the research study.

2.0 **How will the principal investigator ensure that all study personnel are aware of their responsibilities concerning participants' privacy**

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and the confidentiality of their information?

3.0

External Data Access

* **3.1 Will identifiable data be transferred or made available to persons or agencies outside the research team?**

Yes **No**

3.2 If YES, describe in detail what identifiable information will be released, to whom, why they need access, and under what conditions? What safeguards will be used to protect the identity of subjects and the privacy of their data.

3.3 Provide details if identifiable data will be leaving the institution, province, or country *(eg. member of research team is located in another institution or country, etc.)*

6.4 Data Storage, Retention, and Disposal

1.0 * **Describe how research data will be stored, e.g. digital files, hard copies, audio recordings, other. Specify the physical location and how it will be secured to protect confidentiality and privacy.** *(For example, study documents must be kept in a locked filing cabinet and computer files are encrypted, etc. Write N/A if not applicable to your research)*

All non digital data and information such as consent forms, questionnaires or notes will be stored in a locked cabinet in the investigator's office. Digital data data will be stored on an encrypted external hard drive and stored in a locked cabinet in the investigator's office.

2.0 * **University policy requires that you keep your data for a minimum of 5 years following completion of the study but there is no limit on data retention. Specify any plans for future use of the data. If the data will become part of a data repository or if this study involves the creation of a research database or registry for future research use, please provide details.** *(Write N/A if not applicable to your research)*

Data will be used for the thesis paper and will be destroyed after 5 years.

3.0

If you plan to destroy your data, describe when and how this will be done? Indicate your plans for the destruction of the identifiers at the earliest opportunity consistent with the conduct of the research and/or clinical needs:

The non digital data will be destroyed after 5 years and digital data that was collected will be erased after 5 years.

7.1 Documentation

Add documents in this section according to the headers. Use Item 11.0 "Other Documents" for any material not specifically mentioned below.

Sample templates are available in the REMO Home Page in the **Forms and Templates**, or by clicking HERE.

1.0 **Recruitment Materials:**

Document Name	Version	Date	Description
There are no items to display			

2.0 **Letter of Initial Contact:**

Document Name	Version	Date	Description
Email Invitation | History	0.03	5/1/2015 12:02 PM	

3.0

Informed Consent / Information Document(s):

3.1 What is the reading level of the Informed Consent Form(s):

3.2 Informed Consent Form(s)/Information Document(s):

Document Name	Version	Date	Description

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Document Name	Version	Date	Description
Information Letter | History	0.03	4/29/2015 4:09 PM	
Consent Form | History	0.02	4/29/2015 4:09 PM	

4.0 Assent Forms:

Document Name Version Date Description

There are no items to display

5.0 Questionnaires, Cover Letters, Surveys, Tests, Interview Scripts, etc.:

Document Name	Version	Date	Description
Feedback Questionnaire 1 | History	0.01	4/27/2015 12:56 PM	
Feedback Questionnaire 2 | History	0.01	4/27/2015 12:56 PM	

6.0 Protocol:

Document Name Version Date Description

There are no items to display

7.0 Investigator Brochures/Product Monographs *(Clinical Applications only)*:

Document Name Version Date Description

There are no items to display

8.0 Health Canada No Objection Letter *(NOL)*:

Document Name Version Date Description

There are no items to display

9.0 Confidentiality Agreement:

Document Name Version Date Description

There are no items to display

10.0 Conflict of Interest:

Document Name Version Date Description

There are no items to display

11.0 Other Documents:

For example, Study Budget, Course Outline, or other documents not mentioned above

Document Name Version Date Description

There are no items to display

Final Page

You have completed your ethics application! Please select "Exit" to go to your study workspace.

This action will NOT SUBMIT the application for review.

Only the Study Investigator can submit an application to the REB by selecting the "SUBMIT STUDY" button in My Activities for this Study ID: Pro00056819.

You may track the ongoing status of this application via the study workspace.

Please contact the REB Coordinator with any questions or concerns.

Appendix A

Research Project Plan Summary

Research Project: *The interaction of feedback and the user experience with the product on touch screen user interfaces*

Research Background

The main focus of the study is to improve the experience for users and to apply it to quality of life products with touch screen interfaces. The study will look at three types of feedback on a touch screen device, visual, auditory and haptic feedback. The study will explore combinations the feedback which will all include visual feedback. The research could potentially be used by designers to improve the experience for users on touch screen devices and to use appropriate feedback for the best user experience with special regard to quality of life products.

Purpose

The purpose of this research is to better understand and improve the feedback on touch screen user interfaces and improve the experience for users and to apply it to quality of life products with touch screen interfaces.

Study Outline

The study consists of three parts:

1. Answering a simple 5 – 10 minute questionnaire
2. Doing a task on a touch screen user interface device
3. Answering a second 5 – 10 minute follow-up questionnaire

Part 1 – Questionnaire 1

The type of questions in the first questionnaire is about the participant's experience with feedback on various types of touch screen user interface devices.

Part 2 – Task

This part consists of the participant doing a task with a touch screen user interface device. They will be asked to do a simple task and observe the feedback on the device.

The three types of feedback are: visual (V), auditory (A) and haptic (H). The feedback will indicate to the participant if they are doing the task correctly or not.

Each participant will do the task for four sessions. They will receive four combinations of feedback during each session and the order in which they receive the combinations will be randomized for each participant. The feedback combinations for each session are the following:

1. V
2. V + A
3. V + H
4. V + A + H

Each type of feedback will be as simple as possible to allow the participant to focus on the task and not be distracted by the feedback. The purpose of the feedback to guide them while doing the task.

Feedback
Visual – The visual feedback will be displayed on the device's screen. It will display for each four sessions and be the same each time.

Auditory – The touch screen device will emit sounds during the task. The sound may come from internal speakers in the device or possibly through headphones attached to the device.

Haptic – The device itself will vibrate during the session and the participant will be holding the device in their hands or placed on their lap.

Steps

1. Participant will be given the device to hold in their hands or lap.
2. While holding and observing the device, participant will do the task and receive the first combination of feedback (any of 4) which will indicate if the exercise is being done correctly.
3. Participant may rest between each session.
4. Second session, another combination of feedback except the one done in 2.
5. Rest.
6. Third session, another combination of feedback except the one done in 2 or 4.
7. Rest.
8. Fourth session, final remaining combination of feedback.
9. Rest.
10. End of Part 2.

Part 3 – Questionnaire 2
The questions in the follow-up questionnaire are to get their personal opinion and experience on the task done in part 2 of the study.

Research Project Email Invitation

Research Project: *Understanding Feedback on Touch Screen User Interfaces*

Hello,

My name is Juan Fajardo. I am in my second year of my Master of Design program at the University of Alberta. I am currently working on my thesis project regarding feedback on touch screen user interface devices. My research is to better understand and improve the feedback on touch screen user interfaces. The research could potentially be used by designers to improve the experience for users on touch screen devices and to use appropriate feedback for the best user experience with special regard to quality of life products.

The study consists of three parts. The first part is a quick 5 – 10 minute questionnaire to get your experiences with feedback and touchscreen user interfaces. The second part consists of doing a task on a touch screen user interface device. You will be asked to do a task on the touch screen device and observe the feedback on the device. The final part is a follow-up questionnaire to get your opinion and experience with the task done in the second part of the study.

The risk of participating is minimal. The overall study will be no longer than 30 minutes. Please note that your participation is completely voluntary and you will be free to leave any time during the study. No personal identifiable information will be collected nor will any pictures or video recordings be made. You are free to withdraw your data from the study up until July 1, 2015.

Please let me know if you willing to participate in this study by replying to this email.

If you have any questions regarding this study, please do not hesitate to contact myself or my graduate supervisor, Robert Lederer (rlederer@ualberta.ca).

Thank you for your time and consideration.

Sincerely,

Juan Fajardo

Research Project Information Letter

Research Project: *Understanding Feedback on Touch Screen User Interfaces*

Research Investigator
Juan Fajardo
Department of Art and Design
University of Alberta
Edmonton, AB, T6G 2C9
jfajardo@ualberta.ca, (780) 299 - 3768

Supervisor
Robert Lederer
Department of Art and Design
University of Alberta
Edmonton, AB, T6G 2C9
rlederer@ualberta.ca, (780) 492 - 6367

Research Background

- You are being asked to participate in this study because you are in the same age range as most people who use touch screen devices.
- This study is for my Master's thesis which is studying feedback on touch screen user interface devices. The research findings of this study are to be used to support my Master's thesis.
- The main focus is to improve the experience for users and to apply it to quality of life products with touch screen interfaces. The study will look at three types of feedback on a touch screen device, visual, auditory and haptic feedback. The study will look at the combinations of the feedback which will all include visual feedback.
- The potential scientific or scholarly benefits of this research are to better understand and improve feedback on touch screen user interfaces. The research could potentially be used by designers to improve the experience for users on touch screen devices and to use appropriate feedback for the best user experience with special regard to quality of life products.

Purpose

The purpose of this research is to better understand and improve the feedback on touch screen user interfaces. The study would allow designers to improve the experience for users of touch screen devices. The main focus is to improve the experience for users and to apply it to quality of life products with touch screen interfaces.

Study Procedures

- Your participation in this study consists of three parts, 1) Answering a simple 5-10 minute questionnaire, 2) Doing a task on a touch screen user interface device, 3) A second 5 – 10 minute follow-up questionnaire
- The type of questions in the first questionnaire is about your experience with feedback on various types of touch screen user interface devices.
- This part consists of doing a task on a touch screen user interface device. You will be asked to do a simple task on the touch screen device and observe the feedback on the device.
- The questions in the follow-up questionnaire are to get your personal opinion and experience on the task done in the second part of the study.

Benefits

- There is no direct benefit to being in this study.
- However, your participation may assist in the future development and design of feedback for touch screen user interfaces.

- There are no costs involved by participating in the research.
- There is no compensation for the participant for participating in this study.

Risks

- There are no known risks by participating in the study.

Voluntary Participation

- You are under no obligation to participate in this study. Your participation in this study is completely voluntary.
- You may opt out at any time without any penalty. Even if you agree to be in the study, you can change your mind and withdraw at any time.
- In the event that you decide to opt out, please let us know by July 1, 2015 and we will do our best to remove your data from the study. In the event that you decide to opt out after the date above, we cannot guarantee that your data can be removed from the study.

Confidentiality & Anonymity

- Your name will not be associated with any of the data collected.
- The research will be used for my thesis research and for the final thesis presentation. No participant will be identified in any way in the thesis or final presentation.
- All data will be kept confidential and the only people with access to the raw data will be the researcher and the supervisor.
- No name or type of personal identification will be used. There will be no photographs, video or audio recorded for this study of any kind.
- The research data will be kept in a secure place for a minimum of 5 years following completion of the research project. The data will be transcribed into an electronic format and will be kept secure on a password protected file. The data will be destroyed after 5 years.

Further Information

- If you have any further questions regarding this study, please do not hesitate to contact the research investigator Juan Fajardo via email at jfajardo@ualberta.ca or my graduate supervisor Rob Lederer via email at rlederer@ualberta.ca.
- The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

Research Project Consent Form

Research Project: ***Understanding Feedback on Touch Screen User Interfaces***

Research Investigator
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Please circle Yes or No for each question.

Do you understand that you have been asked to be in a research study?	Yes / No
Have you received and read a copy of the Information Sheet?	Yes / No
Do you understand the risks and benefits involved in participation in this study?	Yes / No
Have you had an opportunity to ask questions and discuss this research?	Yes / No
Do you understand that you are free to withdraw or refuse to participate from the research study at any time without any consequence?	Yes / No
Do you understand that you may change your mind and ask your data to be withdrawn from the study up to July 1, 2015?	Yes / No
Has the issue of confidentiality been explained to you?	Yes / No
Do you understand who will have access to your data?	Yes / No

This study was explained to me by: ____

I have read and understood the attached information letter and agree to participate in this study:

________________________________	______________________	___________
Signature of Research Participant	Printed Name	Date

________________________________	______________________	___________
Signature of Research Investigator	Printed Name	Date

Research Project Feedback Questionnaire 1

Research Project: *Understanding Feedback on Touch Screen User Interfaces*

1. Please enter your age:

   ____

2. Please select your sex:

   Male Female

General Questions

3. How much experience do you have using touch screens? (1 - None, 3 - Some, 5 - Very Much)

   1 2 3 4 5

4. How often do you use a touch screen device? (1 - Rarely, 3 - Sometimes, 5 - Daily)

   1 2 3 4 5

Visual Feedback

5. Can you please name a device with primarily only visual feedback?

6. Does the visual feedback assist you in completing tasks on the device named in question 5? (1 - No, 3 - Sometimes, 5 - Very Much)

   1 2 3 4 5

7. How useful is the visual feedback in the device named in question 5 in your opinion? (1 - Not helpful, 3 - Somewhat helpful, 5 - Very helpful)

   1 2 3 4 5

Visual + Auditory Feedback

8. Have you ever used a touch screen device with visual and auditory feedback? (1 - Never, 3 - Sometimes, 5 - Often)

   1 2 3 4 5

9. Can you please name the touch screen device with visual and auditory feedback?

10. How useful is the auditory feedback in the device in question 9 in your opinion?
(1 - Useless, 3 - Somewhat, 5 - Very useful)

1 2 3 4 5

11. What kind of auditory feedback does the device provide? (Ex. beeps, human voice, tones etc)

12. When using the device in question 9 with auditory feedback, do you wear headphones?
(1 - Never, 3 - Sometimes, 5 - Always)

1 2 3 4 5

Visual + Haptic Feedback

13. Have you ever used a touch screen device with visual and haptic feedback?
(1 - Never, 3 - Sometimes, 5 - Often)

1 2 3 4 5

14. Can you please name the touch screen device with visual and haptic feedback?

15. How useful is the haptic feedback in the device in question 14 in your opinion?
(1 - Useless, 3 - Somewhat, 5 - Very useful)

1 2 3 4 5

Visual + Auditory + Haptic Feedback

16. Have you ever used a touch screen device with visual, auditory and haptic feedback?
(1 - Never, 3 - Sometimes, 5 - Often)

1 2 3 4 5

17. Can you please name the touch screen device with visual, auditory and haptic feedback?

18. How useful is the auditory and haptic feedback in the device in question 17 in your opinion?
(1 - Useless, 3 - Somewhat, 5 - Very useful)

1 2 3 4 5

Final Questions

19. Can you rank the combinations of feedback from the devices you named above?
(1 - Least helpful, 2 - Somewhat helpful, 3- Helpful, 4 - Most helpful)

___ Visual

___ Visual + Auditory

___ Visual + Haptic

___ Visual + Auditory + Haptic

20. For the combination that you ranked "Most helpful" in the question 19, can you please explain why you found it most helpful from the others?

21. For the combination that you ranked "Least helpful" in question 19, can you please explain why you found it least helpful from the others?

22. Please write any final thoughts on how the feedback might be improved to assist you in completing tasks on a touch screen user interface device.

Research Project Feedback Questionnaire 2

Research Project: *Understanding Feedback on Touch Screen User Interfaces*

Visual Feedback

1. How helpful in completing the task was the visual feedback?
   (1 - Not helpful, 3 - Somewhat helpful, 5 - Very helpful)

   1 2 3 4 5

2. Did you feel that your performance of the task improved with the visual feedback?

   Yes No

3. If yes, by how much? (1 - Very little, 3 - Somewhat, 5- Very much)

   1 2 3 4 5

4. If no, specifically why not?

Visual + Auditory Feedback

5. How helpful was the visual and auditory feedback in completing the task?
   (1 - Not helpful, 3 - Somewhat helpful, 5 - Very helpful)

   1 2 3 4 5

6. Did you feel that your performance of the task improved with the visual and auditory feedback?

   Yes No

7. If yes, by how much? (1 - Very little, 3 - Somewhat, 5- Very much)

   1 2 3 4 5

8. If no, specifically why not?

Visual + Haptic Feedback

9. How helpful was the visual and haptic feedback in completing the task?
   (1 - Not helpful, 3 - Somewhat helpful, 5 - Very helpful)

   1 2 3 4 5

10. Did you feel that your performance of the task improved with the visual and haptic feedback?

    Yes No

11. If yes, by how much? (1 - Very little, 3 - Somewhat, 5- Very much)

    1 2 3 4 5

12. If no, specifically why not?

Visual + Auditory + Haptic Feedback

13. How helpful was the visual, auditory and haptic feedback in completing the task?
    (1 - Not helpful, 3 - Somewhat helpful, 5 - Very helpful)

    1 2 3 4 5

14. Did you feel that your performance of the task improved with the visual, auditory and haptic feedback?

    Yes No

15. If yes, by how much? (1 - Very little, 3 - Somewhat, 5- Very much)

    1 2 3 4 5

16. If no, specifically why not?

Final Questions

17. Can you rank the combinations of feedback by the following?
    (1 - Least helpful, 2 - Somewhat helpful, 3- Helpful, 4 - Most helpful)

    ___ Visual

    ___ Visual + Auditory

    ___ Visual + Haptic

    ___ Visual + Auditory + Haptic

18. For the combination that you ranked "Most helpful" in question 17, can you please explain why you found it most helpful from the others?

19. For the combination that you ranked "Least helpful" in question 17, can you please explain why you found it least helpful from the others?

20. Please write any final thoughts on how the feedback might be improved to assist you in completing the task.

Participant Number	1. Please enter your age	2. Please select your sex	3. How much experience do you have using touch screens?	4. How often do you use a touch screen device?	5. Can you please name a device with primarily only visual feedback?
1	64	Male	4	5	Computer screen monitor
2	19	Male	5	5	Samsung Galaxy sIII / Tablet / PC
3	51	Male	5	5	Touch screen on my car
4	19	Female	5	5	A TV, or a laptop device using bluetooth
5	22	Female	5	5	No?
6	25	Female	4	5	iPhone
7	26	Female	5	5	Windows 8 computers, iPhone, iPad, information checking machines, ATM machines
8	22	Female	5	5	Laptop
9	19	Female	5	5	Camera
10	19	Male	5	5	Computer monitor
11	26	Female	4	5	Tablet
12	25	Male	5	5	iPhone
13	30	Male	5	5	Laptop screen.
14	44	Male	4	5	iPad
15	24	Male	5	5	iPhone (silent mode)
16	25	Female	3	3	Watch, iPad
17	25	Male	4	5	Samsung Duos Win
18	33	Male	5	5	iPhone / iPad
19	20	Female	5	5	iPhone
20	32	Female	4	5	TV / EMG / smartphone

6. Does the visual feedback assist you in completing tasks on the device named in question 5?	7. How useful is the visual feedback in the device named in question 5 in your opinion?	8. Have you ever used a touch screen device with visual and auditory feedback?	9. Can you please name the touch screen device with visual and auditory feedback?	10. How useful is the auditory feedback in the device in question 9 in your opinion?
5	5	5	iPhone	3
5	5	3	Samsung Galazy sIII	3
5	4	5	Phone	3
3	4	3	Google maps app on iPhone	4
5	5	5	Phone / tablet	2
5	4	5	Map at mall. (Voice tells you how to get somewhere).	4
5	5	5	iPad, iPhone, GPS	5
5	5	5	Smartphone	5
5	4	5	Android phone	3
5	5	3	Galaxy S6 smartphone	2
4		5	Laptop	5
5	5	3	iPhone (on outdoor audio setting)	2
5	5	5	iPhone dial pad.	4
4	4	4	iPad	4
5	5	5	iPhone	5
5	5	3	iPad	2
5	5	4	Samsung Duos Win	3
5	5	5	iPad / iPhone	3
5	5	3	In car GPS.	5
3	5	5	Smartphone / iPad	2

11. What kind of auditory feedback does the device provide?	12. When using the device in question 9 with auditory feedback, do you wear headphones?	13. Have you ever used a touch screen device with visual and haptic feedback?	14. Can you please name the touch screen device with visual and haptic feedback?
Beeps / tones	1	2	iPhone
Human voice	3	4	Samsung Galaxy sIII / Tab Pro
Beeps and tone	2	5	Phone
Computer-voiced driving directions	1	5	Text messaging on iPhone and vibrate alert.
Full range	3	5	Phone
Human voice	1	5	iPhone
Human voices, beeps etc.	3	2	iPhone, some kind GPS provides haptic
Beeps (when getting message... etc. a notification anything). Human voices (having conversation, watching news... etc)	4	5	Smartphone (again)
Ringing tones, vibrations, sound/alarm. Also can talk to you when you click the microphone button.	3	5	Android phone
Beeps / tones	3	5	Galaxy S6 smartphone
Tones	2	4	Phone
Clicking while scrolling menus	1	1	N/A
Beeps	2	2	New macbook force touch track pad.
Tones	2	4	Smartphone (Android)
Human voice	3	5	iPhone
Beeps / clicks when you touch a button, I mainly use the iPad at work and the volume is usually turned off.	1	2	iPhone (My boyfriends)
beeps	5	4	Samsung Duos Win
Tones to distinguish text / email etc.	3	5	iPhone
Human(ish) voice for direction and beeps when you reach the correct turn.	1	2	It was a third party iPad rip-off.
Jingle / beeps / ring / tune	2	1	Only haptic device I have used was a wii-mote, but this was just a remote, not a touch screen.

15. How useful is the haptic feedback in the device in question 12 in your opinion?	16. Have you ever used a touch screen device with visual, auditory and haptic feedback?	17. Can you please name the touch screen device with visual, auditory and haptic feedback?	18. How useful is the auditory and haptic feedback in the device in question 17 in your opinion?	19. Can you rank the combinations of feedback from the devices you named above? [Visual]
3	3	Gaming control	4	4
3	3		3	1
3	5	Phone	5	1
5	3	Text messaging on iPhone to ringtone and vibratory alert.	3	1
4	5	Phone	3	2
4	4	iPhone, apps like games usually do both. Also the timer app vibrates / beeps / shows visual.	5	1
2	2	iPhone, GPS	3	4
4	5	Smartphone	5	1
5	5	Android phone	5	1
4	4	Galaxy S6 smartphone	3	3
4	5	Phone	4	2
	1			4
2	1			1
4	4	Smartphone (Android)	4	1
5	5	iPhone	5	4
3	2	iPhone (boyfriends)	3	1
3	4	Samsung Duos Win	3	1
4	5	iPhone 6	5	1
3	2	Kindle (has a vibrate function when you touch the screen)	2	1
	1	N/A		2

19. Can you rank the combinations of feedback from the devices you named above? [Visual + Auditory]	19. Can you rank the combinations of feedback from the devices you named above? [Visual + Haptic]	19. Can you rank the combinations of feedback from the devices you named above? [Visual + Auditory + Haptic]
1	3	2
2	3	4
4	3	2
2	4	3
1	3	4
3	2	4
3	2	1
3	2	4
2	3	4
2	4	1
4	3	1
3	1	2
2	3	4
2	4	3
2	3	1
2	3	4
4	2	3
2	3	4
4	2	3
1	3	4

20. For the combination that you ranked "Most helpful" in the question 19, can you please explain why you found it most helpful from the others?
Most of my work on computer is assisted by visual and auditory as the auditory confirms a completed task.
I think that by getting the most feedback as possible will apply to a wider audience. This would also help in more feedback(?) to help others.
Visual information is the most clearly defined
If you can't feel vibrations, you need a ring but for me, auditory ringing is unnecessary. But I am often bothered by the auditory feedback of people surrounding me. Therefore, I find visual and haptic most useful for its the ultimate usage.
Has the most options
Less room for error. The more signals put out, the higher the odds of them being received efficiently.
Visuals can be used in any consequences for example, when you are in a room the requires you to be quiet, you are not allowed to use devices that can "speak". Visual + auditory sometimes extremely helpful, because when you are driving, auditory gives you information you want without frequently check the visuals. Visual + haptic, useful when the machine would want to tell you "you are doing wrong". Visual + auditory + haptic, just too much and quite annoying.
Because it provides different kinds of stimulations to my brain. I guess it's also more helpful for me to memorize things.
Its most helpful because it covers all the bases. Sometimes the vibration doesn't go off on my phone so having the visual light to back it up when I look at it helps. Same concepts applies for if I have it turned to sound.
It provides more than just visual reaffirmation of touching tapping the screen. Seems more deliberate.
Visual + auditory and visual + haptic alarms you enough to see the new activity on the device.
It fulfills most of the feedback requirement while being minimally intrusive. The addition of audio though helpful, I find only marginally beneficial.
There are multiple ways of confirmation that the selection did happen and happen correctly.
With touch interfaces, it is difficult to confirm that you have touched the key. Haptic feedback is the best even in noisy environment.
We can see, hear and feel.
If you need to be alerted to something on the device yo are given more opportunities to notice. ex. phone is in your pocket --> you feel it. phone on table --> you see it or your eyes are closed --> you hear it.
Don't like haptic stuff plus hard to feel vibrations. Most attention always by auditory.
Different scenarios benefit from different combinations of feedback. For example --> I often have my phone on silence + benefit greatly from haptic feedback. Other times auditory is useful if the phone is another room. I find it appealing to have choices in adapting to specific scenarios.
I am most familiar with only visual + auditory.
Because the visual + auditory feedback complement one another. For example, with personal reminders, a buzz / jingle alerts me that I should look at my phone. The visual gives me more detail (which I wouldn't want to hear out loud). Haptic would be nice, but have not used much.

21. For the combination that you ranked "Least helpful" in question 19, can you please explain why you found it least helpful from the others?
It only engages me with one sensory input. I have to do a lot of scanning the screen to confirm I have done something
Not as much sensory input
The beep tells me the least and in fact could occur for different reasons so it is the most likely for me to ignore. Also beeps annoy others not using the device.
Because it resonates in parts of my brain, I have a harder time using/remembering thins I only experience visually.
Often sounds are annoying / not in a place where appropriate.
Distractions. It's easy to take your eyes away from something for a moment. Less easy to take your eyes, ears and sense of touch away.
Distracting and annoying.
I'll say it's still helpful but not as impressive as other combination might provide.
Well I ranked it the lowest because of the general hierarchy of it only really covering one thing. (Which was visual) but that also sometimes a visual isn't always completely helpful.
Too much feedback at once and typically using it in public auditory can be an inconvenience / annoying.
Visual + auditory + haptic all 3 are sometimes scary and overwhelming.
I've never used this combination (to my knowledge).
Only rely on visual and it is not that certain.
Same reason as above, visual only interface doesn't give good user interface.
We can only see.
Because it had less features.
Sometimes you need to concentrate on work and can't pay enough attention to just visual.
Visual feedback is essential but any singular type of feedback is limited in adaptability.
It would be difficult to multitask with only visuals, you would have to constantly look at it.
Not enough exposure th this so I'm basing my judgement on anticipated usefulness, I may find 3 forms of feedback overwhelming but cant' say for sure.

22. Please write any final thoughts on how the feedback might be improved to assist you in completing tasks on a touch screen user interface device.
Different styles of touch feedback
I feel like haptic feedback can be better utilized for personal devices in an era when everything is ringing and mot ringtones are the same and music is too easily replicated, auditory feedback has become useless in some senses.
Opt-in for sounds instead of opt-in
Maybe only having the feedback that is necessary at certain times, rather then everything at once, which can be overwhelming. What if the device recognized the way you're picking up info and shifts with our attention.
Strengthen the feedback when system needs to load. Some visual feedback make the waiting time becomes more interesting, less boring.
Maybe consider the size of the touch screen as one variable that might change user experience?
N/A
The one example of all 3 (vis/aud/hap) that I really enjoy is on the dial pad of my smartphone. It makes the dial tones an almost throwback or legacy feel. It doesn't help me with it but I enjoy the experience more.
Having the ability of all 3 is helpful bat at the a time only 2 should be used. It is also helpful to provide user freedom to use them as per his preferences. For example, when I receive a message in class, it is enough to know just with vibrations and visual (very sublte). All 3 feedback are overwhelming
Better to have minimal delay and feedback that make sense.
None I can think of now.
N/A
Maybe to ensure there is no visual clutter on screen?
Adaptive / learning feedback ... or feedback scheduling. For example --> setting combinations at specific times of day. This is available (somewhat) with mute and night settings but I don't find it entirely effective because it is manual only.
I appreciate when I can have the choice between all types of feedback. Then I can pick what makes sense for my task.
I find the portability of touch screen devices THE MOST useful thing in assisting me to complete daily tasks. Auditory feedback is nice to alert me and to reward me at the end, while visual feedback works well for more detailed information. I have not used haptic feedback (eg. vibrate functions) on phone as much so I have limited experience with this.

Participant Number	1. How helpful in completing the task was the visual feedback?	2. Did you feel that your performance of the task improved with the visual feedback?	3. If yes, by how much?	4. If no, specifically why not?
1	5	Yes	4	
2	4	Yes	2	
3	4	Yes	4	
4	2	Yes	1	I only answered yes because it was better than no feedback but it wasn't easy to follow.
5	5	Yes	5	
6	4	No		I had to pay more attention to see if a "task" was being completed.
7	2	No	2	I got confused by the visual one time when doing the test. It works way better when it combines visual and haptic.
8	5	Yes	4	
9	5	Yes	5	
10	5	Yes	5	
11	3	No		Just visual was alarming for a min. because I almost expected the sound. It took me a sec. that it's just visual and I have to keep doing it.
12	5	Yes	5	
13	3	Yes	3	
14	3	No		My performance improved after I get used to the test procedure.
15	2	Yes	2	
16	5	Yes	3	
17	4	Yes	4	
18	5	Yes	5	
19	4	No		The visual feedback just seemed to time me, not motivate.
20	5	Yes	4	

Appendix I

5. How helpful was the visual and auditory feedback in completing the task?	6. Did you feel that your performance of the task improved with the visual and auditory feedback?	7. If yes, by how much?	8. If no, specifically why not?
5	Yes	5	
3	Yes	3	
3	Yes	4	
2	Yes	3	
4	Yes	4	It was nice because the sounds were subtle.
5	Yes	4	
3	Yes	3	
3	No		My attention was caught by the sound that I slightly forgot I have to squeeze the grips tightly.
5	Yes	5	
3	No	2	I was still relying more the visual cue, the auditory didn't necessarily add to it.
5	Yes	5	
3	No		The timing of the audio felt disconnected maybe it should follow after a full movement / task? Not during.
4	Yes	4	
3	No		There was a delay in the auditory feedback that affect my rhythm of performing the task.
3	Yes	3	
5	Yes	5	
4	Yes	4	
3	No		It helped a little, but there was no 'scale'. It made the same sound on all repetitions, which did not indicate progress. The visual + auditory were essentially duplicates... except when I briefly looked away from the screen. In that instance it was useful because it replaced the visual. Also --> the hand grip made a sound on each rep, which also functioned as auditory feedback.
5	Yes	2	
5	Yes	4	

9. How helpful was the visual and haptic feedback in completing the task?	10. Did you feel that your performance of the task improved with the visual and haptic feedback?	11. If yes, by how much?	12. If no, specifically why not?
3	Yes	2	
4	Yes	4	
3	Yes	4	
3	Yes	4	
2	No	2	The buzzer was too forceful and distracting.
3	No		Because, I wouldn't be holding the device all the time. I wasn't in this case and I found the sound of vibration and how it was moving the device a bit distracting.
5	Yes	5	
3	No		Same problem as the combination of visual and auditory, it's too disturbing for me (especially the one-dot one).
4	Yes	3	
2	No	1	I didn't feel any haptic feedback and the vibration was quite loud so it almost felt like a different auditory feedback.
4	Yes	5	However haptic for a consistently long time was annoying.
1	No		Again, the timing felt off. The haptic feedback felt more like noise.
4	Yes	2	I heard the vibration rather than felt it at the grip, it would be more direct if I felt it at the grip.
4	Yes	2	
4	Yes	4	
1	No		I totally missed it! In my brain I think I just registered it as a sound because it was accompanied by a load buzz.
4	Yes	4	
3	No		Same as auditory --> It was a reinforcement of success, but there was no indication of progress. Just a buzz on each rep vs. visual --> which provided color progress indication (red to green / increase in scale).
5	Yes	3	
5	Yes	5	

13. How helpful was the visual, auditory and haptic feedback in completing the task?	14. Did you feel that your performance of the task improved with the visual, auditory and haptic feedback?	15. If yes, by how much?	16. If no, specifically why not?	17. Can you rank the combinations of feedback by the following? [Visual]
3	No		I felt the haptic was redundant.	3
4	Yes	4		1
4	Yes	4		4
3	Yes	3		1
3	No	3	Too much going on.	3
2	No		Same reason as #12, but now with the sound it was even more distracting.	3
4	Yes	4		4
2	No		Just too much.	4
4	Yes	3		3
1	No		The haptoc vibration buzz overshadowed the auditory pop. Pretty much just relied on visual.	4
3	Yes	3		1
1	No		There were a lot of noises / senses to pay attention to, the task felt very distracting.	4
4	Yes	2	Same as Q. 12	1
3	No		I have become used to the test procedure, the feedbacks did not help much.	1
5	Yes	5		1
4	Yes	3		2
5	Yes	5		1
5	Yes	3	It provided robust reinforcement of success. Visual alone is completely satisfactory, but the times where I was not entirely focused on the screen it was nice to have feedback 'backup'.	1
4	No		I didn't really notice the auditory feedback until the last couple of dots, so it was mostly the same as visual + haptic.	1
5	Yes	5		4

17. Can you rank the combinations of feedback by the following? [Visual + Auditory]	17. Can you rank the combinations of feedback by the following? [Visual + Haptic]	17. Can you rank the combinations of feedback by the following? [Visual + Auditory + Haptic]
1	2	4
2	3	4
1	2	3
3	4	2
4	1	2
4	2	1
3	1	2
3	2	1
4	1	2
3	2	1
4	3	2
3	2	1
2	3	4
3	4	2
2	3	4
4	1	3
3	2	4
2	3	4
3	4	2
3	2	1

18. For the combination that you ranked "Most helpful" in question 17, can you please explain why you found it most helpful from the others?
The 2 feedbacks work best. 3 feedback was more that I need.
Felt like I was able to understand and have a more rhythmic pace
I really only paid attention to the visual. Auditory and haptic was largely ignored or even went unnoticed.
Because it was the most applicable response for the task, I feel sound was overstimulating b/c I could still hear vibrations.
It made sense to follow.
Those 2 feedbacks were all that I needed for my own confirmation.
Visual + haptic gives clear instructions of how many moves matches indication with the iPad feedback. If it is a "hold" longtime haptic gives me clues to hold it for longtime.
I can completely concentrate on one thing.
I found the auditory cue to be the most helpful in tracking my progress and going along with the task. I even started counting along with the ticks.
Clarity of input not mixed signals.
Both of them together were alarming but were not confusing and annoying till the point that I don't feel like doing the task.
It seemed appropriate and simple. Feedback was fast and clear. No extra feedback necessary.
More confirmations.
Visual + haptic provides best feedback to the user. The more feedbacks provided are not always the best. Just enough feedbacks are better.
I can see, hear and feel.
I felt like the sounds made the activity go faster. I felt more motivated to finish the exercise.
Feeling of haptic signal
Visual (for me) is the most important / dominant. But it was an enhancement having a more robust system.
I liked haptic for this game because it felt like my effort was really producing something I could feel.
I found this the most rewarding combination of feedback. For the trials without haptic feedback, I definitely missed it. For the trials with haptic feedback, I felt like the haptic part was almost a distraction from the load of the exercise. My mind could focus on the haptic vibration rather than the lactic acid building up in my arm.

19. For the combination that you ranked "Least helpful" in question 17, can you please explain why you found it least helpful from the others?
Too much info became distractive
Only 1 sensory input
Again, I largely ignored all but the visual feedback.
Because it was hard to follow.
The buzz was distracting.
It was too distracting and overwhelming having that many types of feedback. Sensory overload perhaps?
Only visual especially for the "hold" part confuses me because the visual pops out one by one, which make me feel I had to squeeze it one by one instead of hold it for a long time.
There are too many things happening at the same time.
I found the haptic almost distracting and kind of mentally just blocked it out not really paying attention to it.
Overriding signal that overlapped.
Just visual feedback was too passive in comparison to others.
Way too much information to pay attention to.
Not enough certainty.
Visual only feedback is not enough in user-interactivity of today's interface design.
I can only see.
I didn't even realize there were any vibrations and I was distracted by the noise it made.
Wait for device to reply.
I find it to be the most essential form of feedback, but alone it has failure potential due to a variety of circumstances (ex. distracted and look away from screen).
Just visual didn't ever make me feel like I wanted to try harder, and it was easier to loose focus. The only signifier was color change for when the task was done. It was not as rewarding.
I would never rank visual as least helpful. In fact I would never take the visual out. However, the visual + another form of feedback was always better.

20. Please write any final thoughts on how the feedback might be improved to assist you in completing the task.
Feedback / force feedback in the grip
I suspect that these results would be common to many of my experiences with these types of devices. I largely either ignore or are unsure of the meaning of the auditory or haptic feedback.
Perhaps utilizing haptic and auditory responses opposite of each other as to not use them simultaneously.
Balance of elements is key.
Limiting the types of feedback to only what the user requires, too much conflicts with the ability to complete the task efficiently.
Sounds could be more interesting. Sounds in "Hold" section should be different than other sessions.
I think it will be better if the feedback research (experiment?) is proceeded without a person manually helping by side.
N/A.
Just visual is good if you are expecting full attention without any help. The change on the screen (clue) is just enough clue to know that you are moving forward. Visual + auditory and visual + haptic are alarming enough to grab attention and not allowing to sway. Visual + auditory + haptic is annoying till the point if confuses.
1. It's hard to say if my performance "improved" in Q #2 since all of the tasks used visual feedback. 2. The exact timing of feedback seems important in connecting the task and feedback together, especially for audio and haptic. 3. Haptic feedback should be in the device being handled by the user / performing the task ... Maybe audio should be as well?
The feedback is best to be simulating real like experiences.
Perhaps in the future some kind of very low voltage electric shock that can convince out brain to believe we are touching on physical keys with contour and surface finish, instead of just some virtual keys.
Maybe a sound that is pleasing to indicate I have completed the task.
Haptic + auditory differentiation to indicate progress. I want the 10th rep to feel more significant than the 3rd. --> Increases motivation and is a satisfying reward to the exercise.
For something that requires physical effort, haptic feedback make the most sense because it is the closest to what I am experiencing. Maybe if I could have picked the noise for audio, I would have liked it more?
--> The visual as the only one told me how many more trials I still had left or how much longer I still had to go. --> The auditory feedback felt like a reward. --> The haptic almost let me know that the device was working and reading my muscle contraction. It was also a nice distraction from muscle fatigue. --> All 3 together worked as a strong reinforcer to keep help me contract for longer (like a feedback cheering squad).

DESIGNING A MOBILE DEVICE FOR SWALLOWING THERAPY

A SYSTEMATIC & COLLABORATIVE APPROACH

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MOBILI T

Design and Layout by Heide Dagg

INTRODUCTION

A search for iOS applications can leave a patient overwhelmed with choice:

1441 results	health tracking
1575 results	fitness tracking
264 results	nutrition tracking

Patients need to **use applications regularly** to derive the intended health benefits.

Successful uptake of mobile health is associated with:

- Perceived *added* value over existing solutions
- Simple, engaging and comprehensive interfaces
- Feedback on progress
- Potential for personalization, customization and adaptation

Many of the features can be achieved through **patient-centric design.**

There are many approaches to engaging end-users, but this is usually to validate or prototype.

Although some standards exist…

- ISO 13407 (Human-centered design processes for interactive systems)
- ETSI (European Telecommunications Standards Institute) EG 201 472 – Human Factors

…designers recommend an approach that is adaptable to the project rather than rigid guidelines.

AIM

Create a sufficiently appealing mobile health device to ensure its successful uptake.

PURPOSE OF THE DEVICE

Provide access to swallowing therapy using biofeedback, outside the clinic.

CLINICAL POPULATION

Patients with chronic swallowing impairments.

DESIGN TEAM

biomedical engineer, clinician, design students, firmware developer, industrial designer, patient, project lead, project manager, software developer.

RESULTS & REFLECTION

Personas & Demographics **[Useful for this project]**

- Offered a good framework for the discussion
- Team members identified with some of the Persona details and could then empathetically reflect on their design ideas

Top Task Analysis for Activity **[Not useful for this project]**

- The steps in the swallowing exercise are pre-determined
- There are not enough tasks to warrant prioritizing

Patient presence in Design Sprint was instrumental

- Patient contributes, not just tests/validates
- Patient pointed out ideas that would be sensitive areas for this population

The Design Sprint **[Useful for this project]**

- Team members saw overlap in thinking, but also learned not to defend one particular idea
- New ideas generated and knowledge gaps highlighted
- The Industrial Designer walked away with countless ideas (nine participants x six separate exercises x 2-3 ideas per exercise + discussion and validation)
- Given the outcomes and the subsequent discussions, this exercise was timely and will be repeated with a narrower focus

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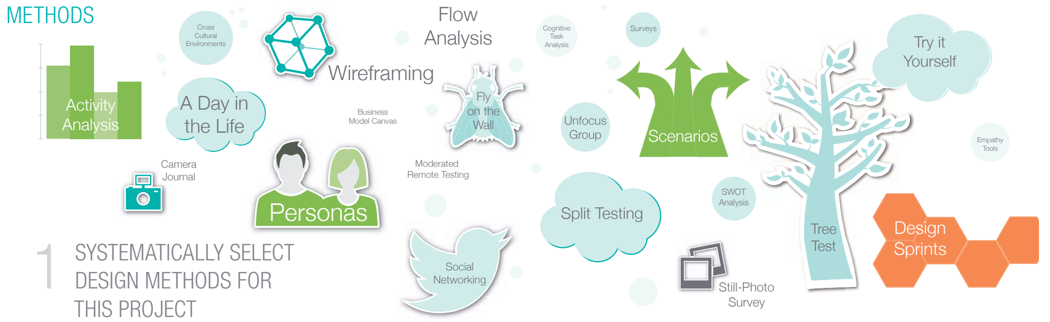
METHODS

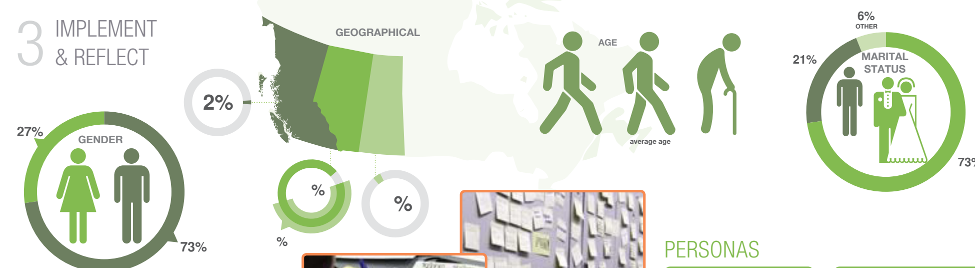


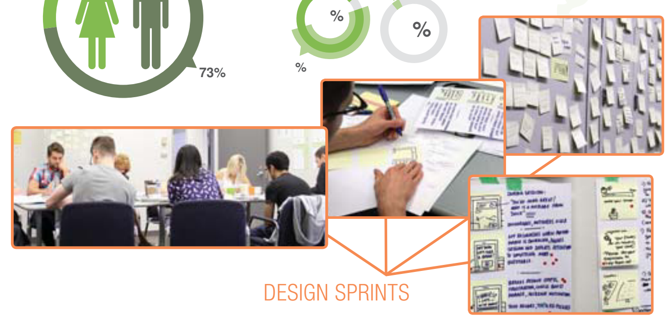
1 SYSTEMATICALLY SELECT DESIGN METHODS FOR THIS PROJECT

2 DECIDE WHEN THE METHOD IS APPROPRIATE TO USE

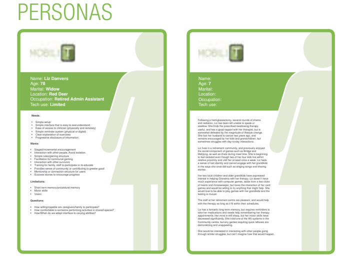
RESEARCH	IDEATION	PROTOTYPE	VALIDATION
A Day in the Life	☑ **Design Sprints**	Flow Analysis	Cognitive Task Analysis
☑ **Activity Analysis**	Draw the Experience	Role Playing	Fly on the Wall
Be Your Customer	Error Analysis	Try it Yourself	Focus Groups
Business Model Canvas	Experience Prototype	Wireframing	Moderated Remote Testing
Camera Journal	Paper Protoyping		Moderated In Person Testing
Card Sort	Quick and Dirty Prototyping		Narration
Long-Range Forecast			Split Testing
☑ **Personas**			
☑ **Scenarios**			
Secondary Research			

3 IMPLEMENT & REFLECT




DESIGN SPRINTS

PERSONAS



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Vodafone. Vodafone mHealth Solutions. Evaluating mHealth Adoption Barriers: Human Behaviour.

Appendix J