Assessing the Effects of MOBILE OS Design on Single-Step Navigation and Task Performance

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Abstract. When working on a task, mobile device users want to complete their work as quickly and efficiently as possible. In order to accomplish this they must use the navigational tools available on the system's interface. The importance of control design to user success requires system designers to consider all aspects of interface design: control tool characteristics, target audience demographics, and even frequency of use, to name a few. This research investigates characteristics (shape, location, and depth vs. breadth) of navigational control tools in order to determine their impact on user performance during common tasks on a mobile device. Cue theory predicts that performance is enhanced when cues are provided during decision-making situations. In the current research, controls with appropriate differentiation are expected to provide the cues necessary for users to more quickly identify their desired target.

Keywords: mobile computing, interface design, navigational control, Cue Theory, Fitt's Law.

1 Introduction

Today's business and personal spaces are seeing an explosive proliferation of mobile devices. According to a recent Gartner report, worldwide smartphone sales reached 149 million units in the fourth quarter of 2011, a 47.3 percent increase from the fourth quarter of 2010 (Gartner 2012). Additionally, Business Insider reported that mobile tablet sales will reach over 450 million units by 2015 and grow at a 50% compound annual growth rate over the next few years due to both falling prices and market penetration in the enterprise and education sectors (Gobry 2012). Ubiquitous computing is becoming a reality around us through the combination of mobile and pervasive computing technologies (Lyytinen and Yoo 2002; Rosenbush et al. 2003). Mobile information technology (IT) services are quickly being adopted at both the personal and organizational levels due to improvements in the data processing capabilities of these mobile devices (Kim et al. 2009). In addition, organizations of all types are seeing the value opportunities of mobility (Barnes and Huff 2003; Clarke III 2001; Yuan and Zhang 2003). As these mobile technologies and services continue to integrate, users are taking advantage of and connecting to them through smaller and

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smaller mobile devices such as smartphones and tablets to meet their computing needs.

One of the negative implications of this incredible technological sprint is that as the person-machine systems become more complex and sophisticated, the knowledge and information necessary to operate and maximize positive outcomes often exceed human capabilities (Rudolph, 2000). With the established knowledge that both type of information and amount of information conveyed is important to user performance (Dick et al, 2005; Kerr, 1973; and Kantowitz & Sorkin, 1987), user interface designers and developers need to consider user limitations and user abilities when launching mobile systems and applications that will potentially be used by untrained or inexperienced individuals.

In his user activity model, Shneiderman (1982) introduced the world to the term direct-manipulation in the context of interface control. Since that idea was introduced, system and interface designers have embraced the concept and most modern interfaces utilize controls that allow some type of direct-manipulation. With the proliferation of mobile technology this is seen as even more important due to size constraints and portability requirements. Though direct-manipulation is accepted as the standard for interface design (Lim, Benbaset, & Todd, 1996), the characteristics of the controls that are used to manipulate the system are still in dispute due to the complex nature of the problem. To find evidence of this, you need look no further than the various mobile operating systems available in the market today. Most design experts state that differentiation in interface controls is crucial to successful system navigation and user efficiency (Schwartz & Norman, 1986; Nielsen, 1999b, 2000). And while the Android OS uses system specific themes and remains fairly consistent in their color pallets and control sizes/shapes, there are differences in the way they operationalize their OS interfaces across different implementations.

While some corporations are designing applications with similar looking icons, small icons, and even icons that appear in different locations on the screen, several corporate entities are at least following the advice of design experts (Nielsen J., 1999a) and grouping tasks into functional categories and other characteristics that aid users in searching for specific items. One motivation for this study stems from this apparent disagreement. Therefore, in this research we will examine the effect that control characteristics (color, size and location) have on user performance.

Research in HCI has examined control design and layout on keyboards and other user devices such as personal digital assistants (PDA) (Card, Moran, & Newell, 1983; Lim, Benbaset & Todd, 1996; Shneiderman, 1998), but less research has been identified that looks at mobile OS icon design. One reason it is important to study this type of system and this type of user is the recent trend of organizations launching mobile applications that are targeted at untrained users on the move. The systems being launched include shopping portals, payments systems, organization, governmental or business portals, registration and enrollment systems, and even social media and networking systems. The users of the systems identified will have differing levels of platform and device proficiency, market and organizational knowledge, and will have little to no access to any help other than that help functionality inherent in the application itself. With these typical systems and users in mind, this research study also aims to capture user satisfaction and perception of the mobile operating system as well as user performance and their intention to use.

The major research questions of interest:

- How do control characteristics (color differentiation, location, and size) affect user performance in select tasks?
- How do control characteristics (color differentiation, location, and size) affect user attitude?
- How is user attitude affected by user performance?
- How is behavioral intention affected by user performance and attitude?

2 Prior Research

2.1 Target Users and Mobile Operating Systems

The typical users targeted by this research have varying levels of mobile technology experience, varying levels of Internet experience, and varying levels of mobile application experience. The occasional user of the mobile operating systems under investigation (Android based OS) would be without system expertise but would nonetheless be required at times to make use of the system.

Customarily, the type of system under investigation in this research would provide neither formal training nor documentation, and would be limited in its support function. In some cases use of the system is mandatory (e.g. company requirement) and users wouldn't have the option to use an alternative method.

2.2 Target Users and Systems

Cue theory states that individuals gain perception by taking in all broadcasted cues and putting them together as one would do with a puzzle to come up with the desired picture. Some researchers have compared it to the board game of Clue or a murder scene investigation where the investigator pieces together all the clues available at the scene to come up with the perpetrator responsible for the crime (Allard, 2001). Cues are used by individuals to see, feel, smell, taste or hear clues and deduce what they mean and what type of response is appropriate. In this research, cues will be operationalized as the characteristics (color) (Teichner et al, 1977) of navigational icons. It is expected that users will more easily and quickly distinguish between icons and select the appropriate one based on this characteristic.

Differentiation is provided by using colored icons for each treatment. Each control icon on the interface would have a unique color. If the icon is on several different pages or layers of the OS, the same color is used for the icon each time it appears (treatment 2 might vary the color). The cue of color differentiation is expected to allow the user to more quickly distinguish between control icons and select their desired target more quickly.

2.3 Fitts' Law

Fitts' law states that the time to acquire or point to an object is a function of the distance to and the size of the object, that is, as the distance to the target is increased the pointing time increases. This law further states that the smaller the target the longer it takes to point to or acquire it. Performance is determined by (1) accuracy and (2) time to achieve the desired task.

When Fitts' Law is applied to interface design and targeting of control icons the same 2 main factors need to be considered, the target size (how big the icon is) and the distance to the target (where the icon is in relation to the hand position). This research was interested in the effect of target size on user performance while using a mobile smart phone device. The relative size of the target was altered for the 2 treatments to test the effect of size on performance.

3 Research Model

This research will examine the effect of mobile OS design characteristics on mobile device users' performance, attitude, and behavioral intention. Performance is measured by taking the average time for participants to complete each assigned task. The time to complete each assigned task will be summed to arrive at an overall time to determine performance. Performance measures based on total number of control button manipulations were also collected though the time measure is what will be utilized for all analysis and data reporting.

Cue theory incorporates the idea that when cues are present they enable a user to quickly and easily distinguish between options (Allard, 2001). In this research cue

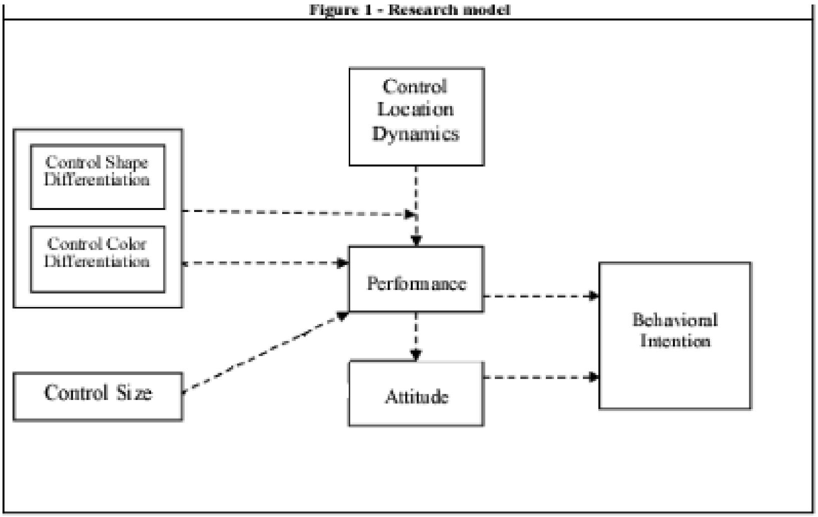

Fig. 1. Research Model

theory has been applied to a search and selection task and it is predicted that performance will be enhanced. Cue theory has been extended to include the concept that learning is enhanced when cues are present (Clibbon, 1995).

Fitts' law is fundamental in offering predictions for performance measures on targeting tasks and has been applied to interface design issues in prior research (Nielsen, 1997; Nielsen, 1998). User performance is a function of both the size of the target and the relative location of the target (Fitts, 1953, 1954). The closer the target to the relative position of the user and the larger the target, the better performance will be (i.e. less time for users to select the desired control button).

- H1: A mobile OS with icons (navigational control) differentiated by color will result in higher user performance than will a mobile OS with consistent colored icons.
- H2: A mobile OS with larger icons will result in higher user performance than will a mobile OS with smaller icons.
- H3: A change in the location of icons (controlled dynamic locations) will result in decreased user performance.
- H4: Color differentiation of icons will reduce the negative effect of control location change on user performance.
- H5: A higher level of user performance will result in an increased level of positive user attitude.
- H6: The more favorable user attitudes towards a mobile OS the higher the level of intention to use the system.
- H7: A mobile OS or application that generates high levels of user performance will result in an increased level of intention to use than will a mobile OS that generates lower levels of user performance.

4 Proposed Method

An experiment is planned using Android mobile devices that are programmed to look like the default factory OS are installed. The experiment will include 4 treatments that manipulate icon color and icon location (2X2). All control button colors for the experiment were selected in accordance with prior research that showed individuals could quickly distinguish one color from another in an interface environment. The colors used for the experiment will include red, blue, yellow, green, black, and white. The study will incorporate a color acuity test to assign any participants who were determined to suffer some degree of color blindness to a treatment where color was not manipulated. The color treatments were assigned to control icons independent of any meaning or purpose of the button. A potential problem could be identified by using colors and assuming that no relationship exists between the color and an inherent meaning attached to it. Colors tend to have prototypical associations attached to them and when an individual sees the color they immediately think of this attached symbol, object or meaning (Helmholtz, H. von, 1925; Rosch, 1975). It might be useful to begin a study with a test that identifies any prototypical meaning attached to the colors used to offer a baseline possible explanation for results observed.

Table 1. Proposed Experimental Design for OS Screen Manipulation

		COLOR	
		Differentiated	Non Differentiated
	Large		
SIZE	Standard		

Control button location will be manipulated as a within subjects treatment. For the first few tasks in the Experiment, the controls will be located in the exact same location on each page where they appear. For the last few tasks the control icons will be rearranged into new locations. The control button size manipulation will be accomplished by using two levels of size: (1) the standard size as developed by the electronic procurement system designers, and (2) a size that is larger in each dimension than the standard.

4.1 Data Capture and Preparation

We plan to include a minimum of 40 participants for this study. Performance will be measured by taking the average time for participants to complete each task. To arrive at this measurement, the total time to complete the assigned list of tasks will be divided by the total tasks completed. Performance measures based on the total number of control icon clicks will also be collected though the time measure, and is what will be utilized for all performance related analysis and data reporting.

Attitudes toward the mobile operating system will be measured by a set of seven 7-point Likert-type questions adapted from Part 3 of the long form of the QUIS (Questionnaire for User Interaction Satisfaction) (Shneiderman, 1998).

4.2 Method of Analysis

For the purposes of this study, assignment of subjects to treatment groups will be random. Randomization will be achieved by assigning the treatments (1-4) in an incremental order to subjects as they walk into the laboratory. Thus, the first four subjects will be assigned treatments 1 through 4 and will form the first set. The assignment will be repeated for the remaining groups of four subjects, so that all individuals form four treatment cells with ten participants in each. The randomization procedure can be checked by analyzing differences in demographic variables among treatment groups such as gender, computer efficacy, and experience. Attitude analysis using Cronbach's alpha will determine reliability. We will also test for the presence of any additional benefit from deleting items from the scale. If not, the attitudes scale will be constructed by averaging all seven items.

General demographic information will be captured but will not be linked to specific participants and will be used in raw data and grouped data analysis only.

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