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Wen Yong Chua
National University of Singapore, wenyong@comp.nus.edu.sg

Klarissa Ting-Ting Chang
National University of Singapore, changtt@comp.nus.edu.sg

Maffee Peng-Hui Wan
National University of Singapore, diswp@nus.edu.sg

Yi Wu
National University of Singapore, wuyi@nus.edu.sg

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Yi Wu
National University of Singapore
wuyi@nus.edu.sg

ABSTRACT

The development of smartphone applications is prevailing globally, including the underserved communities consisting of a huge group of novice users. In spite of the growing number of novice users, we hardly consider usability for users with varying expertise level when we evaluate performance and satisfaction with usage of mobile applications. In this study, we argue that it is not suitable to design one interface for all users of progressively varying communities. Based on theories in design science research, we propose a user-accustomed approach to adapt mobile applications that integrate three types of interaction elements, namely localization, structural navigation and illustration. In an investigation of the proposed approach on mobile application, we empirically proved the effects of user-accustomed interaction techniques on performance and satisfaction between novice and expert users. The findings provide significant theoretical and practical implications for design and implementation of user interfaces on mobile applications.

Keywords

User-Accustomed Interaction, Localization, Structural Navigation, Illustration.

INTRODUCTION

The greatest challenge for developing successful mobile applications is to design an interface that is suitable for all users under different mobile environments (e.g. Spatial, Temporal and Contextual). The environments stress a significant consideration of how mobile application should be designed. Engaging applications on mobile devices has become important in our daily lives. However, engagement of mobile applications is a great challenge for millions of people living in the underserved communities of the developing countries (Deng and Chang 2012). These people are novice users who have inadequate contact with technology resulting in not having sufficient skills to use interactive elements such as menus (Medhi et. al. 2011). Since novice differ from expert whom typical user interfaces are designed for, it is critical to consider how to design usable applications.

Usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO 9241-11 1997). To achieve greater usability, developers have to design interaction on mobile applications to adapt to users' needs and expertise (Vessy 1991). Adaptive systems have shown to improve users' performance and satisfaction (Adipat et. al. 2011). A highly learnable interface emphasizes on needs of novice users, permitting them to gain proficiency and efficiency (MacDorman 2011). However, efforts in adapting mobile applications to users' expertise have been limited to geographical boundaries of regions. To address the gap between the need for mobile applications that cater to users' expertise and lack of interaction techniques in existing literature for diverse users, we propose an approach known as user-accustomed interaction to provide localization, structural navigation and illustration on mobile applications based on users' expertise levels. This research aims to provide answers to two significant research questions:

1. What are the impacts of user-accustomed interaction (localization, structural navigation and illustration) on usability of mobile applications?
2. How does expertise level of users affect the impacts of user-accustomed interaction (localization, structural navigation and illustration) on usability of mobile applications?

Our research is based on the design science research framework (Hevner et. al. 2004), which provides a set of systematic protocols for developing new information systems artifacts to solve a problem in a logical and practical approach. We developed three types of artifacts in this research. First, we created a research model that associates the user-accustomed interaction techniques to users' performance and satisfaction. Second, we analyze and integrate the interaction techniques based on cognitive fit theory (Vessy 1991), information foraging theory (Pirolli 2007) and automaticity theory (Logan 1988). Third, we implement prototypes with various user-accustomed interaction techniques on mobile devices. These prototypes are deployed in an empirical assessment of the proposed approach with novice and expert users.

LITERATURE REVIEW

Following the usability guidelines framework by Seong 2006, we identify key interaction elements for consideration while designing mobile interface to increase usability. The framework consists of 'User Analysis' (e.g. adapting to users' expertise level), 'Interaction' (e.g. localization, illustration) and 'Mobile Learning Interface Design' (e.g. structural navigation). Usability of mobile applications can be affected by content that is delivered (i.e., localization), amount of content on each screen (i.e., structural navigation) and format of the content in terms of textual, image and other visualization cues (i.e., illustration).

Localization (L)

According to the framework, one of the guidelines in the 'Interaction' category is to 'Minimize human cognitive load'. Localization is providing up-to-date location specific information. It is critical for mobile application due to contextual mobility. Mobile devices allow users' geographical location to be used by cellular triangulation and global positioning technologies (Ning et. al. 2009).

Vessy(1991) suggested in cognitive fit theory that a match between users' goal and information available increases users' satisfaction. A mental representation of the problem is created based on the information available. It replicates the representation of the problem in the limited working memory. A discrepancy between the goal and information available requires users to take extra effort to comprehend the information. During comprehension, user might perceive the information to be irrelevant and thus ignoring it. Accuracy of information is compromised, resulting in application to be perceived as not useful (Adipat et. al. 2011). Therefore, we hypothesize:

H1: L will lead to higher degree of usability as compared to content with no L.

Structural Navigation (S)

Another guideline in the 'Interaction' category is 'Small Screen Display'. Structural Navigation is critical for mobile application due to the spatial and temporal mobility where users perform task simultaneously. Taivalsaari (1999) suggested that reducing the number of elements on each screen could resolve issues that arise from a limited screen size of mobile device. The structure an application has for the individual to navigate around the system to perform a task is 'Structural Navigation'. It indicates the way mobile application (i.e., structure), and how efficiently the procedures (i.e., navigation) of mobile application are designed (Hoyoung et. al. 2005).

A user with the "accommodating" learning style learns primarily from "hands-on experience" (Kolb 1984). A task is conducted in a step-by-step manner during learning stage. Solutions can be retrieved directly from memory after learning stage. Automaticity replicates the build-up of routines in memory (Logan 1988). Structural Navigation allows only elements from one level of hierarchy to be shown at each time. Usable mobile applications should be easy to learn and remember. Therefore, we hypothesize:

H2: S will lead a higher degree of usability as compared to flat navigation.

Localization (L) + Structural Navigation (S)

With adherence to the cognitive fit theory, presenting users with localization enable task to be accomplished in a shorter period of time with minimal effort (Adipat et. al. 2011). Localization provides users with up-to-date location-specific information. According to the theory of automaticity and the experiential theory, structural navigation affect users' task performance. With structural navigation, user can receive direction on how the task needs to be completed (Taivalsaari 1999). Hence, we predict that existence of structural navigation with localized content will increase the degree of usability of a user. Therefore, we hypnotize:

H3: L + S will lead to a higher degree of usability as compared to L.

Illustration (I)

'Minimizing Cognitive Load' is another guideline in the 'Interaction' category. Users with low-literacy level will require the help of images to understand the information. Illustration is the visual presentation of information. Orientation, color, density, contrast and size of the texture pattern are effective cues for perceiving an image (Kjelldajl 2003). Information foraging theory (Pirolli 2007), in relation to user-accustomed interaction, explains how decisions are made when engaging in mobile application. It studies how mobile application can be accustomed to improve usability. The theory states that users depend on information scent to determine the information. Information scent in this context is the different information cues. Users will make decision based on information scent. Hence, information scent is crucial in application usage because it guides them to the appropriate choices. Therefore, we hypothesize:

H4: I will lead to higher degree of usability as compared to L.

Localization (L) + Illustration (I)

Localization contain only textual information and illustration contain only images. Images with textual information are better than images-only representation as they are perceived to be easier to use. Hence, we predict that localization with illustration will increase the degree of usability. Specifically, we hypothesize:

H5: L + I will lead to a higher degree of usability as compared to L.

Localization (L) + Illustration (I) + Structural Navigation (ALL)

With the various techniques mentioned, an individual might question if more user-accustomed techniques will increase the degree of usability. Localization provides up-to-date location specific content so as to minimize the problem of information overload. According to the cognitive fit theory (Vessy 1991), presenting user with information that matches the goal of the users' task increases users' task performance as well as users' satisfaction (Adipat et. al. 2011). Pirolli (2007) proposes in the information foraging theory that information cues helps the user to have better understanding of the content presented. According to the theory of automaticity and experiential theory (Logan 1988), a novice user will learn better if the task is carried out in a step-by-step manner, i.e., structural navigation. Therefore, we predict that the degree of usability will be higher when all the user-accustomed techniques are incorporated.

H6: C with I and S will lead to higher degree of usability as compared to L and I.

Expertise Levels

Novice users "know the task but have little knowledge of the system". Expert users "have deep knowledge of tasks and related goals and the actions required to accomplish the goals". An effective user interface of a mobile application is important for enhancing users' satisfaction. However, existing user adapted presentation techniques are targeted at expert users only (Kolb 1984). Existing literatures on mobile users suggest that expert and novice users vary in expertise from two dimensions – goal and prior experience (MacDorman 2011). Nicholls (1984) acknowledged two types of goals - learning and performance goals. Learning goal is a goal where a user wants to learn something new or to improve their current level of competence. A novice user wants to gain proficiency and efficiency to become an expert user (learning goal). An expert user who has already obtained the maximum proficiency would like to compete to be the best among their peers. An example of performance goal is where individuals perform a task to demonstrate their competence with minimal errors (Nicholls 1984). Prior experience refers to the current knowledge a user has that can be transformed into a skill. For example, a novice user who only has a few attempts with mobile application does not have prior experience with mobile application (Norman 1983). This has triggered an inverse relation between the time taken to perform a task and the users' prior experience. That is, an expert takes a lesser amount of time to perform a task as compared to a novice user due to the prior experience gained from the extensive practices (Kolb 1984). Hence, we hypothesize:

H7: The relationship between user-accustomed interaction and degree of usability is contingent on expertise level.

RESEARCH METHODOLOGY

To examine the moderating effect between the user-accustomed interaction techniques and the expertise level, we conducted a controlled laboratory experiment with an 8 x 2 factorial design using prototypes equipped with eight user-accustomed interaction techniques being a within-subject factor and expertise level (expert versus novice) being a between-subjects factor. Participants were randomly assigned to the mobile application prototype that was equipped with different user-accustomed interaction techniques. The participants were asked to start the experiment by performing a pre-experiment survey that has questions regarding to their demographics. The participants were required to perform the post-experiment survey after they have completed the tasks on the mobile prototype. Laboratory experiment allows participants to concentrate on the given tasks with minimal confounding effects of factors such as lighting that often exist in field studies.

Prototypes

To test the hypotheses, we implemented 8 different mobile prototypes. To access the effect of the different user-accustomed techniques, we minimized the potential influence of other actions by ensuring that the placement of information and other elements remained in the same position throughout the system.

Participants

A total of 160 participants participated in this study. 79 were university students and 71 were foreign workers. There are 88 female participants and 72 male participants. Through a pre-experiment survey, we ensured that all participants had no experience with agricultural mobile application. Participants were randomly assigned into 8 presentation user-accustomed groups.

Measurements

Usability was measured through users' performance and satisfaction with the prototype. Users' performance was measured through task completion time. Participants noted the start and end time of the task. We kept track of the time when the first screen was being loaded and the time where the last screen was loaded to verify the accuracy of time noted. Users' perception was measured based on perceived ease of use and perceived usefulness. We adapted from the End-User Computing Satisfaction (EUCS) instrument for measuring users' perception.

DATA ANALYSES

We used ANOVA to analyze the effect user-accustomed interaction. We used Bonferrini multiple comparison as it is a robust method for multiple comparison in the within-subjects designs. Descriptive statistics of perceived ease of use (PEOU) and perceived usefulness (PU) are presented in Table 1.ANOVA reveals a significant main effect of accustomed techniques ($F(7,152) = 2655.21$, $p < 0.05$). It does not reveal a moderating effect from the user-accustomed techniques on users' expertise level ($F(1,158) = 0.02$, $p>0.05$). Hence, H7 is not supported. Result shows that there is significance in the users' PEOU when participants are using prototype with illustration ($P< 0.05$).

Prototype	Expertise level	PEOU		PU	
		Mean	Std. Dev.	Mean	Std. Dev.
All	Expert	6.87	0.23	4.90	0.473
	Novice	6.80	0.53	6.77	0.63
L + I	Expert	6.77	0.22	6.73	0.58
	Novice	6.90	0.22	6.83	0.36
L+ S	Expert	6.83	0.24	1.10	0.32
	Novice	6.87	0.23	1.30	0.29
L	Expert	6.77	0.27	2.70	0.10
	Novice	6.80	0.32	1.47	0.59
I+S	Expert	1.13	0.17	2.73	0.34
	Novice	1.17	0.24	4.53	0.39
I	Expert	1.13	0.23	1.13	0.23
	Novice	1.10	0.22	2.57	0.90
S	Expert	1.13	0.23	4.87	0.45
	Novice	1.20	0.36	1.67	0.50
O	Expert	1.17	0.18	1.23	0.42
	Novice	1.13	0.17	1.33	0.50

Table 1: Descriptive Statistics of PEOU and PU

Therefore, H4, H5 and H6 are supported. However, users' perception is not significant when using the prototype with localization (L, L+I, and L+S) Hence, H1 is not supported. Result has shown that structure (S) technique has only led to a greater impact on a users' perception. Therefore, H2 and H3 are only partially supported.

ANOVA reveals a significant main effect of user-accustomed techniques ($F(1,152) = 35.17$, $p < 0.05$). It reveals a moderating effect from the user-accustomed techniques on users' expertise level ($F(1,158) = 16.70$, $p > 0.05$). Therefore, we analyzed it in a detailed manner by conducting multiple comparisons of user-accustomed techniques on PU at two levels of users' expertise level. Results shows that there is a high level of significance on the prototype that is equipped with localized content for both the novice and expert users. Hence, H3, H5 and H6 are supported. H1 is only partially supported, as it does not have a significant impact on the perception. We can also see that the significance level of the prototype equipped with the structure interaction was high among the expert user but not for the novice users. Therefore, H7 is supported and H2 is also partially supported. The significance level of the prototype that is equipped with image representation alone is high among the novice user. Hence, H4 is also partially supported. The descriptive statistics of search time is reported in Table 2. ANOVA on search time shows a significant main effect of user-accustomed techniques ($F(7,152) = 2.88$, $p < 0.05$) and users' expertise level ($F(1,158) = 166.52$, $p < 0.05$). The significant interaction suggests that the effect of user-accustomed techniques could be moderated by

Prototype	Expertise Level	Task Completion Time (s)		Sample Size
		Mean	Std.Dev.	
All	Expert	109.30	19.89	10
	Novice	255.00	30.28	10
L + I	Expert	94.50	3.03	10
	Novice	355.00	30.28	10
L + S	Expert	124.50	3.03	10
	Novice	255.00	30.28	10
L	Expert	84.50	3.03	10
	Novice	355.00	30.28	10
I	Novice	345.00	30.28	10
	Expert	134.50	3.028	10
S	Novice	356.00	31.70	10
	Expert	154.50	3.028	10
O	Novice	355.00	30.28	10
	Expert	94.50	3.028	10

Table 2: Descriptive Statistics of Task Completion Time

uses' expertise level. Therefore, H7 is supported. Hence, we analyzed task completion time in a more detailed manner by conducting multiple comparisons of user-accustomed techniques at each of the users' expertise level separately. Task completion time used by the participants when they used any of the eight mobile applications with user-adapted interaction was significantly lesser than the task completion time used by participants while using the mobile application that is without any user-accustomed interaction ($p<0.01$). The results show that conditions without Localization (I, S, I+S, O) shows that there was no significance in the time used to perform the task ($p > 0.01$). Hence H1 is supported. Results also show that Structure (S) technique has only led a novice user to perform a task at a significantly shorter time. Expert users on the other hand used a shorter time with the conditions without the structure (L, L+I) conditions. Therefore, H2 and H3 are only partially supported. Hence, expert and novice users have different habits of mobile device usage.

DISCUSSION

There are several major findings in this study. First, the different user-accustomed techniques significantly reduce the mobile task performance time, which increase the degree of usability. The results strongly indicate that restricting number of elements on each screen is effective especially with users who have little experience with mobile application. Second, structural navigation might not have significant impact the users' perception of an expert user as we expected. There are a few possible reasons for these surprise findings: 1) with more usage experience, expert users have a higher expectation of a good mobile application. 2) Expert users prefer shortcut keys to perform the function with minimal clicks in lesser amount of time. Third, illustration has improved the task performance time significantly where users are usually multitasking.

IMPLICATIONS AND FUTURE WORK

Theoretical Implications

This study provides several theoretical implications. First, it integrates uniqueness of user-accustomed interaction such as localization, structural navigation and representation provided by mobile features affecting the usability of the application on a novice user. This research provides insights on how an application can be designed such that a novice user can use it without much hassle. Second, our study differentiates the different user-accustomed interactions techniques and their impact on the usability (task performance time and users' perception of the design) on novice user. Third, it provides insights on the contingency of mobile expertise level of a user on the relationship between user-accustomed interaction techniques and degree of usability of the mobile application on a novice user.

Practical Implications

The findings of this study provide some practical guidelines on how mobile application design can be accustomed. It provides designers with ideas in which information scents can be used on mobile applications. Information scents can be used in the form of an image that would help an individual to recall the information. It provides application developers with the needs of the novice users to be addressed. Application developers often design complicated interface on applications to be unique, thus forgetting the basic needs of a novice user.

Limitations and Future Research

The proposed user-accustomed interaction techniques have covered all aspects in the usage of a mobile application. However, this study has limitations due to resource constraints and technical difficulties. First, our experiment is conducted in a stationary environment that does not comply with a mobile usage setting. Therefore, this experiment could be improved by conducting a field study experiment. Second, the techniques proposed in this study are only appropriate for smartphones where screen is bigger than feature phones that are still used by people living in developing countries. Hence, this study could be improved by introducing other techniques on feature phones. Furthermore, other techniques such as changing brightness of the screen can be introduced.

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