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6-26-2018

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Completed Research Paper

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Abstract

Cross-platform services allow access to information across different devices in different locations and situational contexts. We observed forty-five participants completing tasks while transitioning between a laptop and a mobile phone across different contexts (seated–moving and seated–seated). Findings showed that in each test setting, users were sensitive to the same cross-platform user experience (UX) elements. However, the seated–moving settings generated more issues, for example, more consistency problems. Two moving-related factors (attentiveness and manageability) also affected cross-platform UX. In addition, we found design issues associated with using mobile user interfaces (UIs) while walking. We analyzed the issues and proposed a set of UX design principles for mobile UIs in moving situations, such as reduction and aesthetic simplicity. This suggests designing context-aware cross-platform services that take transitioning into account for enhanced mobility.

Keywords: Mobile User Experience; Cross-Platform UX; Ubiquitous UX; Interusability; Mobile User Interface

Introduction

It is currently common for people to use multiple devices, including desktops and mobile phones, to perform a single task or interrelated tasks, migrating tasks from one device to another as required (Google 2012). There is a growing demand for such *cross-platform* interaction, as users adopt multiple devices for different kinds of needs (Forrester Research 2013; Google 2012; Microsoft 2013; Santosa and Wigdor 2013). Recent research showed that 99 per cent of the surveyed users (n = 111), who use multiple devices including smartphone, acknowledged that they have been using their devices, to interact with cross-platform services to achieve inter-related tasks (Majrashi 2016).

Cross-platform interactions can occur in different modes: *sequential* where a user moves from one device to another at different times, and *simultaneous* where a user interacts with more than one device at the same time (Google 2012; Jokela et al. 2015; Microsoft 2013). In this study, we focus on cross-platform sequential interaction, which according to Google (2012, 90 per cent of users (*n* = 1611) engage in to complete tasks, with 98 per cent of them switching between their devices at different times during a single day.

Since users own multiple devices and move between them throughout the day, the choice of a device for interaction at a particular time can be driven by context (Google 2012; Microsoft 2013). A context of use can refer to a combination of different context variables such as location (e.g., lab/ street/ office) and situation (e.g., seated/ moving) (Ghiani et al. 2015; Öquist et al. 2004). Google (2012 found that PCs and laptops are generally used more at the office and at home, smartphones are normally used while on the move and at home. Movement from one location to another is usually accompanied by the adoption of a different device because of the increasing demand of 'always-on devices' (Forrester Research 2013; Liao and Deng 2014; Microsoft 2013). For example, the smartphone tends to be the 'bridge' between at work and at home in the cross-platform sequential interaction mode (Microsoft 2013). Change in location even in terms of rooms (e.g., from the kitchen to the living room) can involve switching to another device (Forrester Research 2013).

Cross-platform cross-context user sequential interactions with interrelated goals can be illustrated by a cross-platform online shopping service. A user might find a product using the service mobile application while walking to the office, and as soon as they get to their desk, the user switches to the service website via a desktop computer to buy the product.

Given that typical UX studies examine a single context of use, there may be UX issues that would not be discovered, despite cross-platform use becoming more prevalent. In terms of cross-platform usability (or inter-usability) testing, it is still unclear whether evaluating a cross-platform service that involves a mobile UI in a single context of use where users interact with all UIs while seated (e.g., in a lab environment)—is different from evaluating it in multiple contexts of use—in which users interact with interfaces in different contexts (e.g., using a desktop UI while seated in a lab and using a mobile phone application while moving outside the lab).

Previous studies on cross-platform user experience (Majrashi et al. 2016a; Majrashi et al. 2016b; Shin 2016; Wäljas et al. 2010) have not adequately addressed cross-platform *cross-context* user experience. In this paper, our aims are (1) to investigate the differences in testing inter-usability of services encompassing mobile UIs in different contextual settings, (2) to identify mobile context-related factors that affect cross-platform UX and (3) to highlight UX design principles for mobile UIs that are operated while moving in order to design better context-aware cross-platform services that involve using a mobile UI in a walking situation.

Background

In this section, we discuss concepts related to cross-platform service and the configuration of cross-platform service. We explain differences between traditional usability and cross-platform usability, as well as between traditional user experience (UX), and cross-platform UX. We also briefly highlight some related research.

Cross-Platform Service and Configuration

Researchers have used different terms to describe interactive systems with the same information and services that can be accessed by users from different computing platforms (hardware and software). These include Multiple User Interface (MUI) (Majrashi et al. 2015; Pyla et al. 2006; Seffah et al. 2004), Multiple Platform User Interface (Ali et al. 2002; Meskens et al. 2008), multi-channeling, and cross-media (Segerståhl 2009), and cross-platform service (Majrashi et al. 2016a; Majrashi et al. 2016b; Wäljas et al. 2010). In this paper, we use the term "cross-platform service" to refer to a single service encompassing various user interfaces on at least two computational platforms for interacting with the service. We use this term to emphasise the user's transitioning from one platform to another to complete tasks.

Cross-platform services can be configured depending on different user or business needs, or based on some specific platform's constraints or capabilities. Configuration of a cross-platform service can be described according to the way devices are organised. Denis and Karsenty (2004 identified three degrees of device redundancy with respect to data and function availability: redundant devices, complementary devices and exclusive devices. In the redundant degree, cross-device interactive systems allow access to the same data and functions. With the complementary degree, the interactive systems across devices have a zone of shared data and functions, but one or more of the devices offer access to data or functions that are inaccessible on the other device(s). With the exclusive degree, each interactive system in each device gives access to different data and functions.

Cross-Platform Usability and User Experience

Cross-platform usability can be different to traditional usability (Denis and Karsenty 2004; Majrashi and Hamilton 2015; Seffah et al. 2004). Traditional usability concerns characteristics (e.g., ease of use) of an individual system within a specific platform. Usability of an individual system can be achieved through applying specific design principles or guidelines, for instance, Nielsen's ten usability heuristics (Nielsen 1995), and guidelines for a specific interface (Gong and Tarasewich 2004; Seong 2006). Cross-platform usability deals with the ease of use of multiple user interfaces and how well users can reuse their knowledge and skills for a given functionality when switching to other devices (Denis and Karsenty 2004). Cross-platform user experience is also different to traditional user experience (Väänänen-Vainio-Mattila et al. 2009). While traditional user experience considers user perceptions of using an interactive product in particular contexts of use (Hassenzahl 2005), cross-platform user experience (or distributed UX or intermodal UX) considers interaction with a system that involves multiple interaction devices or styles (Segerståhl and Oinas-Kukkonen 2007; Väänänen-Vainio-Mattila et al. 2009) and the user's transition between them.

Related Work

There have been few studies on cross-platform user experience and inter-usability. The main cross-platform UX themes identified in these studies are: continuity (how tasks and actions are migrated across platforms) (Denis and Karsenty 2004; Majrashi et al. 2016b; Wäljas et al. 2010), composition (the organisation of devices and their functionality) (Majrashi et al. 2016b; Segerståhl 2009; Wäljas et al. 2010) and consistency (how consistency is leveraged through different system components) (Denis and Karsenty 2004; Majrashi et al. 2016a; Majrashi et al. 2016b). In this paper, we investigate cross-platform cross-context user experience elements, focusing on mobile and ubiquitous transitioning experience.

Ghiani et al. (2015 conducted research to gain an understanding of user needs and the technical requirements for context-aware information sharing in multi-device environments. They found that switching between devices necessitated information sharing and that this need was often context specific (i.e., it arose when switching between home, work or public places). For example, they found that there was a need to share items such as documents, which was often related to task continuation on another device in a different location (e.g., accessing documents from a work computer at home). However, their research focused more on the requirements for information sharing and the user preferences for how a system should react to such requirements and did not investigate user needs as a whole. Hence, there is still a necessity to investigate UX when transitioning from one device to another when user transitioning is accompanied by a change in context (location and/or situation).

Cross-Context User Study

We wished to discover how UX varies with different situations, such as being seated or moving, and how this interacts with cross-platform use. We called for volunteer users to attempt a set of inter-related tasks using cross-platform services in two testing settings: seated–moving and seated–seated. We used 'seated–moving' and 'seated–seated' to refer to the contextual testing settings in our study. In the seated–moving context, the cross-platform interaction involved switching between a laptop device in a seated situation (in a lab environment) and a mobile device in a moving situation outside the lab (in an educational institute environment). This means that switching between the two devices in the seated–moving setting also involved changing the context of use. In the seated–seated context, the cross-platform interaction involved switching between a laptop and a mobile device in a seated situation (in a lab environment).

In this section, we describe the data collection methods, cross-platform services, devices used to access the services, and implementation types of user interfaces, and participants. We also define the horizontal task concept, and explain how tasks and participants were organised in the study.

Data Collection

Data were collected using a combination of techniques. We recorded users as they interacted with the cross-platform services. Participants verbalised their thoughts in Arabic since it was the participants' native language. We observed users and recorded design issues. Two questionnaires (post-transitioning and post-test questionnaires) were used to complement the qualitative data. Participants received all questionnaires in the Arabic language. The questionnaires were designed with a five-point Likert format that ranged from ''strongly disagree'' (1) to ''strongly agree'' (5).

The post-transitioning questionnaire was undertaken after a user completed two sub-tasks which involved moving from one device to another. The post-transitioning questionnaire with the *seamless transitioning scale* were used to measure user satisfaction about seamless transitioning between devices based on the attribute of 'continuity' pertaining to cross-platform usability (Denis and Karsenty 2004). The *seamless transitioning scale* consisted of the following three statements*:*

1. I am satisfied with the amount of time it took to resume the interpreted task from [specified device, e.g., the mobile phone].
2. I found I needed to remember information from the user interface on [specified device, e.g., the mobile phone] to be able to continue the task using the user interface on [specified device, e.g., the laptop].
3. I felt I could continue seamlessly in my task after switching from the user interface on [specified device, e.g., the mobile phone] to the user interface on [specified device, e.g., the laptop].

The post-test questionnaire was completed after the participant had undertaken all tasks in the testing project. The questionnaire consisted of a *cross-platform usability scale* with eight statements (as shown below) addressing a range of usability attributes pertaining to cross-platform user interaction: productivity, ease of use, expectation, degree of improvement, integration, learnability, consistency and frustration.

1. I felt productive when using many platforms.
2. It was easy to use each user interface.
3. I found that each user interface across platforms was designed the way I expected it.
4. I felt that the cross-platform user interfaces needed much improvement.
5. I found the various cross-platform functions to be well integrated.
6. I needed to learn how to use each user interface separately.
7. I noticed inconsistencies between cross-platform user interfaces.
8. I was frustrated by the different designs of each user interface.

Both seamless transitioning and cross-platform usability scales were validated previously (e.g., in terms of reliability) by Majrashi (2016). With each questionnaire, users could comment on their impressions of tasks across platforms with open-ended questions.

Participants were audio-recorded. Device screens were video recorded. We used cameras to film mobile screens, and user hands when operating the mobile devices in both testing settings.

Cross-Platform Services, Devices and Implementation Types

For this study, we selected five services: YouTube (youtube.com), Jeeran (jeeran.com), Jarir Reader (jarirreader.com), Hotels.com and Panda (panda.com.sa). These services are from different domains (media and video, travel, books and online shopping). Most of these domains are popular among users who conduct cross-platform activities (Google 2012). For example, cross-platform video watching is common among 43 per cent of users (n = 1455) who often perform cross-platform sequential activities. The selected services apply complementary levels of redundancy, which is the most common cross-device configuration (Denis and Karsenty 2004).

The participants were given two devices to interact with the services: a MacBook Pro (15 inch) and an Apple iPhone. The device categories (PC/laptop and smartphone) are commonly used in cross-platform sequential and simultaneous interaction modes (Google 2012). Users also use these devices in a single context (e.g., at home) or in different contexts (at home for PC/laptop and on-the-go for mobile phones) (Google 2012). Each tested service comprised two different implementation types across platforms: desktop website and native mobile application. Users interacted with the Arabic versions of the services.

The YouTube (Y) cross-platform service allows users to discover, watch and share videos. Jeeran (J) is a cross-platform travel service. It is designed to help locals and visitors to find the best places and services (such as restaurants and ATMs) in different cities and different countries, such as Saudi Arabia and Jordan. It also allows users to add reviews and photos of places that they visit. Jarir Reader (JR) is a cross-platform ebook service that allows users to search for, browse, download and read electronic books. Hotels.com (H) is a cross-platform service that allows users to search for, browse and book hotels online. Panda (PA) is a cross-platform service for a grocery retailing company that allows users to shop online for different types of products. Users can search for items or browse different categories and purchase items online.

Participants

Forty-five volunteers (11 female) participated in this study. The participants were students and staff who were studying or working at the Institute of Public Administration (IPA) in Saudi Arabia. Participants' major areas of study included public administration, computer science and business. All participants had basic computer skills and had been using the Internet for more than 3 years. Almost all participants had been using multiple devices to interact with cross-platform services to complete interrelated tasks for at least one year. The participants were not compensated because the participation was fully voluntary.

The participants had previous experience with the devices used in the study. Most of the participants across the two testing settings had never used Jeeran, Jarir Reader, Hotels.com and Panda services, neither through the mobile applications or desktop websites. YouTube were mostly used by the participants across the two settings through desktop and mobile interfaces.

Horizontal Task

We used the term horizontal task (HT) to refer to inter-related tasks that a user can perform across platforms. We made each horizontal task that a user needs to carry out across platforms as realistic as possible. An example of a horizontal task that Hotels.com (H) users carried out across the two devices is shown below:

- Subtask 1: Find Al Mashreq Boutique Hotel.
- Subtask 2: Find the contact information for "Al Mashreq Boutique Hotel"

Organisation of Tasks and Participants

Participants were divided into ten main groups using matched-group design, in which the subjects are matched based on demographic variables (e.g., age, gender and area of study) and then allocated into groups. For example, the 11 female participants were split between the 10 groups. Whenever possible, we matched the user group of each specific service in the seated–moving setting with the user group of the same service in seated–seated setting based on user characteristics. Five groups attempted their HTs using the services via laptop and mobile phone in the first experiment setting (seated–moving). Participants were asked to complete the tasks using the laptop while they were seated in the lab and using the mobile while they were walking around the IPA campus. The other five groups attempted their tasks using services accessed via laptop and mobile phone in the second experiment setting (seated–seated). Participants attempted their tasks via both laptop and mobile phone while seated in the lab.

In both settings, each group performed HTs on a single cross-platform service. To achieve a HT (or two related subtasks), the participant interacted with two UIs on laptop and mobile phone devices. Each participant attempted two HTs. Users of the same service, but in different settings, received the same HTs. Participants received their tasks in Arabic. We conducted the testing with each participant separately.

The first horizontal task was attempted with the order: laptop user interface and then mobile user interface. The second horizontal task used reverse device order to eliminate ordering effects and to inspect inter-usability of the different orders.

For ease of reference, in this paper, we use the service abbreviations indicated above with numbers (e.g., PA1), to refer participants. Table 1 shows the participants in each service and setting.

Table 1. Participants in each service and setting

Setting	Service				
	Y	J	JR	H	PA
Seated-Moving	Y1, Y2, Y3, Y4	J1, J2, J3, J4, J5	JR1, JR2, JR3, JR4, JR5	H1, H2, H3, H4, H5	PA1, PA2, PA3, PA4, PA5, PA6
Seated-Seated	Y5, Y6, Y7, Y8	J6, J7, J8, J9	JR6, JR7, JR8, JR9	H6, H7, H8, H9	PA7, PA8, PA9, PA10

Qualitative Data Analysis

All qualitative data collected through thinking aloud, observation and questionnaires were transcribed in Arabic by the first author. The first author speaks Arabic and has experience in idioms and terms used in Saudi dialect, which participants used widely while thinking aloud during the sessions. The first author open-coded the transcripts. A software engineering specialist who speaks Arabic and has also experience in Saudi dialect collaborated during the axial coding stage and clustering process. Affinity diagraming was also used as explained in Holtzblatt and Beyer (2016 to identify additional thematic clusters and to confirm generated themes. The first author, who also speaks English, conducted a meeting session with co-authors and explained users' comments and themes generated for a further check of the clusters. Some themes were refined based on the outcome of the session. During the analysis, we focused only on themes related to our study goals.

Findings and Analysis

Cross-Platform User Experience Issues

Participants in both settings (seated–moving and seated–seated) reported cross-platform UX issues under the same following UX elements identified during our analysis:

- Consistency (how consistent are the system components across platforms),
- Fluency (how fluently can users resume interrupted tasks after transferring from one device to another),
- Configuration (how appropriate is the organisation of devices and content),
- Learnability (the extent that each user interface needs to be learned separately),
- Recognition (the extent to which the user interfaces support recognition of elements rather than forcing users to remember information from one device to another to be able to continue on interrupted task).

An example of issues under the consistency element is '*inconsistency of labelling system components across devices*', which reported by participants JR1, Y2 and PA1 in the seated-moving setting, and participants Y6, JR8 and PA8 in the seated-seated setting.

Our findings of consistency, fluency and configuration confirmed the importance of these cross-platform UX elements, which were identified in previous research (Denis and Karsenty 2004; Majrashi et al. 2016a; Wäljas et al. 2010).

Consistency and fluency were the most sensitive elements across all the tested cross-platform services in both settings. That is, consistency issues were reported by all participants in both settings and fluency issues were reported by 96 per cent of participants in the seated–moving setting and 85 per cent of participants in the seated–seated setting. Concerning the configuration problems, 40 per cent of participants in each setting encountered issues related to this element across all the services. Learnability issues were encountered by 56 per cent of participants in the seated–moving setting and 50 per cent of participants in the seated–seated setting. Recognition problems were identified by 44 per cent of participants in the seated–moving context compared to 30 per cent of participants in the seated–seated context.

Consistency appeared to be a more frequent issue for users in both settings. We investigated the number of unique consistency issues reported by each participant for each tested service. Figure 1 shows the number of unique consistency issues encountered by each user of each tested service across the two settings. In the seated–seated setting, it is clear that each user of each service reported two or less consistency problems. In the seated–moving setting, each user of each service reported at least two consistency

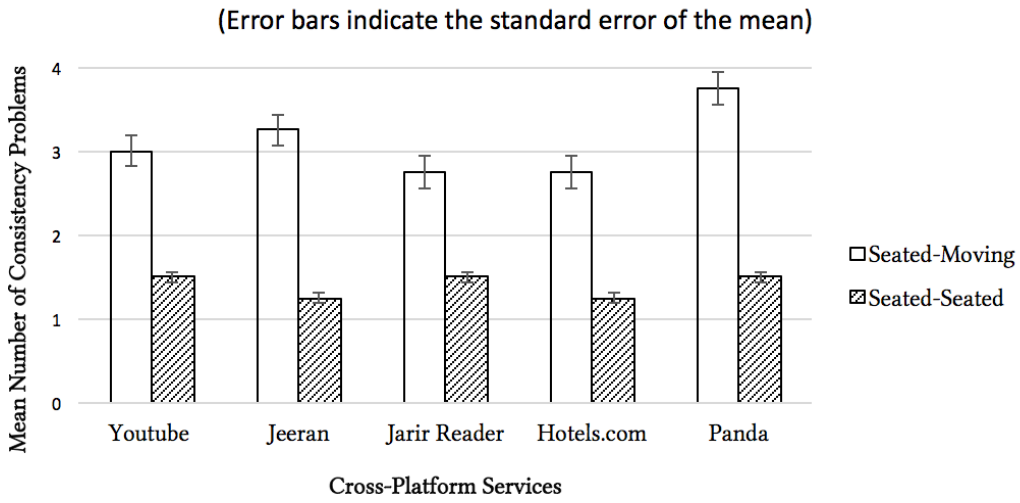

Figure 1. Mean number of consistency issues encountered by users of each service in the two settings.

We performed independent-samples t-tests to discover whether there were any significant differences in the number of reported consistency issues between the two settings. Since there were unequal sample sizes in most of the testing cases, we conducted a random selection of participants using SPSS statistical software before performing the independent-samples t-tests. The independent-samples t-tests suggested that there were significant differences in the number of consistency issues reported by participants between the two settings for the four tested services as well as for the combined data set (see Table 2). We interpret this to mean that the testing in seated–moving setting generated more consistency issues than the seated–seated setting.

Table 2. Independent-samples t-test results (n = 4 for each service per setting and n= 20 for the combined data set per setting)

Service	Mean of consistency issues		t value	*p* value
	Seated-Moving	Seated-seated		
Y	3	1.5	3.00	< 0.05
J	3.25	1.25	3.70	< 0.05
JR	2.75	1.5	2.23	= 0.06
H	2.75	1.25	2.77	< 0.05
PA	3.73	1.50	2.80	< 0.05
Combined data sets	3.10	1.40	7.01	< 0.001

Cross-Platform User Satisfaction

To investigate whether user satisfaction with the tested services was different from one testing setting to another, we calculated the Post Transformation (PT) mean of user satisfaction scores generated through cross-platform usability scale. The PT mean adjusts the scores of negative statements 4, 6, 7 and 8, so that positive responses are associated with a larger number, as are the other four (positive) statements. With the PT mean, the larger numbers for positive statements 1, 2, 3 and 5 mean that these statements received more positive responses (agreement) and the larger numbers for negative statements 4, 6, 7 and 8 indicate that these statements received more positive responses (disagreement).

In Table 3, we highlight the mean of user satisfaction in bold if it is lower than the corresponding mean given by the users of the same service in the other setting. Overall, the tested services in both settings received low satisfaction averages. However, users who attempted their tasks in the seated–moving setting were less satisfied with the services compared to users in the seated–seated setting, with significant statistical differences with Y, J and H services.

Table 3. Post transformation mean of user satisfaction with each service as perceived by participants in the two testing settings: seated-moving and seated-seated

Service	PT-mean of overall user satisfaction		t value	*p* value
	Seated-Moving	Seated-seated		
Y	**1.56**	2.68	7.60	< 0.001
J	**1.42**	2.09	3.62	< 0.01
JR	**1.37**	1.71	1.49	> 0.05
H	**1.50**	2.09	2.57	< 0.05
PA	**1.75**	1.76	0.84	> 0.05

Seamless Transition

We calculated the PT mean of user satisfaction with the seamless transitioning between devices for each service as perceived by each participant group in both settings, based on participants' responses to the seamless transitioning scale. To calculate the PT mean, we transformed the responses to statement 2—the negative statement—to conform to the positive statements on the scales. Table 4 shows the PT mean of seamless transition satisfaction for switching from laptop to mobile and vice versa as perceived by participants in both settings. We highlight the mean in bold if it is lower than the corresponding mean provided by users from the other group for the same service and for each specific device order.

For the first HT in which users switched from the laptop to the mobile UI, all services in the seated–moving setting received lower seamless transition satisfaction means compared to the seated–seated setting (see Columns 2 and 3 in Table 4), and the differences were statistically significant. For the second HT, in which users transferred from the mobile to the laptop UI, the averages of the seamless transition satisfaction showed an inconsistent pattern of results across the two testing settings (see Columns 6 and 7 in Table 4), with no statistically significant differences. That is, the services Y, JR and PA received lower satisfaction averages in the seated–moving settings and the services J and H received lower satisfaction means in the seated–seated setting.

Table 4. The post transformation mean of the seamless transition satisfaction for switching from laptop to mobile and vice versa as perceived by participants in the two different settings: seated-moving and seated-seated

	Laptop to mobile (HT1)				Mobile to laptop (HT2)			
Service	Seated-moving	Seated-seated	t value	p value	Seated-moving	Seated-seated	t value	p value
Y	**1.16**	2.08	3.42	< 0.05	**1.91**	3.5	1.60	> 0.05
J	**1.40**	2.83	4.26	< 0.01	2.33	**2.16**	-0.39	> 0.05
JR	**1.40**	2.41	5.10	< 0.01	**2.06**	2.50	0.58	> 0.05
H	**1.40**	3.00	4.36	< 0.01	2.13	**2.00**	-0.15	> 0.05
PA	**1.33**	2.00	5.36	< 0.01	**2.55**	3.58	1.80	> 0.05

Contextual Factors Influencing Cross-Platform User Experience

We analysed the collected qualitative data to discover any possible context-related factors that influenced cross-platform UX. We found that there were two main factors: attentiveness and manageability. These two factors influenced the cross-platform UX when users transferred to complete their tasks using the mobile interfaces in the moving context. Our findings of the two factors are consistent with previous research (Öquist et al. 2004; Pascoe et al. 2000; Yamabe and Takahashi 2007). Results related to the two factors and their impacts on cross-platform UX are discussed below.

Attentiveness

In the moving context, multitasking occurs while users operate a mobile device (e.g., users watch their steps), which leads to divided attention. Users were also more easily distracted outside the lab environment, which affected their attention to the task at hand. Hence, 18 users reported several issues and associated them with the limited attention that they were able to pay to the UI.

The limited attention issues were reported in association with the cross-platform UX elements (consistency, fluency, configuration, learnability and recognition). For example, some users reported that, since they used the mobile application in a situation where their attention was limited, inconsistency between the mobile application and the desktop website made it more difficult to complete their tasks easily. For instance, user PA4 mentioned that the mobile application was not consistent with the desktop website and, as they were not able to pay full attention to the interface to deal with the inconsistency issues, their interaction resulted in many errors. The user indicated that they wanted to reuse the knowledge obtained from the desktop website to complete the task easily on the mobile application without the need to pay full attention to the interface.

Some users also indicated that the mobile applications in the moving context should support them to resume their tasks more easily and show less content, should not require them to learn new things and should support the recognition factor to enable users to continue their tasks easily in a situation where their attentions were divided.

Users reported consistency, fluency, configuration, learnability and recognition issues in both testing settings; however, it appears that the issues become more problematic when using the mobile interface in the moving situation because of the attentiveness factor.

Manageability

Manageability refers to user capability for managing the mobile device using one hand while they walk and interact with the mobile UI at the same time. Thirteen users reported difficulty managing the mobile device in the moving context, which, in turn, affected their capacities to resume the task easily after transitioning to the mobile UI. This finding could be read as supporting task continuity in the service design as more important in the moving situation, since manageability issues could delay users from completing their tasks easily and fluently.

UX Design for the Moving Context

We found that users reported several UX issues when using mobile UIs in the moving context. These issues were either not identified or considered less severe when using the UIs on the laptop and mobiles in a seated context. An example of the issues was *"the advertisements interrupt my attention on user interface targeted elements and they should be removed or hidden"*, as expressed by PA2. We present the issues as eight UX design recommendations for mobile UIs in the moving context and the users who encountered the issues in Figure 2. Four of the UX design recommendations (Numbers 1, 3, 6 and 7 in Figure 2) are associated with both male and female users.

Six of the UX design recommendations (Numbers 1, 2, 3, 4, 7 and 8 in Figure 2) are uniquely associated with the mobile UIs in the moving context. For example, design recommendation Number 1, suggests that mobile UIs should hide advertisements when users start walking since these advertisements could affect the limited attention users can pay to the interface while walking (see Figure 2 (1)).

UX design recommendation 5 is associated with mobile UIs in seated and moving situations. That is, unnecessary steps and optional form fields should be removed from mobile UIs. According to our observation, the issue of presenting unnecessary steps and optional form fields on mobile UIs becomes more problematic for users in the walking situation because of the movement-related factor of 'attentiveness' (see Figure 2 (5)). Users wanted to see less content on the mobile UI because more content could cause more difficulty concentrating and achieving a task in a situation where attention is limited.

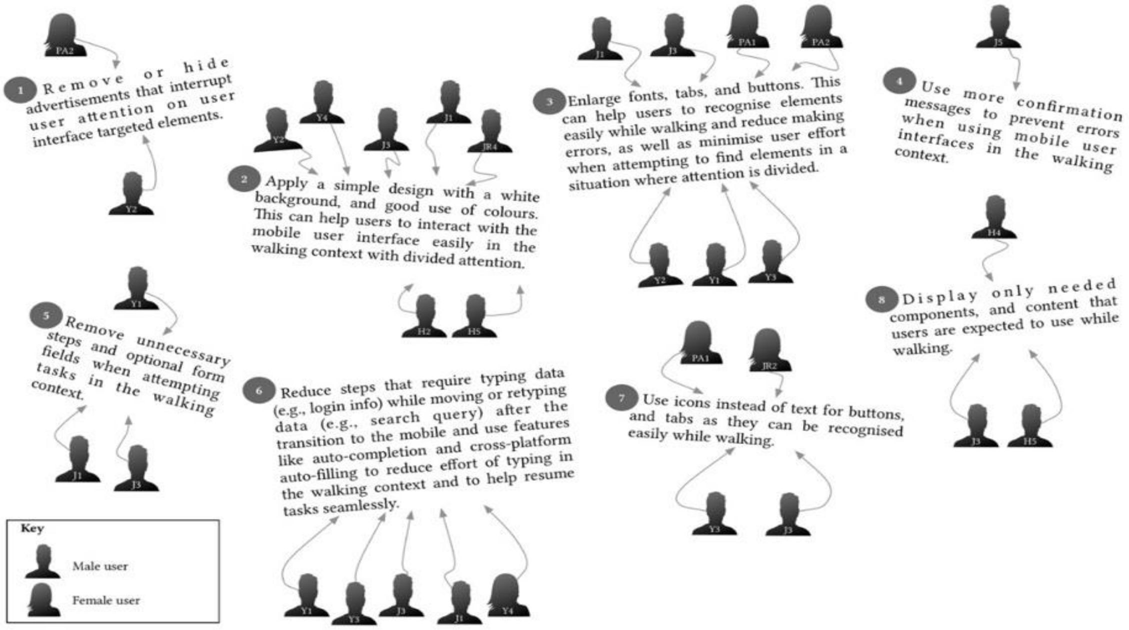

Figure 2. User experience design recommendations for mobile user interfaces in the moving context

UX design recommendation 6 is partially associated with all UIs across the different contexts. For example, some service Y and J users reported that they did not want to retype things (e.g., to retype a search query) after switching from the desktop interface to the mobile interface and vice versa. They wanted features such as the synchronisation of search histories and auto-completion support for resuming tasks quickly without the need for retyping after the transition. This need becomes more essential when users switch to mobile interfaces in the moving context, according to our observations and the user comments from the study. Users found it difficult to type while walking (see Figure 2 (6)).

Designing for Ambulatory Adaptability

To improve cross-platform UX for users who switch between different devices and use a mobile device in moving context, we recommend considering ambulatory adaptability factors when designing any mobile UIs. Ambulatory adaptability refers to the requirement for a mobile UI to adapt its elements, design or layout to user needs to support user interaction while they are walking.

However, adapting the design or content to the moving context of use could generate other problems in terms of the core cross-platform UX elements (consistency, fluency, configuration, learnability and recognition). For example, one UX design recommendation for mobile UIs in a moving context is to change the background of the mobile UI to be white in colour (refer to Figure 2 (2)). However, the change of the background of the mobile UI could generate an issue with cross-platform appearance consistency. Hence, we recommend that designers take into consideration other cross-platform UX aspects when designing for mobile interfaces in the moving context. That is, there should be no conflict between the UX design requirements.

We compare the movement-related UX design recommendations presented in Figure 6 with the cross-platform UX aspects identified in our user study and/or previous research. This is to ensure that the UX design recommendations for movement-related contexts do not conflict with other cross-platform UX design requirements. In the following, we present the UX design recommendations and discuss whether they conflict with other cross-platform UX design requirements.

Recommendation 1: Remove or hide advertisements that interrupt user attention to UI targeted elements. As this design recommendation does not conflict with other cross-platform UX design requirements, it should be applied to mobile UIs in the moving context. This recommendation can also be applied to the mobile UIs in all contexts (e.g., moving and seated) to support user interaction through small screens. That is, users in general do not expect to see more content (unnecessary content) from mobile interfaces, according to our analysis of issues under the configuration element as well as those found in previous studies (Majrashi 2016; Majrashi et al. 2016b).

Recommendation 2: Apply a simple design and make the background white. As mentioned above, this recommendation conflicts with cross-platform appearance consistency requirements. Hence, this recommendation should be applied to all UIs across platforms and across contexts to satisfy both user needs (simplicity of the mobile UI in a moving context and cross-platform appearance consistency).

Recommendation 3: Make fonts, buttons, and tabs large enough to be recognised. This recommendation does not conflict with other cross-platform UX design requirements, so it should be applied to all mobile use interfaces in the moving context.

Recommendation 4: Use more confirmation messages to prevent errors. This recommendation does not conflict with other cross-platform UX design requirements, so it should be applied to all mobile use interfaces in the moving context. However, it might be argued that this recommendation could conflict with operational consistency, which refers to the similarity of operations for attaining a specific goal from all devices (Denis and Karsenty 2004; Majrashi 2016; Wäljas et al. 2010). However, we believe that using confirmation messages might not produce inconsistency in the number of operations required to achieve a goal since confirmation messages are not a new additional operation that a user needs to learn. While confirmation messages could take time and attention from the user to respond before they can continue, their use in a moving situation can be limited to critical actions such as deleting data.

Recommendation 5: Remove unnecessary steps and optional form fields. The removal of steps could generate inconsistency in the number of operations required to achieve a task cross-platform. Therefore, we recommend that UIs should have a minimal number of steps to achieve any particular task from any platform, while removing unnecessary steps from all platforms. This is to keep UIs consistent cross-platform and support user interaction in the moving context. The removal of optional form fields conforms to the appropriateness of the distribution aspect. That is, users generally expect to see less content, for example, fewer form fields, on the mobile platform, as indicated previously. Therefore, optional form fields need to be removed from mobile UIs in all contexts (seated and moving).

Recommendation 6: Reduce steps that require typing while moving or retyping after the transition and use features like auto-completion and cross-platform auto-filling (the synchronisation of data entered into form fields from one platform to another). According to our observation, users generally found it difficult to type using mobile platforms. This issue could become more critical when typing on mobile UIs in a moving situation. Hence, optional steps that require typing should be removed from mobile UIs. However, this should not affect the operational consistency aspect of cross-platform UIs.

Features such as the auto-completion and synchronisation of data entered into form fields from one platform to another can be implemented to reduce the effort of retyping data after transitioning to complete a task using a mobile interface in a walking situation. These features should be applied to all UIs cross-platform as they can support task continuity when transferring from one interface to another according to our user comments in this study as well as based on findings by (Majrashi 2016).

Recommendation 7: Use icons rather than text. Users of mobile UIs in the moving context prefer to see icons instead of text for some UI elements such as navigation menus. This is because icons can be recognised easily while walking. However, using icons for UI elements for only one platform within a specific context could generate a consistency issue. Therefore, we recommend that all UIs across platforms and contexts use icons, which should be consistent in shape to fulfil the appearance consistency, which is as an important requirement according to previous studies (Denis and Karsenty 2004; Majrashi 2016). It is also important to note that using a combination of icons and text could be a better approach since some icons might not be meaningful for some users, as found in (Majrashi et al. 2016b).

Recommendation 8: Display only required content and UI components in the moving context. Content and components that users might not need to see while moving should not be displayed. However, we recommend that this should not impact the provision of core content across all user interfaces as an essential requirement for many successful cross-platform services (Majrashi 2016; Wäljas et al. 2010).

Ambulatory Adaptability UX Design Model

A cross-platform service can be a combination of different UIs including a mobile UI. A mobile UI can be used in different contexts (seated and moving). Hence, when designing for cross-platform UX, the design of the mobile interface with considerations to its contexts of use should be considered. In the previous section, we discuss the UX design recommendations of mobile UIs in the moving context. In this section, we grouped the recommendations into five main UX design principles to form the ambulatory adaptability UX design model (see Figure 3).

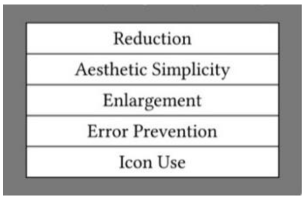

Figure 3. Ambulatory Adaptability UX Design Model

In the model, reduction involves recommendations 1, 5, 6 and 8 (presented in the previous section) that concern reducing content and tasks that require typing and UI components in the walking situation. Aesthetic simplicity represents recommendation 2, which was to use a white background and employ appropriate colours to help users interact with the mobile interface easily in a walking situation. Enlargement refers to recommendation 3 to make the font, buttons and tabs larger when a UI is used in a moving context. Error prevention refers to recommendation 4 to design the interface in the moving context to use techniques such as confirmation messages to prevent errors. Icon use refers to designing UIs with icons to support users to recognise UI components easily while walking. The use of icons should be consistent cross-platform and must be combined with labels.

Designers can use this model as a guide to designing mobile interfaces in the moving context. The model can also be used in combination with other cross-platform UX design frameworks generated previously (e.g., in (Majrashi 2016; Wäljas et al. 2010), when designing for cross-platform service UX.

Conclusion

In this paper, we investigated cross-platform UX that involves using mobile UIs in two different settings (seated–moving and seated–seated). We found that participants in both settings reported cross-platform UX issues related to consistency, fluency, configuration, learnability and recognition elements. Testing in seated–moving setting allowed the identification of more cross-platform UX issues than in a seated–seated setting, for example, more consistency problems. We also found that users in the seated–moving setting were less satisfied about the service inter-usability compared to users in the seated–seated setting. Users were also less satisfied with transitioning to mobile UIs in the moving context compared to those who switched to use the UIs in the seated context. We also found that there were two main factors (attentiveness and manageability) affecting cross-platform UX when users switched to continue their tasks using the mobile applications in the moving context. Hence, when testing UX of a cross-platform service that involves desktop and mobile UIs, testing the mobile UI in a moving context of use is necessary for a comprehensive evaluation.

We further discovered that users reported several UX issues when using mobile UIs in the moving context. Some of these issues were encountered when using mobile applications and/or the desktop websites in the seated context but they were less severe. Based on our findings, discussion and recommendations, we propose an ambulatory adaptability design model of five UX design principles (reduction, aesthetic simplicity, enlargement, error prevention and icon use). This model can be used as a guide for designing context-aware cross-platform services that involve using a mobile UI in a walking situation.

References

Ali, M. F., Perez-Quinones, M. A., Abrams, M., and Shell, E. 2002. "Building Multi-Platform User Interfaces with Uiml," in *Computer-Aided Design of User Interfaces Iii*, C. Kolski and J. Vanderdonckt (eds.). Springer, pp. 255-266.

Denis, C., and Karsenty, L. 2004. "Inter-Usability of Multi-Device Systems: A Conceptual Framework," in *Multiple User Interfaces: Cross-Platform Applications and Context-Aware Interfaces*, S. Ahmed and J. Homa (eds.). New York: Wiley, pp. 373-384.

Forrester Research. 2013. "The European Tablet Landscape. A Technographics Data Essentials Document." Retrieved May 30, 2016, from http://www.forrester.com/European?Technographics?Consumer?Technology?Online?Survey?Q4?2012/-/E-SUS1711 - /The?European?Tablet?Landscape/quickscan/-/E-RES91561

Ghiani, G., Polet, J., Antila, V., and Mäntyjärvi, J. 2015. "Evaluating Context-Aware User Interface Migration in Multi-Device Environments," *Journal of Ambient Intelligence and Humanized Computing* (6:2), pp. 259-277.

Gong, J., and Tarasewich, P. 2004. "Guidelines for Handheld Mobile Device Interface Design," in Proceedings of the *DSI 2004 Annual Meeting*: Citeseer, pp. 3751-3756.

Google. 2012. "The New Multi-Screen World: Understanding Cross-Platform Consumer Behavior." *Research Report, August 2012* Retrieved May 30, 2016, from http://services.google.com/fh/files/misc/multiscreenworld_final.pdf

Hassenzahl, M. 2005. "The Thing and I: Understanding the Relationship between User and Product," in *Funology: From Usability to Enjoyment*, M.A. Blythe, K. Overbeeke, A.F. Monk and P.C. Wright (eds.). Dordrecht Netherlands: Springer, pp. 31-42.

Holtzblatt, K., and Beyer, H. 2016. *Contextual Design: Design for Life*. Morgan Kaufmann.

Jokela, T., Ojala, J., and Olsson, T. 2015. "A Diary Study on Combining Multiple Information Devices in Everyday Activities and Tasks," in Proceedings of the *33rd Annual ACM Conference on Human Factors in Computing Systems*, Seoul, Korea: ACM, pp. 3903-3912.

Liao, I.-C., and Deng, Y.-S. 2014. "Understand User-Device Relationship in Multiscreen Exercise Activity," in Proceedings of the *5th International Conference on Kanesi Engineering and Emotion Research* S. Schütte and P. Levy (eds.), LINKÖPING, Sweden: Linköping University Electronic Press.

Majrashi, K. 2016. "Cross-Platform User Experience," (Doctoral thesis), RMIT University. Retrieved from https://researchbank.rmit. edu.au/view/rmit:161955.

Majrashi, K., and Hamilton, M. 2015. "A Cross-Platform Usability Measurement Model," *Lecture Notes on Software Engineering* (3:2), p. 132.

Majrashi, K., Hamilton, M., and Uitdenbogerd, A. L. 2015. "Multiple User Interfaces and Cross-Platform User Experience: Theoretical Foundations," in Proceedings of the *Fifth International Conference on Computer Science, Engineering and Applications (CCSEA-2015)*, S. Vaidyanathan and D. Nagamalai (eds.): AIRCC Publishing Corporation, pp. 43-57.

Majrashi, K., Hamilton, M., and Uitdenbogerd, A. L. 2016a. "Correlating Cross-Platform Usability Problems with Eye Tracking Patterns," in Proceedings of the *30th British Human Computer Interaction Conference (HCI 2016)*, Bournemouth, UK: BCS Learning and Development.

Majrashi, K., Hamilton, M., and Uitdenbogerd, A. L. 2016b. "Cross-Platform Cross-Cultural User Experience," in Proceedings of the *30th British Human Computer Interaction Conference (HCI 2016)*, Bournemouth, UK: BCS Learning and Development.

Meskens, J., Vermeulen, J., Luyten, K., and Coninx, K. 2008. "Gummy for Multi-Platform User Interface Designs: Shape Me, Multiply Me, Fix Me, Use Me," in Proceedings of the *Working conference on Advanced visual interfaces*, P. Bottoni and S. Levialdi (eds.), Naples, Italy: ACM, pp. 233-240.

Microsoft. 2013. "Cross-Screen Engagement: Multi-Screen Pathways Reveal New Opportunities for Marketers to Reach and Engage Consumers." *Microsoft Advertising, Flamingo & Ipsos OTX* Retrieved May 31, 2016, from https://advertising.microsoft.com/en/wwdocs/user/display/cl/researchreport/1932/global /Microsoft-Advertising-Insights-Cross-Screen-Engagement-White-Paper.pdf

Nielsen, J. 1995. "10 Heuristics for User Interface Design." Retrieved February 1, 2016, from https://www.nngroup.com/articles/ten-usability-heuristics/

Öquist, G., Goldstein, M., and Chincholle, D. 2004. "Assessing Usability across Multiple User Interfaces," in *Multiple User Interfaces: Cross-Platform Applications and Context-Aware Interfaces*, A. Seffah and H. Javahery (eds.). New York, NY: John Wiley & Sons, pp. 327-349.

Pascoe, J., Ryan, N., and Morse, D. 2000. "Using While Moving: Hci Issues in Fieldwork Environments," *ACM Transactions on Computer-Human Interaction (TOCHI)* (7:3), pp. 417-437.

Pyla, P. S., Tungare, M., and Pérez-Quinones, M. 2006. "Multiple User Interfaces: Why Consistency Is Not Everything, and Seamless Task Migration Is Key," in Proceedings of the *CHI 2006 workshop on the many faces of consistency in cross-platform design*, Montreal, Quebec, Canada.

Santosa, S., and Wigdor, D. 2013. "A Field Study of Multi-Device Workflows in Distributed Workspaces," in Proceedings of the *2013 ACM international joint conference on Pervasive and ubiquitous computing*, Zurich, Switzerland: ACM, pp. 63-72.

Seffah, A., Forbrig, P., and Javahery, H. 2004. "Multi-Devices "Multiple" User Interfaces: Development Models and Research Opportunities," *Journal of Systems and Software* (73:2), pp. 287-300.

Segerståhl, K. 2009. "Crossmedia Systems Constructed around Human Activities: A Field Study and Implications for Design," in Proceedings of the *IFIP Conference on Human-Computer Interaction*, T. Gross, J. Gulliksen, P. Kotzé, L. Oestreicher, P. Palanque, R.O. Prates and M. Winckler (eds.), Uppsala, Sweden: Springer, pp. 354-367.

Segerståhl, K., and Oinas-Kukkonen, H. 2007. "Distributed User Experience in Persuasive Technology Environments," in *Persuasive Technology: Second International Conference on Persuasive Technology, Persuasive 2007*, Y. Kort, W. Ijsselsteijn, C. Midden, B. Eggen and B.J. Fogg (eds.). Berlin, Heidelberg: Springer, pp. 80-91.

Seong, D. S. 2006. "Usability Guidelines for Designing Mobile Learning Portals," in Proceedings of the *3rd international conference on Mobile technology, applications & systems*, Bangkok, Thailand ACM, p. 25.

Shin, D.-H. 2016. "Cross-Platform Users' Experiences toward Designing Interusable Systems," *International Journal of Human-Computer Interaction* (32:7), pp. 503-514.

Väänänen-Vainio-Mattila, K., Väätäjä, H., and Vainio, T. 2009. "Opportunities and Challenges of Designing the Service User Experience (Sux) in Web 2.0," in *Future Interaction Design Ii,* H. Isomäki and P. Saariluoma (eds.). London: Springer, pp. 117-139.

Wäljas, M., Segerståhl, K., Väänänen-Vainio-Mattila, K., and Oinas-Kukkonen, H. 2010. "Cross-Platform Service User Experience: A Field Study and an Initial Framework," in Proceedings of the *12th international conference on Human computer interaction with mobile devices and services*, Lisbon, Portugal: ACM, pp. 219-228.

Yamabe, T., and Takahashi, K. 2007. "Experiments in Mobile User Interface Adaptation for Walking Users," in Proceedings of the *2007 International Conference on Intelligent Pervasive Computing (IPC)*, Jeju, Korea: IEEE, pp. 280-284.