Usability Heuristics for Touchscreen-based Mobile Devices: Update

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ABSTRACT
The idea of usability as something optional and only applicable in latest stages of the development process is obsolete. Usability is very valuable for users, reason why counting with proper tools for assessing usability in products like touchscreen-based mobile devices is needed. One traditional usability evaluation method is the heuristic evaluation, where evaluators through the use of usability heuristics detect usability issues. In this paper we introduce a revised version of our previously proposed set of 12 usability heuristics for touchscreen-based mobile devices. Three types of validation experiments were performed: inquiry tests, heuristic evaluations and experts' opinion. Results supported and checked the utility of the proposal.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – Ergonomics, Graphical user interfaces (GUI), Input devices and strategies, Interaction styles, Screen design, User- centered design.

General Terms
Experimentation, Human Factors, Verification.

Keywords
Usability heuristics, usability evaluation, touchscreen-based mobile devices, update.

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1. INTRODUCTION
Nowadays we can see the raise and consolidation of the smartphone industry with billions of sold devices around the world. Manufacturers exploit the available hardware building amazing devices. It is possible to group smartphones by hardware capabilities where the only difference between them is design. Not only the physical design of the product is important to users when choosing a device, also usability is considered. Usability is considered a key user requirement for the design of new products, and highly important to people when buying a product [13]. From the product success point of view, the IS Success Model shows how system quality is related with the satisfaction of the user [1]. Developers traditionally saw usability as something mildly interesting, optional and only important by the end of a project, but now that perspective is obsolete. Through a heuristic evaluation it is possible to detect usability issues by making use of heuristics. [14].

Heuristic evaluation involves the participation of usability specialists analyzing every interactive element and dialog following a set of established usability design principles called heuristics. It is one of the most widely used usability evaluation methods. Usually, for a heuristic evaluation, 3 to 5 evaluators are required. Less experienced evaluators may be useful in some cases [15].

When choosing heuristics for performing a heuristic evaluation there are mainly two alternatives: generic heuristics and specific heuristics. Specific heuristics may become hard to understand and hard to apply but they can detect usability issues related to the application area. Generic heuristics are, usually, easy to understand and to apply, but they can miss some usability issues. General heuristics, complemented by specific usability checklists will probably work better most of the time. [6]

In this paper we present an update of the previously proposed set of 12 usability heuristics for touchscreen-based mobile devices [6]. Changes were made in the heuristics' definition, in order to support a better understandability of the principles. In the process of updating (and validating) the heuristics we followed a flexible methodology [16] and performed three types of experiments: inquiry tests, heuristic evaluations and experts' opinion.

This work is structured as follows. Section 2 presents the theoretical background as the foundations of the work. Section 3 describes our previous work while section 4 shows the update process along with the related activities. Section 5 presents the redefinition of the usability heuristics for touchscreen-based mobile devices. Finally, section 6 depicts the conclusions and future work.

2. THEORETICAL BACKGROUND

2.1 Mobile Devices

A mobile device is as a small electronic appliance, with some processing capabilities, with permanent or intermittent connection to a network. According to this definition, some examples of mobile devices are: mp3 music players, cellphones, laptops or GPS devices, among others [6].

The adopted taxonomy, proposed by Schiefer and Decker in [17], classifies mobile devices according to the following criteria: (1) Size and weight, (2) Input modes, (3) Output modes, (4) Performance, (5) Kind of usage, (6) Communication capabilities, (7) Type of operating system and (8) Expandability.

Touchscreen-based mobile devices are every mobile device that has a touch-sensitive display (touch-screen). Consequently, according to the adopted taxonomy, touchscreen-based mobile devices are part of almost every class. The results of this work can be applied, almost without adaptation to any touchscreen-based mobile device, but they are mainly focused on smartphones due to its popularity and easiness of access by our research group.

2.2 Usability

One of the most common definitions of usability is the one proposed by the ISO/IEC 9241: "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" [8]. Usability measures the quality of the user experience when he interacts with a product, i.e.: website, software application, mobile technology or any device operated by the user.

ISO/IEC 9126-1 describes six categories of software quality that are relevant during product development including quality in use with usability defined more narrowly as ease of use [9]. ISO/IEC 14598 give a general framework for the evaluation of software products using the model described in ISO/IEC 9126-1 [7].

ISO 20282 related to ease of operation is concerned with the usability of the user interface of everyday products. Part 1 of the standard explains how to identify which aspects are relevant in the context of use and describes how to identify the characteristics which cause variance within the intended user population. Part 2 specifies a test method for measuring the ease of operation of public walk up and use products and of everyday consumer products [11].

The ISO/IEC 25000 series of standards was developed to replace and extend ISO/IEC 9126 and ISO/IEC 14598. The main goal of the ISO/IEC 25000 SQuaRE (Software Product Quality Requeriments and Evaluation) standard is to organize, enhance and unify concepts related to two main processes: software quality requirements specification and software quality evaluation, supported by the process of software quality measurement [10]. Usability is considered in the whole standard, but it is especially mentioned in DTR 25060 (Common Industry Format (CIF) for Usability - General Framework for Usability-related Information) and ISO 25062:2006 (Common Industry Format (CIF) for usability test reports).

Shackel [18], on the other hand defines usability as: "the capability in human functional terms for a system to be used easily and effectively by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of scenarios".

As we can see, the usability concept is very wide. Nielsen proposes that usability is composed by a set of paradigms, principles and attributes as proposed in his book "Usability Engineering" [14].

2.3 Usability Evaluation in Touchscreen-based Mobile Devices

For evaluating usability in touchscreen-based mobile devices, it is important to consider the challenging aspects of such products. According to Heo et al., mobile devices are portable communication and information systems [2]. Their design is influenced by three main aspects:

- They are mainly used on the user's hands.
- They are operated in a wireless way.
- They support the addition of new applications and Internet connection.

Other important aspects to consider are [12]:

- They have small screen size to display huge amounts of information at the same time.
- Buttons usually have more than one functionality.
- The devices have limited processing, power and memory capabilities.

Other challenges when evaluating usability in touchscreen-based mobile devices are related to formal experiments. For traditional applications, evaluators have a live view of the user' screen and face. But, how can this be done in touchscreen-based mobile devices? Old smartphones did not have proper hardware to allow live streaming of the screen, reason why some authors proposed the use of video cameras attached to the user's head [3]. The question is how does this affect the natural interaction of the user with the device? Nowadays smartphones have powerful hardware which allows live screen streaming, solving such problem.

Another challenge is the context of use of touchscreen-based mobile devices. In traditional applications the context of use is well defined in terms of light, sound and interaction form (mouse and keyboard) [7]. In the case of mobile devices this is not well defined; it depends on where the interaction is taking part and how it is done. The user might be standing in line in the bank, while using the device with one hand. Another possibility is sitting in a bench in the park, using the device with both hands in landscape mode, among others.

As we can see, usability evaluation in touchscreen-based mobile devices can be difficult if the proper tools are not used. In our preliminary literature review we did not find any specific usability heuristics set for touchscreen-based mobile devices. After the first proposal of heuristics and an early validation experiment, the proposed usability heuristics depicted a slightly better performance against the traditional Nielsen's usability heuristics [5].

3. EARLY WORK

In our previous work, we presented two sets of usability heuristics for touchscreen-based mobile devices. For the development of the proposal we used a methodology proposed by Rusu et al. which consists of 6 steps [16]. The flexibility of the methodology allowed us to skip some steps for our two iterations. For the first iteration all steps of the methodology were followed and a set of 11 specific usability heuristics of touchscreen-based mobile devices were proposed [5]. For the second iteration, Steps 5 and 6 were performed in order to refine the first set and defined a set of 12 specific usability heuristics for touchscreen-based mobile devices [6]. Step 5 consisted of a validation (experimental) stage to check touchscreen-based mobile devices heuristics against traditional (Nielsen's) heuristics by experiments, through heuristic evaluations performed on selected case studies. Step 6 consisted of a refinement stage based on the feedback from the validation stage.

This paper shows the update of the set of 12 usability heuristics in terms of heuristic definition. After some experiments presented in section 4, we got a "new" set of 12 heuristics for touchscreen-based mobile devices.

4. REFINING THE PROPOSAL

4.1 Inquiry Tests

An inquiry test was performed over the set of 12 usability heuristics for touchscreen-based mobile devices. An online survey [4] was carried out in order to obtain feedback from evaluators related to heuristics understandability. The survey consisted of both closed and open questions. Closed questions were designed using a 5-point Likert scale where users had to evaluate both particular and global heuristic's understandability answering from "very hard to understand" (1) to "very easy to understand" (5). Open questions asked users for additional observations. A total of 27 participants with different background experience in heuristic evaluation were asked to fill the survey. The average value of global understandability was 4.00 of a maximum of 5.00.

4.2 Heuristic Evaluations

As stated in [6] a heuristic evaluation was performed as a validation experiment of the set of 12 usability heuristics for touchscreen-based mobile devices. The evaluation was carried out examining a Samsung Galaxy Ace (GT-S5830L) terminal running Android OS (v. 2.3.4). The analyzed applications were: (1) menu, (2) address book, (3) calendar, (4) basic messaging and (5) camera.

Two separate groups of evaluators inspected the device. Each group was composed by three evaluators. One group used the proposed heuristics while the other group used Nielsen's. A total of 37 usability problems were identified by the six evaluators. More usability problems were captured using the proposal, than using Nielsen's (23 usability issues were detected using the proposal, while 14 were detected using Nielsen's). However, the usability problems identified by the group of evaluators using the usability heuristics for touchscreen-based mobile devices were qualified as less severe than the ones detected using traditional Nielsen's heuristics.

After analyzing the number of usability problems by heuristic we detected that no problems were detected by TMD6 (Minimize the user's memory load), TMD9 (Aesthetic and minimalist design) and TMD10 (Help users recognize, diagnose, and recover from errors). This could occur due to evaluator's subjectiveness or issues in heuristic's understandability.

4.3 Experts' opinion

The set of 12 usability heuristics for touchscreen-based mobile devices was revised and discussed with members of the UseCV Research Group, from the Escuela de Ingeniería Informática, part of the Pontificia Universidad Católica de Valparaíso, Chile. Each heuristic' definition was mainly checked for understandability, clarity and consistency.

5. HEURISTICS' DEFINITION UPDATE

After analyzing the results obtained from the experiments performed and described in section 4, we redefined the set of 12 usability heuristics for touchscreen based mobile devices. The reviewed definition is presented below.

Table 1. Heuristics' definition update

ID	Heuristic	Definition
TMD1	Visibility of system status	The device should keep the user informed about all the processes and state changes through feedback and in a reasonable time.
TMD2	Match between system and the real world	The device should speak the users' language instead of system-oriented concepts and technicalities. The device should follow the real world conventions and display the information in a logical and natural order.
TMD3	User control and freedom	The device should allow the user to undo and redo his actions, and provide clearly pointed "emergency exits" to leave unwanted states. These options should be preferably through a physical button or similar.
TMD4	Consistency and standards	The device should follow the established conventions, on condition that the user should be able to do things in a familiar, standard and consistent way.
TMD5	Error prevention	The device should hide or deactivate unavailable functionalities, warn users about critical actions and provide access to additional information.

TMD6	Minimize the user's memory load	The device should offer visible objects, actions and options in order to prevent users to memorize information from one part of the dialogue to another.
TMD7	Customization and shortcuts	The device should provide basic and advanced configuration options, allow definition and customization of (or to provide) shortcuts to frequent actions.
TMD8	Efficiency of use and performance	The device should be able to load and display the required information in a reasonable time and minimize the required steps to perform a task. Animations and transitions should be displayed smoothly.
TMD9	Aesthetic and minimalist design	The device should avoid displaying unwanted information in a defined context of use.
TMD10	Help users recognize, diagnose, and recover from errors	The device should display error messages in a language familiar to the user, indicating the issue in a precise way and suggesting a constructive solution.
TMD11	Help and documentation	The device should provide easy-to-find documentation and help, centered on the user's current task and indicating concrete steps to follow.
TMD12	Physical interaction and ergonomics	The device should provide physical buttons or similar for main functionalities, located in recognizable positions by the user, which should fit the natural posture of the user's hands.

For comparative purposes some of the modified heuristics are presented below. The most drastic changed heuristics were chosen in order to illustrate changes and the reasons to perform them.

TMD5. Error prevention

Original definition: The device should have a careful graphic user interface and physical user interface design, in order to prevent errors. The non-available functionalities should be hidden or disabled and the user should be able to get additional information about all available functionality. Users should be warned when errors are likely to occur.

Updated definition: The device should hide or deactivate unavailable functionalities, warn users about critical actions and provide access to additional information.

Main changes: The phrase "The device should have a careful graphic user interface and physical user interface design" makes reference to two other usability heuristics: TMD9 (Aesthetic and minimalist design) and TMD12 (Physical interaction and ergonomics) which may be confusing for evaluators. The phrase "non-available functionalities" was changed for "unavailable functionalities" which is more accurate. The phrase "the user should be able to get additional information about all available functionality" emphasizes in help and documentation which may be confused with TMD11 (Help and documentation). Figure 1 shows an appropriate example of warning messages for critical actions, in this case a full storage format.

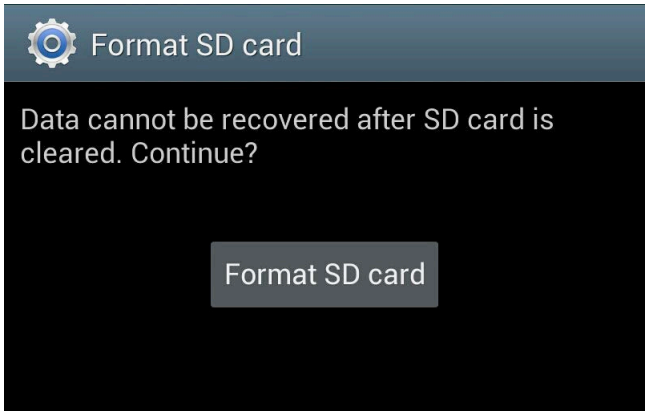

Figure 1. TMD5: Error prevention

TMD6. Minimize the user's memory load

Original definition: The device should minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

Updated definition: The device should offer visible objects, actions and options in order to prevent users to memorize information from one part of the dialogue to another.

Main changes: The phrase "The device should minimize the user's memory load" presents redundancy with the heuristic's name. The phrase "Instructions for use of the system should be visible or easily retrievable whenever appropriate" may be confused with the heuristic TMD11 (Help and documentation). Figure 2 shows an example of heuristic compliance. The system shows a header with the name of the current contact, even if the user scrolls down the screen.

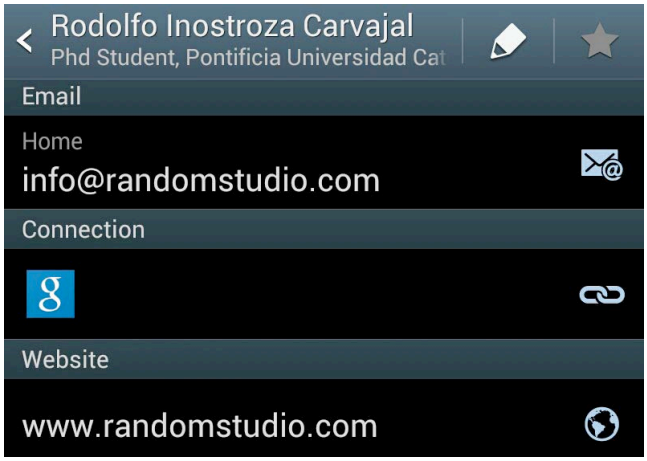

Figure 2. TMD6: Minimize the user's memory load

TMD7. Customization and shortcuts

Original definition: The device should provide basic configuration options and should give expert users access to advanced configuration options. The device should provide shortcuts to the most frequent tasks and should allow their customization and/or definition.

Updated definition: The device should provide basic and advanced configuration options, allow definition and customization of (or to provide) shortcuts to frequent actions.

Main changes: The phrase "should give expert users access to advanced configuration options" seems to be restrictive with "non-expert" users in terms of not letting them to access advanced options. The phrase "The device should provide shortcuts" may be interpreted as if the system should provide shortcuts as first preference, when it is most valuable for the user to define and customize them. Figure 3 shows the action of creating a shortcut in compliance of the heuristic.

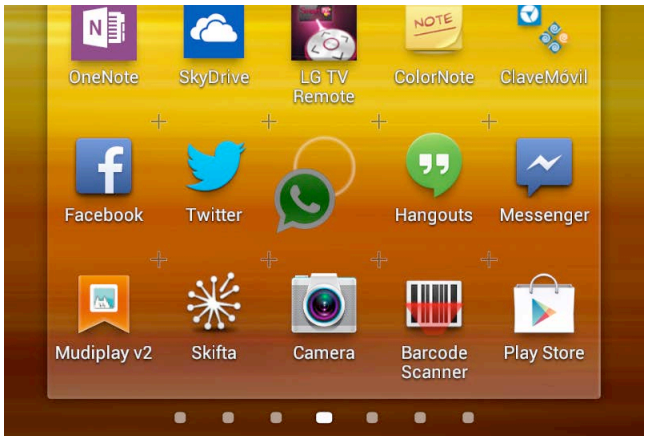

Figure 3. TMD7: Customization and shortcuts

TMD8. Efficiency of use and performance

Original definition: The device should provide basic configuration options and give the chance for expert users to gain access to advanced configuration options. The system should allow the user to customize, define and/or provide shortcuts to the most frequent tasks.

Updated definition: The device should be able to load and display the required information in a reasonable time and minimize the required steps to perform a task. Animations and transitions should be displayed smoothly.

Main changes: In first place we detected that the original definition of TMD8 (Efficiency of use and performance) was very similar to TMD7 (Customization and shortcuts) which could be very confusing for evaluators. The first part of the updated definition makes reference to the efficiency of use. The second part refers to performance. Due to its dynamic characteristic, it is not possible to illustrate this heuristic.

TMD12. Physical interaction and ergonomics

Original definition: The device should provide physical buttons or similar user interface elements for main functionalities. Elements should be placed in a recognizable position. The device's dimensions, shape, and user interface elements in general, should fit the natural posture of the hand.

Updated definition: The device should provide physical buttons or similar for main functionalities, located in recognizable positions by the user, which should fit the natural posture of the user's hands.

Main changes: The phrase "similar user interface elements" presents redundancy when mentioning the user interface, because the user always interacts with the user interface. The phrase "The device's dimensions, shape, and user interface elements in general" is too specific. The latest can be part of design patterns. Figure 4 shows a Samsung Galaxy Note device which, with its 5.3 inches screen, does not fit the user's hand. This is a usability issue according to this heuristic.

Figure 4. TMD12: Physical interaction and ergonomics

Most of the definition's updates are shorter than its original. Sometimes "less is more", especially if evaluators need to learn new heuristics.

6. CONCLUSIONS AND FUTURE WORK

With the consolidation of the mobile industry and the massive production of new products, usability is a key differentiating factor and a main attribute in product (software) quality. Customer's fidelization can be made through an easy-to-use interface.

We try to satisfy the need of proper tools for assessing usability in touchscreen-based mobile devices through the proposal of

usability heuristics for such products. The methodology used in the development of the heuristics allowed an iterative process which led to three products (in three iterations). The flexibility of the methodology supported a fast and reliable development and refinement process of the proposal having as a latest product a set of 12 revised heuristics for touchscreen-based mobile devices.

Formal specification through a defined template supports understandability of the heuristics, especially for new evaluators. Empirical validation retrieves valuable feedback for the refining stage of the development process. Preliminary results show that the proposal of 12 usability heuristics for touchscreen-based mobile devices work slightly better in detecting usability issues. However, there is always room for more validation and refinement of the proposal.

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