Mobile UX

Survey Report

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Chapter 1

Introduction to Usability

Usability, as defined by the ISO, 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.* [1] Leading web usability consultant Jakob Nielsen proposes the following five usability components:

- **Learnability:** How easy is it for users to accomplish basic tasks the first time they encounter the design?
- **Efficiency:** Once users have learned the design, how quickly can they perform tasks?
- **Memorability:** When users return to the design after a period of not using it, how easily can they reestablish proficiency?
- **Errors:** How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
- **Satisfaction:** How pleasant is it to use the design?[2]

Combined with the ISO definition, we obtain the following six usability elements, as proposed by Keith Andrews:

1. **Effectiveness:** completeness with which users achieve their goal.
2. **Learnability:** ease of learning for novice users.
3. **Efficiency:** steady-state performance of expert users.
4. **Memorability:** ease of using system intermittently for casual users.
5. **Errors:** error rate for minor and catastrophic errors.
6. **Satisfaction:** how satisfying a system is to use, from user's point of view.[3]

Chapter 2

Mobile Usability

In recent times there has been an increased focus on mobile usability studies. *"Until 2007, the concept of UX had been hard to explain. We didn't have a poster child we could point to and say, 'Here! That's what I mean when I say UX.' But in June 2007, Steve Jobs gave us that poster child in the form of the first generation iPhone"*.[4]

2.1 Why Mobile UX Matters More Than Ever?

If we were to look at some forecast numbers the figures are astonishing. Global Market research firm International Data Corporation (IDC) predicts that worldwide mobile apps revenues will continue to increase and will surpass $35 billion in download prices alone by 2014.[5] In 2011 smart phones outsold desktops and laptops combined. [6] It is also projected that by 2015 tablets alone will outsell laptops and desktop computers.[7] It took AOL 9 months to get 1 million users, whereas it took Facebook 9 weeks and Draw Something 9 days to get 1 million users.[8] Google Chairman Eric Schmidt said that his company now sees approximately 1.3 million Android devices activated per day, up from 1 million in June.[9] It might however be falsely interpreted that we are already at the peak in the mobile world. In fact, this is just the beginning.

2.2 Relationship between Usability and User Experience

"Some people mistakenly use the terms user experience and usability almost interchangeably. However, usability is increasingly being used to refer specifically to the ease with which users can complete their intended tasks, and is closely associated with usability testing. Therefore, many perceive usability to be a rather tactical aspect of product design. In contrast, UX professionals use the term user experience much more broadly, to cover everything ranging from ease of use to user engagement to visual appeal. User experience better captures all of the psychological and behavioral aspects of users' interactions with products."[10]

User experience is a much broader concept than Usability. User experience is the *"consequence of the presentation, functionality, system performance, interactive behaviour, and assistive capabilities of the interactive system"*.[11]

A different way to look at this relationship is by subdividing user experience into utility, usability, desirability and brand experience as shown in the diagram below:

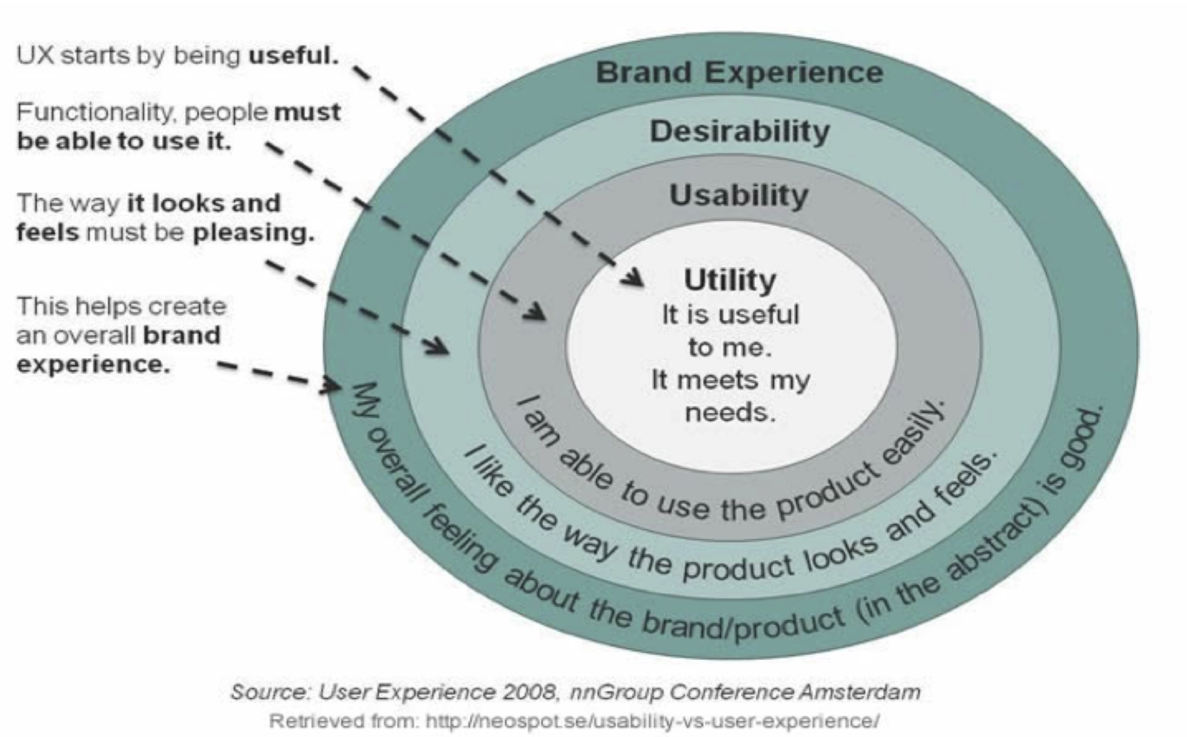

Figure 2.1: User Experience

2.3 Usability

While people sometimes use the term usability to refer to all elements relating to user experience, it should more appropriately be viewed as just a subset of user experience.[10] Usability is about how easily users can complete their intended tasks using a product. A poor usability indicates that despite of the user's active involvement with the product, the user is facing problems completing the intended tasks.

2.4 Utility

"While usability is an important aspect of product design, it is certainly not the most critical aspect of user experience when it comes to driving business success. There are many products that have good usability, but do not enjoy success in the marketplace".[10]

Coherence between product features and user requirement establishes products value to the user. The user will consider the product valuable if it supports their needs. Utility is also intimately related to the other aspects of user experience including usability and desirability, If the product fails to fulfill user's needs despite of how well it is designed it does not provide a meaningful user experience.

2.5 Desirability

Products may be easy to use and useful but they fail to take their place in the market due to desirability. In fact it is possible that some products may have poor usability but due to a strong desirability of the user it is popular among users. An example of that are many video games, which despite their poor usability, complex instruction and poor navigation and readability are still accepted by the user because they are so attractive. Desirability is often ascribed to a novel visual design. Thus users may find the experience with certain product enjoyable in spite of having trouble performing the routine tasks. So we can say the product has good desirability but requires enhancement with usability.

2.6 Brand experience

Brand experience helps to create an overall product experience. The overall feeling of the user about the product is good. It is closely related to usability, in order to improve brand experience product's design workflows should be as such it fully supports user's natural way of discovering the information.

In order to improve Brand experience the natural context in which a user first gets exposed to the product needs to be taken in account as well as how it impacts the design of the installation flow.

Where Usability and User Experience are distinct in their existence they have integral relationship between them. Once we understand distinct elements of user experience we can design products which cover all aspects of user experience in a holistic manner. As result this would provide a enjoyable user experience and a driving force of business success. As we have seen with Apple's iPhone. It is a good example of getting user experience right.

2.7 How is Mobile Usability different?

A question may arise how mobile usability is different than conventional desktop usability. In this section we would look at some of the key elements that make mobile usability distinct from conventional desktop usability.

2.7.1 Mobile user environment is dynamic

One of the main reasons for mobile users to have poor experience when it is neglected the fact the user is mobile. As Moll has stated *"mobile' refers to the user, and not the device or the application"*.[12]

The mobile web or apps are used by people who are on the move. This dynamic environment needs to be considered to accomplish a healthy user experience. Mobile user may be enjoying a cab ride or travelling in an airplane or a train. What are the services and contents the user would require in these sort of environments?

2.7.2 Context

An important question to be considered when designing for mobile is the context it will be used. The desktop web is restricted to certain contextual and physical limitation. It needs a fixed place and environment and both hands free to use it. It also requires when and why to use it. In contrast to this mobile web does not have any of these contextual and physical limitations. Mobile user could be travelling, enjoying a football game or relaxing on the sofa. All of these situations represent different state of mind of the user and enhance different user experience. It is also important to consider the bandwidth and coverage that is available to the user.

In a nut shell, mobile user experience needs to be much more convenient than the desktop experience and focus more on achieving the goal and the task.

2.7.3 Difference in devices

Indeed mobile devices are very different in their technical requirements, browser formats and functional possibilities and restriction in comparison with desktop and laptop computers. Mobiles have small screens and keyboards or may have a touch screen. These all present different technical requirements, browser formats and functional possibilities and restrictions. In short when designing for a mobile user exploring the outer limits of browser and device capabilities needs to be taken into account. The

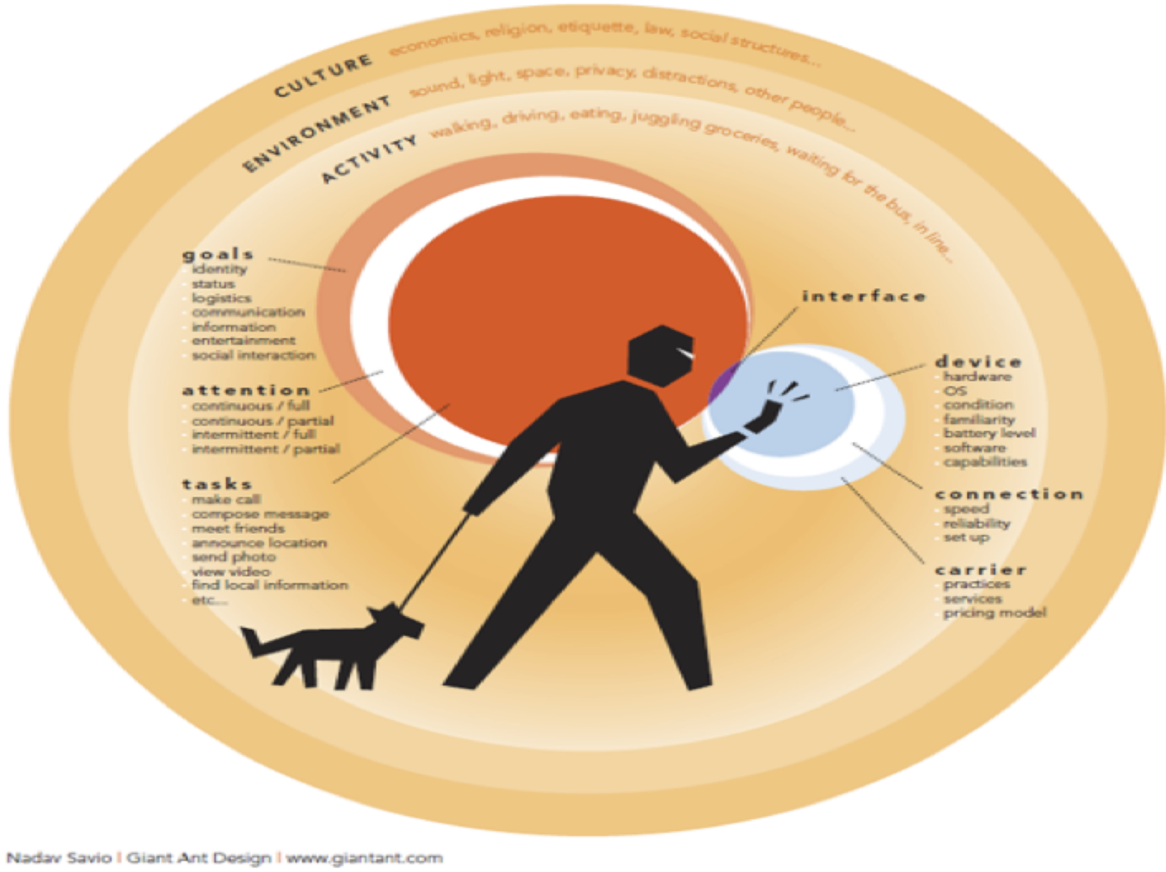

Figure 2.2: User Context

effort required to enter data on mobile devices should be minimized and not require the use of both hands. Input should be limited to essential fields.

"Mobilize, don't miniaturize."[13] Many people try to minimize or port over desktop experiences. But the two experiences are completely different from each other.

Chapter 3

Mobile User Experience

Another area that has a big effect on both native and Web mobile applications is the *user experience.* User experience, compared to *Usability*, can even extend outside the application. Mobile is not just making things smaller. It requires an entire new user interface to generate the same or better user experience compared to an full-sized interface.

Generally, user experience on a mobile platform can be divided into two primary categories [14]:

- **Context:** This includes elements that must be understood but cannot be changed or controlled. Basically, this includes hardware affordances, platform capabilities and the surrounding environment in which the application is used. The context directly affects the users' expectations. Due to the fact that a mobile application can be used almost everywhere, the context radically differs from one user to the next, even on the same platform. Generally, it is not *one* single context, rather there are *multiple* contexts.

  First of all, the **hardware** influences the context. Considering different devices, such as the android device ecosystem, they are varying significantly in terms of display size, resolution, aspect ratio, input mechanism, cameras, cpu power, storage, antenna and so on. All these properties impact how the application will appear and the range of possible ways the user might choose to interact with it. A successful application must be capable of all the different variations of these properties.

  Another factor that influences the context is specific **platform conventions**. Each platform provides its own user-interface conventions, such as Apple's user-interface guideline documentation. Typically, these conventions describe how a developer has to build a user-interface for this platform. For example, on Android and Blackberry devices, we typically have a physical back-button built in the device. In contrast on Apple's iOS there is no physical back-button. Each application, if necessary, adds a virtual button to the user-interface that acts as a back-button.

  Furthermore, the **environment** in which a mobile device is used does also influence the context. For example, there is a huge difference in the context when the application is used at day or by night. The application must also be aware of the fact that the user could be moving while using the application. In fact, the variables that influence the environment are completely endless. The environment does not only affect native applications, it is the same for mobile web applications.

- **Implementation:** This includes factors that can be controlled by the developer or the application directly, such as performance, design and platform features. For example, platform features accelerometer data or notifications. In order to support expectations set out by a user's particular context the application must deliver an appropriate design and code.

3.1 Evaluation Methods

One problem with measuring user experience on mobile devices is the fact that it is a matter of the personal mental feelings of a user. By definition it is unstable, subjective, and complex [15]. Therefore it is not possible to obtain the degree of the users' satisfaction in an accurate way. Basically, usability is a qualitative attribute that specifies how easy a user interface is to use. For further details on the evaluation methods see chapter 4.

3.2 Mobile Web versus Native Apps

According to Charland and Leroux in [14], Apple resetted completely everything in mobile user experiences with their introduction of the first iPhone. The initial plan was that developers should use open web technology to develop third-party applications for the iPhone. This was in 2007, but nowadays native applications are the norm because of performance reasons.

However, there are **two** points against this way of thinking. The **first** one is that building native applications for every platform can be very expensive. Especially for companies who build intern applications for their employees. As a matter of fact they have to support every device of every manufacturer. **Second**, the performance argument can only be applied for 3D games. There is of course a latency and the device requires a permanent Internet connection, but in cities the performance is mostly acceptable. [14]

One example for web applications is Google. They say that they are not rich enough to support all the different mobile platforms out there [14]. For sure there are advantages of native applications but on the other side there are also advantages for web applications. This section describes also a third alternative. The so-called hybrid-applications. This is a fairly new approach that tries to combine the advantages of native control elements with the advantage of the mobile web. Basically, this is accomplished by using native elements for displaying web content.

3.2.1 Trend

Since 2011 there is a trend for native mobile applications. Before 2011, the mobile web had significantly more usage per day compared to native mobile applications. Figure 3.1 shows this trend since 2010.

According to [16] it depends on the task which a user wants to perform on which type of development is better. The traditional user prefers mobile web applications over mobile native applications for shopping. For detailed statistics see Table 3.1.

Table 3.1: User Preference by Task [16]

Task	Mobile Web	Mobile Native App
Shop	73%	27%
Search	63%	37%
Entertain	60%	40%
Manage	46%	54%
Inform	39%	61%
Navigate	35%	65%
Connect	31%	69%

3.2.2 Coding an Application

The first step when it comes to implementing an application begins with code. In order to provide native applications it is necessary to write the code in a language that is supported by the device. This

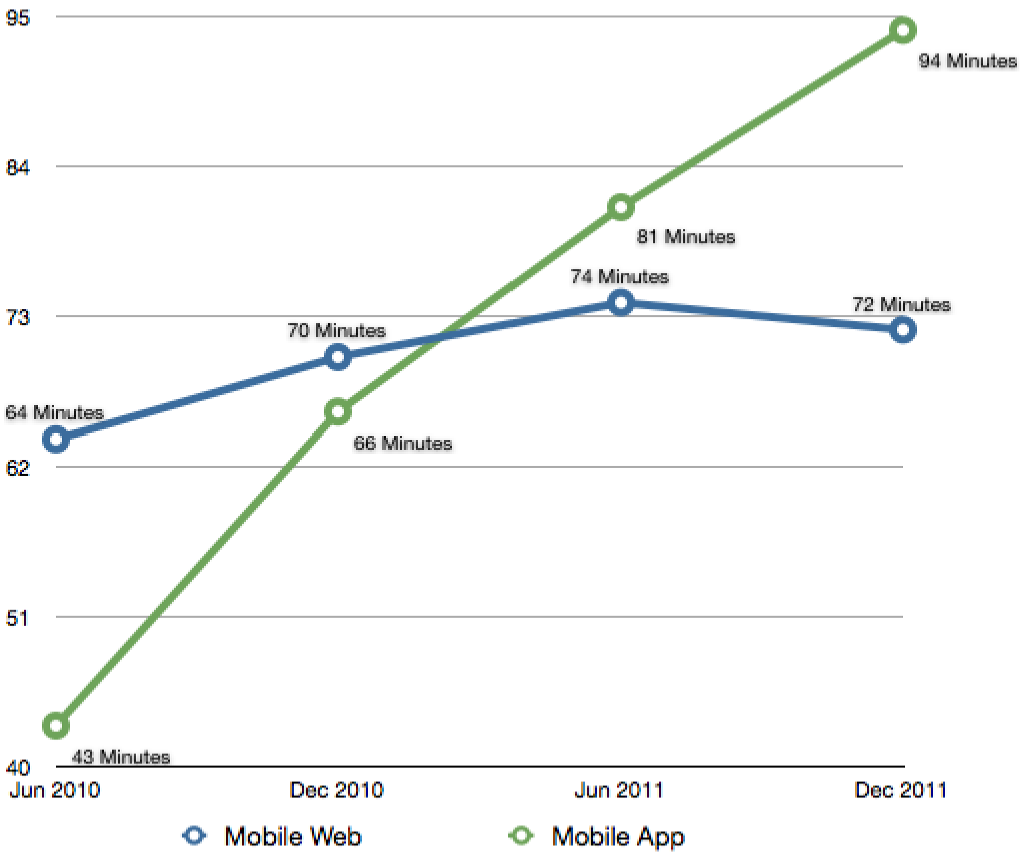

Figure 3.1: Mobile Web vs Mobile App Usage per Day [16]

fact leads to the first big difference. When developing native applications the developers have to write the application for multiple platforms. Therefore, because of the fact that different platforms often require different programming languages, he has to develop multiple versions of the same application in different programming languages. At least almost every platform supports C. Theoretically, it is possible to develop an application in C and adopt it for the different platforms. However, this is very common for game developers, but not for applications in other categories. Considering the time that is needed for developing an application in C without any help of the underlying API it is often better to write it several times in different languages[1]. Despite the fact that this is much more expensive compared to web applications, still most developers prefer it. Table 3.2 shows the different programming languages used on the different platforms.

Table 3.2: Programming languages used for different OS types [14]

Mobile OS Type	Programming Language
Apple iOS	C, Objective C
Google Android	Java
RIM Blackberry	Java
Symbian	C, C++, Python, HTML/CSS/JS
Microsoft Windows Phone	.NET
HP webOS	HTML/CSS/JS

[1]When we talk about "languages" we mean programming languages.

One fact is the same on each platform. They provide a web browser with JavaScript support. Additionally, there are tools available that provide the ability to access the native underlying API of the operating system by using JavaScript. For example, one tool is called *PhoneGap*[2] and it has been developed during the first *iPhoneDevCamp* in 2008 [14]. Today there is support for geolocation, accelerometer and much more.

In order to compare these approaches we have to understand the basic principles. Native code is compiled as compared to JavaScript, which is interpreted at run-time. In order to create user interfaces, browsers use HTML and CSS to create it. Using native code, the pixels get directly painted onto the screen trough proprietary APIs.

The advantages of using native code are at least user-interface control elements. Normally, they provide beautiful and easy to use user-interface controls. This is also one of the biggest disadvantages of native code. No two platforms have the same user-interface paradigms. APIs are there to instantiate and access them but those are completely different for each platform. Compared to the Web platform this is a huge disadvantage. On the Web the controls are limited but despite the fact that browsers interpret HTML and CSS often in a different way, mostly they look the same on different platforms. This is because of the fact that most browsers use the WebKit rendering engine on mobile devices [14]. There only small differences prevail.

Another issue when using Web is the fact that it runs in a sandbox that restricts access to lower-level APIs. Often this access is necessary to use an acceleration sensor, GPS position sensor and many others. Fortunately, most mobile browsers support geolocation today, such as Apple's iOS and Google Android. Furthermore, Apple has added the accelerometer to it. These APIs are standardized in HTML5 by the *Device API Working Group*[3]. There is also *PhoneGap*[4] available. It is used to access the underlying system APIs by JavaScript.

[2] http://phonegap.com
[3] http://www.w3.org/2009/dap
[4] http://www.phonegap.com

Chapter 4

Testing and Evaluation

Usability evaluation and testing is a process to analyze the usability of a system with adequate usability evaluation methods. [17] The mobility of wearable devices makes usability and user experience testing difficult. Many factors must be considered for the testing and evaluation. The user's interactions with the device, as well as the context the user is using it in must be examined. [18]

There are **two** types of evaluation: summative and formative. The **summative evaluation** is carried out at the end of the development stage. The goal is to gain insights for future products or to compare the quality of several products. Using the **formative evaluation**, the product is analyzed during the development aiming for an improvement or stabilization of the product during the ongoing process. [17]

Before the evaluation gets started, the usability goals must be defined. Therefore Gediga and Hambord describe a rough classification of questions in [19]:

1. "Which is better?"
   Comparison of two or more systems or of different variants of a specific function.

2. "How good?"
   Determination of the quality of specific functions.

3. "Why bad?"
   Identification of vulnerabilities during the development process.

If question 1 or 2 should be answered, the summative evaluation is used. The formative evaluation is needed to answer question 3.

Furthermore, testing and inspection methods are differentiated. Sometimes they are also called empirical and analytical methods. The **testing methods** focus on observing test users while they interact with the system. Using this method, series of tasks with corresponding targets are prepared which the user has to work through. In contrast, **inspection methods** are based on experts' experiences who examine the application regarding predefined heuristics. [20]

4.1 Tools

Different tools are used to fulfill the objectives of a mobile usability or user experience test. Nakhimovsky et al. identify three major categories of goals of tools in [21]:

1. Gathering and managing self-reports by users

2. Capturing interaction and system state

3. Recognizing and capturing user context and state

Gathering and managing self-reports by users
These so-called diary studies usually mean much work for the user as they are often asked to report events that may occur in busy, mobile circumstances. Additionally, this method is unreliable as it is fully dependent on the user. Some tools (for example "txt 4 l8r" [22]) aim to lessen this problem, but in order to get good results, this approach of UX testing is not recommended.
Recognizing and capturing user context and state
The test users get observed and interviewed to make sense of the user context. A tool that is often used are interaction logs. Combining the logs with the captured user context, the role of the context in the interaction can be analyzed.
Capturing interaction and system state
The user's interaction with the system and the system state must be captured in enough detail for analysis. This can be done as a quantitative dependent variable or as a resource for diagnosing usability problems. Mobile device cameras are often used to capture video of the screen and the physical interface. Application events help to create logs or annotations of the video.[21]

4.1.1 Screen Capture

Tools for screen capturing are meant to record a video of the device screen. But so far there is no way to record the real-time output of an iPhone or Android device without jail-breaking or rooting it, which often leads to problems. But there are still other ways to record a video of the device's screen. The probably easiest one is to mirror the screen of the mobile device onto a computer and use a recording utility on it. Apple's iPhones' or iPads' screens can be mirrored by using the AirPlay function [23]. There are many different applications for that purpose, for example *Reflection* [24] for iOS devices. Similar applications are available for Android devices as well. An example for such an application is *Wi-Fi CERTIFIED Miracast*[25].

Apart from mirroring the device screen, HDMI recording can also be used. This requires an HDMI output on the device though.[26]

Besides the video capture of the device's screen, another problem to be solved is that capturing the user's fingers and the movement or rotation of the phone is important in UX testing, but currently impossible to record without jail breaking or rooting the device.

4.1.2 Mobile Device Camera

In the testing procedure, mobile device cameras are used to film mobile phones, tablets or other handheld devices from the user's point of view. The screen is recorded as well as the users' fingertips as they interact with the device. Therefore, different camera mounts are designed and used. In order to gain a great output of the user study, a few requirements for camera mounts should be met [27]:

1. *The mount has to be adaptable for a variety of research scenarios and physical positions without interruption.* In dependence of the research question, it is sometimes necessary to only capture the screen and the interaction of the user's fingers with the mobile device, but often the facial expressions of the user are needed for analysis as well. Furthermore, the user may use the device with one hand and touch it with a finger in some situations use two thumbs for navigating in others. The camera mount should suit different situations without re-adjusting it.

2. *The mount must not bother or influence the user's physical interaction with the device under normal circumstances.* The test subject should behave as natural as possible during the evaluation. Hence, the less the user recognizes the camera, the more realistic is the test output.

3. *The mount must contribute to achieve high quality recording and to keep costs and file sizes low.* The small font sizes, usually used in mobile applications or mobile web pages, need to be clearly recorded with reasonable priced cameras. Additionally large file sizes should be avoided to spare hours of editing, rendering, uploading and downloading.

A reasonable idea to mount a camera is using a tripod and a swivel. The problem is that the camera does not move while the device does, though. Thus a tripod only works good if users set the device down. A better approach is to mount the camera more or less onto the mobile device. Using such a mount, the screen capture is not impaired by the user's motion.[27]

If capturing the user's face is necessary, a second camera is used. It should rather be put on a desk, tripod etc. than on the mount of the screen capturing camera. It not only makes the whole setup heavier, it also does not work, because the user does not always move with the device, while the camera mount does.[27] Figure 4.1 shows one of many mobile device cameras named Mr Tappy.

Figure 4.1: Mr Tappy [28]

4.1.3 Eye Tracker

Using eye tracking for the user studies, the aim is to identify and analyze the visual attention patterns of the users while interacting with the device and working through specific tasks. There are different kinds of eye trackers, which all have their benefits as well as drawbacks and therefore are used in dependence of the research scenario. The currently three categories of eye trackers are *head-mounted eye trackers*, *monitor-based eye trackers* and *standalone eye trackers*.[29]

Eye tracking glasses belong to the head-mounted eye trackers and are worn like normal glasses. Both eyes are tracked and a scene camera captures the general environment from the user's point of view.[30] In Figure 4.2, the eye tracking glasses of *Senso Motoric Instruments GmbH* are shown.

Figure 4.2: SMI Eye Tracking Glasses [30]

Monitor-based eye trackers are very accurate but currently can only be used when interacting on a monitor, for example using simulators for mobile device testing. However, this leads to a less natural behavior of the user.

Standalone eye trackers do have some limitations as well, as the test user must not obstruct the field of view of the eye tracker in order to capture all eye tracking data. It can be combined with a scene camera for capturing the device screen and the user's fingertips while interacting though, as the *Tobii* product combination shows in Figure 4.3.

Besides the three mentioned categories of eye trackers, a new category is in development. Much research work is done in the field of using in-built mobile device cameras for eye tracking (for example in [31], [32]). There have been some successes already, but the technique is not yet fully developed.

Figure 4.3: Tobii Mobile Device Stand with Tobii Scene Camera and Tobii Eye Tracker [29]

In [31] a method is described which uses the iPhone's camera and the appropriate image processing techniques to detect and track the eyes position in real-time and interpret it in screen coordinates. A study has shown that currently the accuracy of rightly detected eye fixations amounts to 79,1% if the phone is docked and 53,5% if the user holds the phone naturally. [31]

4.1.4 Wearable Lab Environment

Reichl et al. developed a wearable lab environment for outdoor user tests of mobile devices called LiLiPUT [33]. The user is followed by an observer during the entire testing process. The LiLiPUT system consists of a hat for the user and a receiving unit for the observer. A wireless camera is mounted onto the hat to capture the environment including the mobile device from the user's point of view. Another camera is attached to the hat to observe the user's facial expressions. Furthermore, a microphone for catching the user's comments and a battery pack for power supply are applied to the hat. The observer is following the test user with a maximum distance of 50 meters. A camera, which is mounted onto the observer's shoulder, is directed to the test user and catches the general environment. The observer also carries receivers for the camera and microphone signals, a battery pack for power supply and a laptop for recording the videos and sounds. Figure 4.4 shows the architecture of the LiLiPUT system and the output on the laptop which are the user's view, the user's facial expressions, the user from the observer's view and the screen capture of the application/website under evaluation.

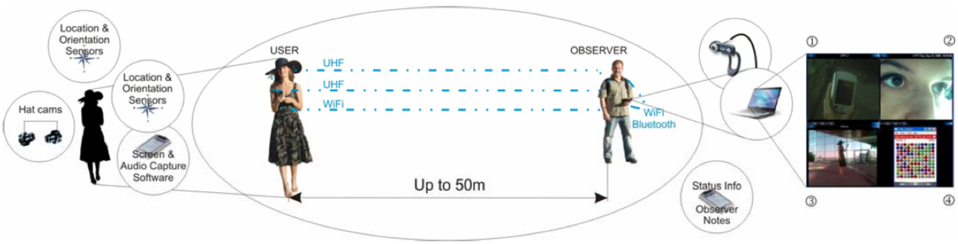

Figure 4.4: LiLiPUT architecture [33]

4.2 Discussion

The screen capture tool is the cheapest of the four tools described in section 4.1, but has many limitations. As explained in 4.1.1, screen capturing currently faces the two problems of recording the real-time output of a device and capturing the touch events and movements of the device of the user.

Using mobile device cameras is a rather cheap solution as well. Test results benefit from recorded user interactions with the device and facial expressions if needed. What is important when using a camera mounted onto a mobile device is, that the camera mount must distract the test user as little

as possible for realistic test results.
Eye tracking is a powerful tool for ux evaluation as it shows what the user is actually looking at and which elements are catching the user's attraction. Used in combination with a scene camera the benefits of mobile device cameras are added. Still, a major drawback is the high costs of eye tracking tools. However, in the near future the use of mobile devices' built-in cameras might be the answer to that problem. But this approach is still in development as mentioned in section 4.1.3.

The wearable lab environment might be also a good approach for mobile device testing in the future as user studies can be carried out in realistic (outdoor) trial situations. The LiLiPUT system is still a prototype, so more research would be necessary to eliminate a few problems, like the weight of the hat which is 1750 grams.

Chapter 5

Dangers and Challenges

Mobile UX entails a couple of dangers and challenges.

5.1 Environmental Challenges

As outlined in chapter 3, mobile user experience might be influenced by environmental distractions, such as auditory, visual or social distractions.[34]

Tsiaousis et al. propose a research model, shown in Figure 5.1 , which sketches out these distractions and derive ten hypotheses.

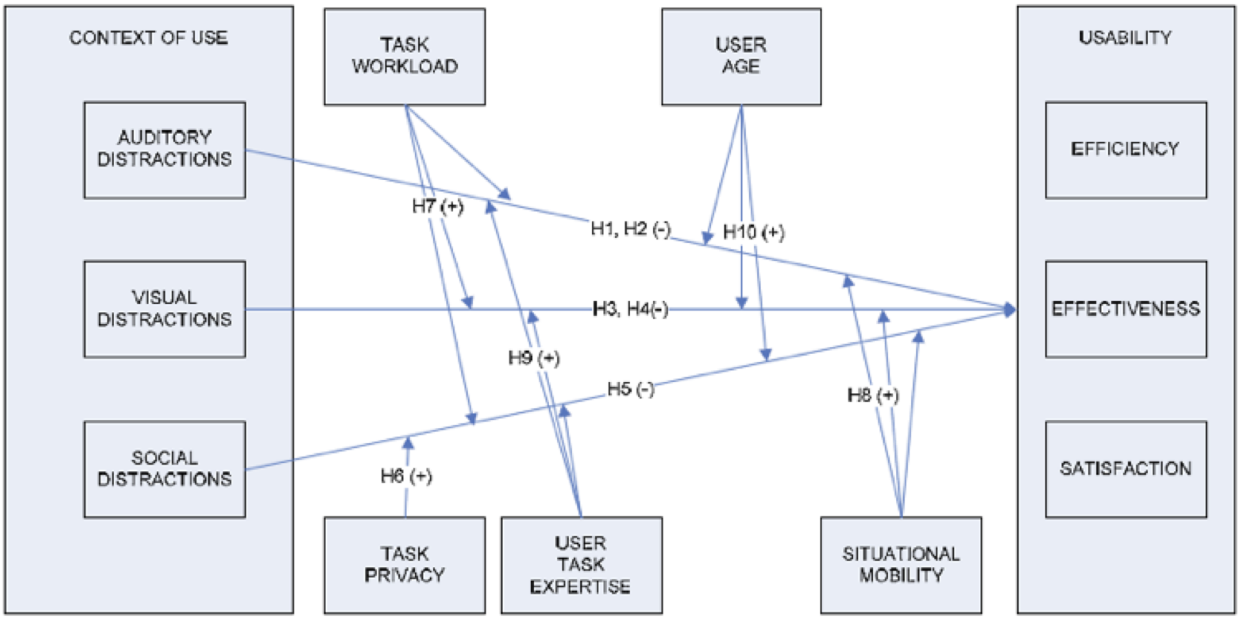

Figure 5.1: Research model [34]

H1. *The variance of auditory distractions will have a negative effect on mobile web usability*

H2. *The semantics of auditory distractions will have a negative effect on mobile web usability*

H3. *The luminosity of visual distractions will have a negative effect on mobile web usability*

H4. *The motion of visual distractions will have a negative effect on mobile web usability*

H5. *Proximity of nearby people will have a negative effect on mobile web usability*

H6. *The effect of social distractions on mobile web usability will be positively influenced by perceived task privacy*

H7. *The effect of visual, auditory and social distractions on mobile web usability will be positively influenced by task workload*

H8. *The effect of visual, auditory and social distractions on mobile web usability will be positively influenced by situational mobility*

H9. *The effect of visual, auditory and social distractions on mobile web usability will be higher for task-novice than for task-expert users*

H10. *The effect of visual, auditory and social distractions on mobile web usability will be higher for older than for younger users.*[34]

5.2 Social challenges

In addition to environmental distractions, Marek Pawlowski and Sherry Turkle dread the social implications of robots that are more and more advanced. Pawlowski cited Turkle's work at MIT and her

Figure 5.2: Social Implications of User Experience[35]

book *Alone Together*, identifying changing social behaviour where users, even close family members, sit together, but disconnected from each other. They are instead absorbed through digital devices in their own virtual worlds. He went on to identify the correlation between declining face to face human interaction and a rise in machine to machine communication.[35] [36]

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