Multidimensional modelling of quality of experience for mobile Web browsing

Sabina Baraković [a], Lea Skorin-Kapov [b],*

[a] Ministry of Security of Bosnia and Herzegovina, Trg BiH 1, 71000 Sarajevo, Bosnia and Herzegovina
[b] Faculty of Electrical Engineering and Computing, Unska 3, 10000 Zagreb, Croatia

A B S T R A C T

The increasing use of mobile devices for Web browsing has driven a rising interest amongst actors involved in the service provisioning chain in understanding the factors influencing user experience. Research activities stemming from both the fields of human–computer interaction (focusing on user experience, UX) and networking and telecommunications (focusing on Quality of Experience, QoE) have addressed different factors, both aiming for a similar goal – understanding and enhancing the user experience when accessing mobile Web sites. We draw these diverged studies under a common umbrella with the aim of studying multiple factors that impact QoE while browsing the mobile Web, focusing on design, information quality, and loading time. We present a multidimensional analysis of the quality of user experience in the context of browsing information, thematic, and e-mail portals on smartphones and tablet devices. Experiments were conducted in field settings with 77 participants during a two-month period. Based on factor manipulations, participants rated sixteen versions of an information portal and a thematic portal, and eight versions of an e-mail portal by using a smartphone or a tablet. For the purpose of data analysis and hypotheses testing, analysis of variance, Pearson correlation analysis, and multiple regression analysis have been reported. Results show the existence of significant effects of examined factors on QoE. Mutual relations between QoE and multiple perceivable characteristics of the experience that contribute to its quality, referred to as QoE features, are found to be highly and positively correlated, and are further quantified using multiple linear regression models.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Throughout the last decades the Internet has experienced a phenomenal growth and thereby completely changed the lives of most people as well as the ways in which they communicate, obtain information or entertain by offering a wide spectrum of various applications and services delivered via the World Wide Web (Web). Simultaneously, the rapid development of wireless mobile communications has increased users' requirements and expectations in terms of accessing a wide variety of Web services, i.e., anywhere, anytime, and via multiple devices (Baraković & Skorin-Kapov, 2013; Ickin et al., 2012; Stankiewicz & Jajszczyk, 2011). With the proliferation of new mobile devices such as smartphones and tablets, the applications being accessed by users have vastly evolved and changed beyond making calls and sending text messages (e.g., reading email, browsing news sites, checking facebook, etc.).

According to Smartinsights statistics (2014), 84% of people possessing mobile devices browse the Web via those devices. Additionally, according to the Morgan Stanley study (Mekeer, Devitt, & Wu, 2010), mobile Web browsing is expected to surpass desktop Web browsing by 2015, since mobile devices are becoming much more convenient for everyday use. In this context, different actors such as service providers, network operators, Web designers, and device manufacturers are interested in understanding the factors (and their interplay) that contribute to the overall quality of the user experience when accessing mobile Web content.

While there have been numerous attempts to define Quality of Experience (QoE) in both literature and standards (cf. ITU-T Recommendation P.10, 2006), a recent widespread joint effort by the research community (in the scope of the EU COST action Qualinet[1]) resulted in a White Paper (Le Callet, Möller, & Perkis, 2013) defining QoE as "*the degree of delight or annoyance of the user of an application or service. It results from the fulfilment of his or her*

---

* Corresponding author. Tel.: +385 1 6129 768; fax: +385 1 6129 832.
E-mail address: lea.skorin-kapov@fer.hr (L. Skorin-Kapov).

[1] www.qualinet.eu, European Network on Quality of Experience in Multimedia Systems and Services.

expectations with respect to the utility and/or enjoyment of the application or service in the light of the user's personality and current state. In the context of communication services, QoE is influenced by service, content, device, application, and context of use". Further, we will abide by the definitions of QoE influence factors (IFs) and QoE features as defined in the Qualinet White Paper. QoE influence factors, defined as "*any characteristic of a user, system, service, application, or context whose actual state or setting may have influence on the Quality of Experience*", have been categorized into three broad categories, namely system-, context-, and user-related factors. With quality evaluation clearly being a complex process, overall QoE is considered to be a multidimensional construct that can be decomposed into multiple perceptual QoE features, referring to "*perceivable, recognizable, and nameable characteristics of the individual's experience of a service which contributes to its quality*" (Jekosch, 2005; Le Callet et al., 2013).

Given the results of previous major studies, summarized in detail in the following section, we conclude that most studies addressing different factors that impact the user experience, or quality thereof (referring also to studies of user satisfaction or preferences) in the context of accessing Web sites focus on a limited set of factors, and hence offer an incomplete view of the User Experience (UX) and QoE. Some examples of questions that arise in the context of the Web browsing experience include: *What are the relationships between perceived usability, perceived aesthetics, and user preference?* (Lee & Koubek, 2010; Tuch, Roth, Hornbaek, Opwis, & Bargas-Avila, 2012) *How tolerant are users towards Web site loading times?* (Egger, Hoβfeld, Schatz, & Fiedler, 2012; Egger, Reichl, Hoβfeld, & Schatz, 2012; Ickin et al., 2012; Schatz & Egger, 2011; Schatz, Egger, & Platzer, 2011; etc.) *Is the user experience more significantly impacted by the aesthetics, usability, or loading time of a Web site?* (Varela, Mäki, Skorin-Kapov, & Hoβfeld, 2013; Varela, Mäki, Skorin-Kapov, & Hoβfeld, 2015) What is missing in previous studies is a multidimensional approach to QoE, i.e., the quantification and deeper understanding of multiple influence factors affecting QoE and features describing it, together with their mutual interplay particularly in the context of *mobile Web browsing*. While it is clear that not all factors can be addressed together in a single study, our focus is on exploring the impact of a chosen set of influence factors and their perceptions (QoE features) on the user rating of overall perceived QoE. Therefore, as the ultimate goal of the study and the novel contribution of this paper, we aim to quantify, i.e., model, the relations amongst perceptions of selected IFs – QoE features, and overall QoE for different types of mobile Web content and devices, based on which one is able to identify the importance of distinct dimensions in terms of overall user perceived QoE.

The paper is organized as follows: We first reviewed state-of-the-art literature in the domain of UX and QoE in the context of desktop and mobile Web browsing, and conducted a pre-study user survey (described in Section 3). The pre-study statistical analysis, in addition to findings in existing literature, was used to derive the design and setup of subsequent empirical experiments in terms of determination of types of mobile Web sites to be developed for testing, as well as the confirmation of the most influential factors and the most important QoE features to be considered and manipulated. The results showed the need to address the impacts of the following QoE features: perception of aesthetics of Web site, perception of usability of Web site, perception of information quality, and perception of Web loading times on overall QoE when browsing the Web via browsers on mobile devices. We then conducted two user studies differing in the type of device used to browse Web content (smartphone and tablet device). We note that we do not focus on user mobility *per se*, but rather on the use of mobile devices. We also consider the impact of the aforementioned

influence factors on QoE for different types of content (news site, thematic portal, and email site), to explore possible differences in effects. As stated, the ultimate goal of this study approaching QoE from a multidimensional perspective is the quantification of mutual relations between selected QoE features and QoE. We specifically focus on Web browsing, given that accessing Web content is more commonly realized as a session of page requests and responses, rather than single page views (ITU-T Recommendation G.1030, 2014).

2. Literature review

When looking to assess the quality of the user experience while accessing Web sites, two different relevant lines of research may be identified. Studies stemming from the field of human–computer interaction (HCI) addressing user preferences and experiences in relation to aspects such as usability and aesthetics of Web-related content which are very mature, and studies stemming from the networking and telecommunications domain which are rather young and have focused on analysing the impacts of network performance and waiting times (resulting from page/element loading times) on end user (QoE). *Web QoE* has been previously defined as the "*Quality of Experience of interactive services that are based on the HTTP protocol and accessed via a browser*" (Hoβfeld et al., 2011). Consequently, to date the fields of *Web QoE* and HCI-related Web studies have been for the most part diverged (an exception is Varela et al., 2015). However, both fields aim for a similar goal, that being to understand (and ultimately improve) the end user experience and overall satisfaction when accessing Web sites and applications.

We note that a great deal of empirical research to date has focused on the domain of UX (e.g., as discussed in Bargas-Avila & Hornbæk, 2011; Hassenzahl & Tractinsky, 2006), driven by a human-centred approach at the level of both theory and practice (Roto, Law, Vermeeren, & Hoonhout, 2011). A thorough comparison of QoE and UX is given by Wechsung and De Moor (2014), who highlight the theoretical-conceptual and methodological-practical differences. Although a number of similarities were identified, the differences between these two notions are profound and reflect in (Wechsung & De Moor, 2014): (i) origin – QoE is primarily used by the telecommunications community while UX has been used within the HCI community; (ii) driving force – UX is human-centred, while QoE is considered to be primarily system- and technology-centred; (iii) theoretical basis – UX has a strong influence from the field of hedonic psychology, i.e., it has a strong theoretical basis, while QoE evolved in an application- and practice-driven way, i.e., lacks a strong theoretical basis; (iv) measurement and evaluation – UX draws qualitative research methods, while QoE is based on quantitative approaches; and (v) focus – UX is concentrated on experience, while QoE focuses on the quality formation process and features that contribute to the perception of quality. One of the most prominent differences between these two notions is that the main focus of UX is to evaluate and understand user experience and the process of experiencing, while QoE is focused on the evaluation of quality perception and gathering the input to guide the optimization of technical parameters at different layers, i.e., QoE is aimed at quantifying the relations and then gaining understanding of the experience based on them. However, an important conclusion that Wechsung and De Moor (2014) draw is that bringing the concepts and methodologies from the UX field into the domain of QoE is needed in order to put the aforementioned holistic definition of QoE into practice. Hence, given that we explore multiple perceptual dimensions that contribute to the overall user judgement of the quality of their experience in