Technological Forecasting & Social Change xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

How augmented reality apps are accepted by consumers: A comparative analysis using scales and opinions

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ARTICLE INFO

Article history:
Received 7 September 2015
Received in revised form 12 October 2016
Accepted 14 October 2016
Available online xxxx

Keywords:
Augmented reality (AR)
Scan function
Virtual mirror
E-commerce
Technology acceptance model (TAM)
Markerless
Marker-based

ABSTRACT

Increasingly, retailers rely on interactive technologies to improve consumers' shopping experiences. On the one side, interactive kiosks and smart mirrors make use of dedicated devices and software to explain, configure, and recommend products. On the other side, computer programs – so-called apps – are installed on the consumer's own device for the same purpose. They can be used at home, or – if installed on a mobile device – in retail outlets or on the move. In all cases, augmented reality (AR) can support these purposes by placing virtual content (e.g. new furniture) in a real environment (the consumer's home). The overall perception and acceptance toward such interactive technologies are discussed in this paper. Users' perceptions and experiences are measured by applying a modified technology acceptance model (TAM). Four experiments, two with marker-based and two with markerless AR apps are presented to support the generalization of the results, the measurement models and the measurement approach. The results are satisfactory with regard to the robustness of the TAM model. However, the relative importance of hedonic (enjoyment, pleasure, fun) and utilitarian (information) aspects varies for different kinds of AR apps and has to be considered for improvement to occur. From a measurement point of view the acquiescence bias has to be dealt with when developing scale items.

1. Introduction

Augmented reality (AR) integrates computer-generated objects with the real environment and allows real-time interactions (Azuma, 1997). AR is rapidly gaining attention worldwide. Applications (apps) were first developed in the 1990s, e.g. an aircraft wire bundle assembly guidance system supporting manufacturing and repair for Boeing (Caudell and Mizell, 1992; for more examples see Azuma, 1997). For some time, large and unwieldy dedicated devices hampered AR popularity. However, with the widespread adoption of smartphones and other handheld devices the interest of developers and companies in AR has significantly increased. Many companies are now developing and implementing AR. Consequently, Daponte et al. (2014, p.54) state that AR is moving from the laboratory into consumer markets. This also applies to the retailing industry where smart or virtual mirrors for consumer experiences were AR front-runners (Demirkan and Spohrer, 2014; Pantano and Naccarato, 2010). Pantano (2014, p. 348) emphasizes the potential of AR in terms of "capturing consumers' attention and influencing their purchasing decision".

Research has concentrated on getting AR technology to work by focusing on enabling technologies such as displays, other interface devices, or algorithms. However, experiments with users have to be made to evaluate AR devices and AR apps. So far research has focused on the evaluation of technical demonstrators, user perception and cognition, user task performance, or the development of user-oriented guidelines for design (Olsson et al., 2013, p.389). Besides visualization and interaction the overall perception and acceptance of AR is important. Overall, user studies are scarce, and this applies in particular to AR apps relying on handheld devices (Bulearca and Tamarjan, 2010; Dey and Sandor, 2014).

With regard to potential usage or adoption of technical innovations in retailing by consumers, the theoretical considerations as well as empirical studies have extensively focused on the technology acceptance model (TAM) (Pantano, 2014). The TAM model has been described "as the most influential and commonly employed theory of information systems" (Lee et al., 2003, p.752). Originally developed as a simple model, and relying on four basic constructs (*perceived ease of use (PEOU), perceived usefulness (PU), attitude toward using (AT) and behavioral intention to use (BI)*) (Davis, 1986, 1989), it has been extended depending on the context with various (external) variables (for an overview with regard to retailing see Pantano and Di Pietro, 2012). One aim of the paper is to identify potential interesting variables with regard to AR in retailing taking previous TAM studies, but also

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http://dx.doi.org/10.1016/j.techfore.2016.10.010
0040-1625/

studies from contextually similar areas and applications (e.g. virtual worlds, innovative retailing), into account. Two main features of AR and potential variables of interest mentioned in the literature are the provision of additional information on products, services or the store shopping environment and "stimulating and pleasant experiences" (Olsson et al., 2013, p.287).

Despite its popularity, TAM has been criticized with regard to measure validation and measurements "resulting in conflicting and somewhat confusing findings which vary considerably in terms of statistical significance, direction and magnitude" (Yousafzai et al., 2007a, p.1746). In particular, the usage of self-reported measurement scales is referred to as "the most commonly reported limitation" (Lee et al., 2003, p.762). Even though self-reported constructs significantly correlate with self-reported usage (e.g. Davis, 1989), there is an absence of absolute measures making the accurate comparison of usage levels more difficult, e.g. with regard to the technological context (Segars and Grover, 1993). Several authors have emphasized the need for and conducted replication studies to determine the predicted relationships of the TAM model (for an overview including the aspect of replication studies to validate the TAM model and measurements see Lee et al., 2003).

This paper aims to shed light on these two gaps by investigating the acceptance of four AR apps in the German marketing and retail markets and comparing two different interaction principles. The mobile IKEA catalogue app and the mobile AUTO BILD app both rely on a scan function used in combination with a printed version of a catalogue or magazine, whereas the Mister Spex and Ray Ban (eyewear) AR apps implement a virtual mirror. User acceptance of these four AR apps in consumer markets is examined with usability experiments in a laboratory setting. A TAM analysis is performed. Besides a scale-based approach relying on batteries of TAM items, a more direct measurement approach based on pre-defined adjective semantic differential pairs is used. The results of the semantic differential and the TAM scales approach for the four AR apps are compared with regard to the quality of measurement and the variables included in the model.

The paper is structured as follows: The next section gives insight into the conceptual and theoretical background for TAM and for AR with a focus on marketing and retailing. In the following sections a modified TAM for AR apps is developed and tested in the context of four AR apps. In the last section, theoretical and practical implications, limitations, and avenues for further research are presented.

2. The concept of AR against the background of marketing and retailing

In the literature the definition of Azuma (1997, p.355) is predominantly used; this defines AR as a system "in which 3D virtual objects are integrated into a 3D real environment in real time". The superimposition of 3D virtual objects in the environment of the user AR "enriches the sensorial perception of a person" (Daponte et al., 2014, p. 53). AR is based on techniques developed for virtual reality (Azuma, 1997) "but does not replace the real environment, rather AR uses the real environment as a background" (Fonseca et al., 2014, p.435).

For user interface technology (Rekimoto and Nagao, 1995), aspects such as visualization and real time rendering, wireless communication, interaction technologies, tracking and registration, data storage and access technologies are important (Adhani and Rambli, 2012; Mekni and Lemieux, 2014). AR enabling technologies in particular include "(d)isplays, trackers, and graphics computers and software" (Van Krevelen and Poelman, 2010, p.2). Recent advances in processor performance, display technology and device equipment (e.g. video camera, internet connection bandwidth (by LTE – long-term evolution), GPS, and sensors such as an Inertial-Measurement Unit) have also increased the interest in AR on mobile devices (smartphones, tablets, glasses) (see Daponte et al., 2014). Several AR apps have been introduced for computers and/or smartphones (for recent surveys on the use of the term and system development see Daponte et al., 2014, Mekni and Lemieux, 2014, or Van Krevelen and Poelman, 2010). Besides application fields such as entertainment and games, cultural heritage, medical, education and training, navigation and tourism, social networking, marketing has been identified as a potential application field (Adhani and Rambli, 2012; Gervautz and Schmalstieg, 2012; Mekni and Lemieux, 2014). Gervautz and Schmalstieg (2012, p.30) describe marketing together with advertising and sales as the "largest application opportunity for AR". Retailers can use AR to engage customers in particular by "virtual trial and product education" as well as gamification to enhance customer experience (Baier et al., 2015). By presenting additional product information in terms of virtual content the AR app can support consumers in their product decision (Adhani and Rambli, 2012). This is in particular the case if consumers can use their own image to interact with the product and "dress their virtual model with the items they prefer" (Blazquez, 2014, p.100). In addition, the experience of the customer either in the store or at home can be enhanced, since it is fun to use the AR app interactively (Gervautz and Schmalstieg, 2012). Other marketing application possibilities – which are not the focus of this paper – are navigation aids to localize stores and in-store-navigation, warehouse space optimization, brand recognition and promotion, or support of sales team members (Gervautz and Schmalstieg, 2012). These recent surveys of AR apps indicate a broadening of the definition of AR: AR in the wide sense is the integration of virtual objects (of any type) into a real environment in real time.

3. Theory building and research model

3.1. Technology adoption of AR in marketing and retailing: theories and shortcomings

Fifty years after Ivan Sutherland's Sketch Pad graphical user interface (Sutherland, 1964), research in (end user) technology acceptance is one of the mature areas in information systems research for the simple reason that consumer acceptance is crucial for the market success of a new technology. And within this research area, the technology acceptance model (TAM) of Davis (1986) (in one of its variants) is the most prominent model. This is supported by a Google Scholar search (June 15th, 2016) resulting in about 1.66 million links for the TAM model.

To predict technology acceptance Davis (1986) relied on a simple Stimulus-Organism-Response model which was refined with the Theory of Reasoned Action (TRA) of Fishbein and Ajzen (1975). Davis (1986) suggested that the motivation of a user to use the system is best explained by the latent construct *attitude toward using* (AT) – and AT from *perceived usefulness* (PU) and *perceived ease of use* (PEOU). Meta analyses have shown that TAM explains about 40% of the variance in the *behavioral intention to use* (BI) an innovative IT system (Legris et al., 2003). In addition, the BI of an innovative system is a direct predictor of actual system usage explaining about 37% of the variance after post-training in a voluntary setting and 35% of the variance in a mandatory setting (Venkatesh et al., 2003).

TAM as a theoretical framework has been criticized due to its simplicity for turning the research focus away from "design- and implementation based antecedents" as well as human behavior and experience (Benbasat and Barki, 2007, p.212). Thus, the TAM model has been extended with various constructs, e.g. the TAM2 model (Venkatesh and Davis, 2000) adds antecedents to PU and the TAM3 model (Venkatesh and Bala, 2008) to PEOU. Aiming at specific guidance for designing IT systems, Wixom and Todd (2005) combine user satisfaction models with the TAM model and rely on determinants such as *System Quality* and *Information Quality*. Aspects of concepts like user experience (Hassenzahl and Tractinsky, 2006) investigating the drivers of positive experience of interactive computer technology, e.g. the internal state of the user, characteristics of the system (e.g. usability), and the environment, have been integrated into the

Please cite this article as: Rese, A., et al., How augmented reality apps are accepted by consumers: A comparative analysis using scales and opinions, Technol. Forecast. Soc. Change (2016), http://dx.doi.org/10.1016/j.techfore.2016.10.010