Extending reality

Uses, processes, and persuasive effects of augmented reality apps

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[Link to publication]

General Introduction and Dissertation Outline

Augmented Reality (AR) technology superimposes virtual objects (text, pictures, video, or 3D graphics) upon the physical world and can be experienced via mobile or web applications ("apps"), digital screens, or wearable devices (Azuma, 1997; Javornik, 2016a; Scholz & Smith, 2015). Over the last decade, AR technology has shown a tremendous increase in investments by big tech companies in AR apps, AR devices, and AR developer platforms (Liao, 2019; Porter & Heppelmann, 2017). This has led to a simultaneous increase in the number of AR apps available to consumers. While some of the early-stage AR apps were considered a gimmick that failed to meet consumer expectations (Javornik, 2016b; Scholz & Smith, 2015), recent technological advancements have led to better equipped devices and apps to unleash AR's potential (Liao, 2019; Porter & Heppelmann, 2017).

The first, early-stage consumer AR apps date back to 2008 and 2009, when Wikitude and Layar introduced the first AR browsers for mobile phones (Liao, 2015). After a short hype cycle, the popularity of AR was especially triggered by the launch of AR game Pokémon GO in 2016, which "brought augmented reality to a mass audience" (Wingfield & Isaac, 2016). Moreover, through the integration of AR in existing social media platforms, a growing number of consumers are familiarized with AR. These developments, along with the expected, continued growth of AR over the next years, indicate that AR technology is entering the mainstream (Porter & Heppelmann, 2017). Apple's CEO Tim Cook even regards AR as "a big idea like the smartphone", which will become incorporated into people's everyday lives (Statt, 2017).

AR has three unique features that distinguish the technology from other digital media and technologies. First of all, *the real and the virtual world are combined*, by projecting virtual objects within the user's physical world. This differentiates AR from other immersive technologies such as Virtual Reality, that immerse users in a completely virtual world (Azuma, 1997). Second, the virtual objects can be interacted with in *real time*, which distinguishes AR from photos enriched with digital content (Liao, 2019). Third, the virtual objects are *registered in 3D*, which means that they have a fixed location in the physical space (Azuma, 1997). In comparison, other digital media mostly rely upon two-dimensional screens to obtain digital information (Porter & Heppelmann, 2017). Thus, unlike any other technology, AR apps enable users to bridge the virtual and the physical world and as such **extend reality**.

Due to its unique features, AR shows potential to change the way consumers interact with technology, brands, and each other (Liao, 2019; Porter & Heppelmann, 2017; Scholz & Smith, 2015). AR apps could bring about experiences that are contextually relevant, personalized, and more direct than non-AR experiences (Javornik, 2016b; Scholz & Smith, 2015). For example, by using a virtual overlay, AR apps can visualize products

as if they are really there, provide more information on nearby physical locations or objects, or display entertaining content or games within one's direct surroundings. As such, AR shows potential to enrich existing digital media (e.g., mobile media, websites), and could enhance consumer experiences and lead to increased persuasion.

Since AR apps allow for new ways of interacting through media devices, it is important to understand whether, when, and why AR apps differently shape the persuasion process as opposed to other digital media or technologies (e.g., mobile media, websites) and whether the effects of AR apps can be explained through similar underlying processes and gratifications. However, given the novelty of this technology, knowledge on the uses, processes, and persuasive effects of AR apps is still scarce (Flavián et al., 2019). Therefore, this dissertation investigates 1) the prevalence, user characteristics, and gratifications of AR apps, 2) the persuasive effects of AR apps and its underlying processes, and 3) the effects of type of AR device on user experiences.

Focus of the Dissertation and Research Questions

This dissertation will contribute to our understanding of the AR app user landscape, covering the use of different AR apps and AR devices, its persuasive effects and underlying processes. As can be seen in Figure 1.1, this dissertation focuses on the individual characteristics that predict the use of AR apps and subsequently, the gratifications, underlying processes, and persuasive effects of AR app use. Furthermore, this dissertation focuses on the use of AR apps (as opposed to non-AR apps), and considers different app types (e.g., shopping apps, game apps), AR devices (handheld versus wearable AR devices), and types of augmentation (self vs. surroundings). In the following, three main research questions are posed to examine the relations as proposed in Figure 1.1.

Figure 1.1 Conceptual Model of the Dissertation
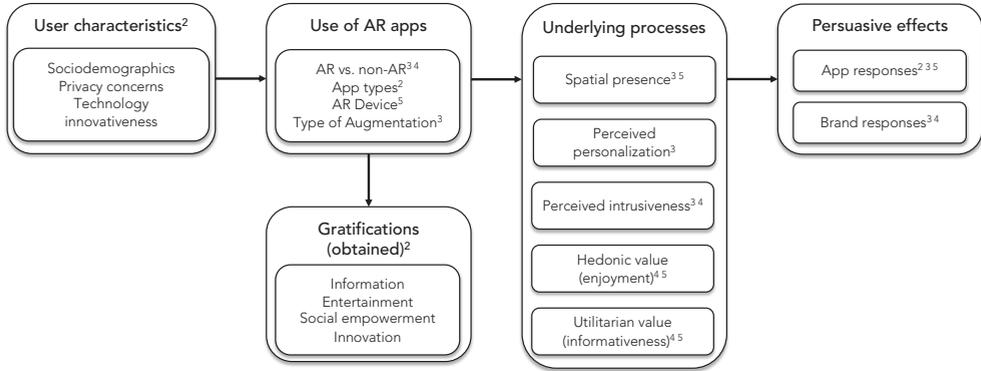
Note. [2] Chapter 2, [3] Chapter 3, [4] Chapter 4, [5] Chapter 5

Prevalence, User Characteristics and Gratifications of AR Apps

While marketers have started experimenting with AR, a lack of understanding about the technology, its users, and a clear vision on the added value of AR has been a barrier to move past an experimental phase (BCG, 2018). Moreover, despite the increased popularity of AR consumer apps, developers are still struggling to find out what works and what does not work in developing successful AR apps (Digi-Capital, 2019). For example, opportunities vary from developing first-party (branded) AR apps, to buying 'advertising space' in existing third-party apps such as social media or game apps that incorporate branded AR experiences (BCG, 2018). However, it is unclear to what extent such AR apps are actually used and appreciated by consumers. Moreover, different types of AR apps (e.g., shopping apps, game apps) may induce different experiences (e.g., more informative or entertaining), and attract different audiences in terms of user characteristics. However, it is unclear to what extent (different types of) AR apps are actually used, by which type of people, and what kind of apps provide value to consumers.

So far, insights into the use of AR apps comes from industry reports, that have given a basic understanding on the prevalence of AR app use (e.g., Mindshare, 2018), but lack a differentiation between app types. Since academic research has mostly focused on the use of one type of AR app (e.g., shopping apps), used non-representative

samples, or did not consider actual AR app users, insights on consumers' use of AR apps is very fragmented. Academics have also signaled the need for research focusing on the users of AR apps, as well as non-users, in terms of individual characteristics, usage patterns, and their attitudes towards AR (Liao, 2019). Moreover, since AR brings about a new way of interacting with digital information, this also questions whether it may lead to new gratifications in relation to AR app use (Sundar & Limperos, 2013).

Based on *diffusion of innovations theory* (Rogers, 2003), and the *Uses & Gratifications framework* (Ruggiero, 2000), this dissertation identifies relevant individual characteristics and gratifications in relation to the use of different types of AR apps. Such knowledge can advance our theoretical understanding of the factors (e.g., user characteristics, gratifications) that enhance or limit adoption of AR apps, and can contribute to a more differentiated understanding on consumers' use of AR apps. Such knowledge is also relevant for the industry, as it can help to identify potential target groups of AR apps, and to build AR apps that provide value to consumers. In sum, both academic research and practice can benefit from a comprehensive overview covering the prevalence, user characteristics, and gratifications of AR app use. Therefore, the first question that will be answered in this dissertation is:

RQ1: Which user characteristics and gratifications are associated with the use of (different types of) AR apps?

Persuasive Effects of AR Apps and its Underlying Processes

While consumers previously had to rely upon two-dimensional screens to obtain digital information, AR adds an extra, three-dimensional layer to the consumer experience that can be interacted with in real time. This gives consumers a more firsthand, direct experience that was previously not available (Verhagen et al., 2014). Due to its unique features, it is assumed that AR apps could affect the persuasion process. However, it is unclear whether and through which processes AR apps can lead to positive, as well as negative persuasive effects. Because of the novelty of AR technology, at the start of this Ph.D. project (April 2016), research on the persuasive effects of AR apps was still in its infancy. Only recently academic research has begun to explore the effects of AR apps and potential theoretical explanations (e.g., Javornik, 2016a; Verhagen et al., 2014). However, these studies showed mixed results as to whether AR apps enhanced brand responses and did not consider potential negative effects. Therefore, a better understanding is needed of the persuasive effects of AR apps and the theoretical explanations underlying these effects. Moreover, the industry could also benefit from a better understanding of the processes underlying the effects

of AR apps, to induce positive app and brand responses, while diminishing potential negative effects and protect potential vulnerable consumers.

Building upon literature on the effects of AR and other digital media (e.g., personalized advertising; Baek & Morimoto, 2012) this dissertation aims to explain why AR apps lead to more positive or negative persuasive effects (app and brand responses), as opposed to a non-AR app. On the one hand, it is argued that the real-time and interactive nature of AR experiences allow for enhanced persuasion by realistically overlaying virtual objects or information directly in a personally relevant context (i.e., spatial presence, perceived personalization; Hilken et al., 2017; Porter & Heppelmann, 2017). Moreover, it is argued that the user experience will be enhanced through both hedonic (e.g., perceived enjoyment) and utilitarian processes (e.g., perceived informativeness; Hilken et al., 2017). On the other hand, the integration of a virtual overlay in a personal context through one's mobile camera, could also induce negative reactions (e.g., perceived intrusiveness; Baek & Morimoto, 2012) and therefore decrease persuasion. In sum, the following research question will be answered:

RQ2: What are the positive and negative persuasive effects of AR apps and its underlying processes?

Effects of Type of AR Device on User Experiences

So far, consumers have started adopting AR apps largely through their mobile (handheld) devices, since smartphones already have a high penetration rate and possess the technological requirements to employ AR (e.g., a camera). Therefore, mobile handheld devices are the easiest route to consumer adoption (Liao, 2018). However, large investments are being made in the development of wearable AR devices, such as head-mounted displays or smart glasses, which are see-through glasses that project virtual objects in the direct view of the users' surroundings (Azuma, 2017). Currently, such devices are expensive, and mostly used for enterprise solutions. However, more lightweight, affordable wearable devices are being developed by big tech companies and will enter the consumer market in the next years (Liao, 2018; Wilk, 2020). Wearable AR devices are expected to become a consumer product in the future, as advocates argue it provides a more meaningful way of employing AR (Liao, 2018). It is even predicted that by integrating AR in wearable devices, it may ultimately replace smartphones and other display forms such as monitors or TVs (Azuma, 2017).

Wearable AR devices could provide a more positive user experience than handheld devices, because virtual objects are superimposed over the direct view of the surroundings. This enables users to have a hand-free experience in which they can

directly interact with the virtual objects using naturalistic gestures, touch, and body movements (Lindgren & Johnson-Glenberg, 2013). As such, users can more directly embody the technology and can interact with virtual objects in a similar way as one would interact with physical objects in the real world (i.e., *embodied congruence*; Hilken et al., 2017). In comparison, when using AR on a mobile handheld device, the user has to hold up the device to see and interact with the virtual objects displayed in the physical world via their screen (Azuma, 2017). Therefore, advocates of wearable devices argue that mobile AR devices cannot fully make use of the capabilities of AR, since it is limited by interacting through the device (Azuma, 2017; Liao, 2018).

While academic literature has noted the differences between handheld and wearable AR devices and acknowledged the potential of wearable devices to become a future consumer device (e.g., Azuma, 2017; Porter & Heppelmann, 2017), no studies have compared whether user experiences differ between handheld and wearable AR devices. Previous research has shown that both devices can separately induce positive user experiences through hedonic and utilitarian processes (Hilken et al., 2017; Tussyadiah et al., 2017), or focused on factors that influenced consumers' intention to adopt AR on handheld or wearable AR devices (e.g., Rauschnabel, 2018; Rese et al., 2017). However, to support the claimed potential of wearable AR devices as 'the future of AR', it should first be examined whether wearable AR devices are actually capable of delivering more positive user experiences (hedonic and utilitarian value) than handheld devices. Therefore, the following research question is formulated:

RQ3: What is the effect of type of AR device (wearable versus handheld) on user experiences in AR?

DISSERTATION OUTLINE

The research questions of this dissertation will be addressed by four empirical studies and are based on five different datasets. Each study is covered in a separate chapter (Chapter 2, 3, 4, and 5) and is published or has been submitted for publication. Therefore, all chapters are self-contained and can be read individually. The conceptual overview of this dissertation can be found in Figure 1.1 and shows which relations are being examined in this dissertation and which factors and variables are covered in each chapter.

The first empirical chapter (**Chapter 2**) addresses the prevalence, user characteristics, and gratifications associated with AR app use, as posed in **RQ1**. Using a large-scale survey (N = 1978) among a sample representative of the Dutch population (18 to 65 years old), this chapter examined 1) the prevalence and frequency of AR app use, 2) the individual characteristics that predict AR app use (comparing users to non-users), 3) the gratifications obtained from AR app use, and 4) the preference for AR in both users and non-users. Guided by our AR app classification, this chapter provides a comprehensive overview of the AR user landscape by considering factors influencing the usage of (different types of) AR apps.

Chapter 3 and 4 address the positive and negative persuasive effects of AR apps on app and brand responses and its underlying processes (**RQ2**). **Chapter 3** examines three underlying processes (spatial presence, perceived personalization, and perceived intrusiveness) that could explain the effects of AR apps on app and brand responses by comparing an AR app to a non-AR app. Two experiments were employed (N^1 = 113; N^2 = 76), focusing on two AR shopping apps differing in type of augmentation. The first experiment focused on an AR app that enabled users to visualize virtual products on their own face (self-augmentation; e.g., make-up). The second experiment examined whether the findings could be replicated when focusing on an AR app that enabled users to visualize products within their surroundings (augmentation of the surroundings; e.g., furniture).

Chapter 4 aims to further disentangle the effects of AR shopping apps that overlay virtual products on the users' face (i.e., self-augmentation), by eliminating a potential confound in previous AR studies. Since Chapter 3 compared an AR app showing products on one's own face, opposed to a non-AR app showing products on a model, it was unclear which part of these effects could be attributed specifically to using AR, and which part to seeing one's own face. Therefore, this chapter employed an experiment (N = 132) comparing online product presentation with AR to two non-AR conditions, either using a picture of the user's own face, or a model. By comparing

these conditions, this chapter examined the effects of AR shopping apps on brand responses via three underlying processes: perceived informativeness, perceived enjoyment, and perceived intrusiveness.

Chapter 5 addresses the effects of type of AR device on user experiences (RQ3). In an experiment (*N* = 165), participants played an AR game using a handheld AR device (a smartphone), or a wearable AR device (a Hololens). The chapter argues, based on embodied cognition theory (Wilson, 2002), that wearable AR devices are characterized by high embodied congruence (the extent to which the interactions with the virtual objects match and align with the physical movements of the user), while handheld AR devices are characterized by low embodied congruence. Comparing these devices, this chapter examined the effects of embodied congruence in AR on user experiences (hedonic value, utilitarian value, and use intention), via spatial presence.

The final chapter (Chapter 6) provides the general conclusion and discussion based on the findings of the empirical chapters, and addresses the theoretical and practical implications, along with limitations and directions for future research.

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