Augmented Reality Smart Glasses: Definition, Concepts and Impact on Firm Value Creation

Young K. Ro, Alexander Brem and Philipp A. Rauschnabel

Abstract In recent decades, the developments of new media have revolutionized individuals' behaviors tremendously. Mobile devices, in particular, have developed an 'always and everywhere online' mentality. But what comes next? Recent developments emphasize the rise of a new technology that is termed 'Wearable Augmented Reality Devices', where Augmented Reality Smart Glasses (such as Microsoft HoloLens or Google Glass) represent prominent examples. These technologies offer huge innovation potential for companies and societies, which are discussed in this article. By doing so, this paper provides managers and researchers an applied description of the technology and a discussion of how it differs from existing mobile and augmented reality technologies. Finally, insights are given into how these technologies may increase firm value and further change the behaviors of consumers and adopters.

Keywords Augmented reality smart glasses · ARSGs · Mixed reality · Head mounted display · Definitions · Firm value · Future research

1 Introduction

Augmented Reality Smart Glasses (ARSGs), such as Google Glass or Microsoft HoloLens, have recently gained increased attention . Broadly speaking, ARSGs are a new wearable augmented reality (AR) device that capture and process a user's physical environment and augments it with virtual elements. Recent forecasts

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predict that ARSGs will substantially influence societal media behaviors, and market research institutes predict tremendous growth rates for this new type of technology (e. g., Technavio 2015; Stockinger 2016). Consumers and media have discussed the advantages and potential concerns of this technology for individuals and society as a whole, such as data security concerns (Fodor and Brem 2015). Although there is a huge potential for ARSGs to create value for consumers, companies and societies as a whole, little research has been published in this area to date (Stockinger 2016). However, academics and managers call for early market knowledge to better understand the mechanisms that drive this promising technology (Rauschnabel et al. 2015; Eisenmann et al. 2014; Tomiuc 2014).

Knowledge about new technologies and their (potential) customers is important in the early stages of innovation diffusion (Brem and Viardot 2015). In these critical phases, knowledge about the opportunities and challenges might increase the probability of successful implementation, decrease the probability of product failures, and thus increase diffusion speed (Attewell 1992). Likewise, early knowledge can provide an advantage for companies that might increase efficiency when using ARSGs (Hein and Rauschnabel 2016). This knowledge can also help policy makers focus on laws that cover the specific appropriate and inappropriate use characteristics of ARSGs—e.g., that ARSGs could distract people from driving a car or that wearing ARSGs in public might violate privacy and copyright laws.

In this article,[1] we address the research gap of deficient early knowledge on the strengths and weaknesses of ARSGs as follows: First, we provide a new classification of online technologies. By doing so, we integrate ARSGs in the evolution of media technologies and discuss its distinctiveness compared to other technologies, such as virtual reality glasses. Second, we generate an outline explaining how ARSGs can increase firm value. Besides enhancing or improving the performance of existing tasks, the potential for new business models for innovative applications arise.

2 Virtual and Augmented Reality Devices

2.1 Overview

Driven by new technologies, virtual and augmented worlds are converging. Recently, ARSGs have attracted a lot of attention as a new breakthrough innovation (Technavio 2015; Rauschnabel et al. 2015; Rauschnabel and Ro 2016; Eisenmann et al. 2014; Tomiuc 2014; Jung et al. 2015). Figure 1 proposes a novel media evolution framework of five media generations. The x-axis in this figure reflects the passage of time and the y-axis the influence of each generation's technologies on users' lives.

[1]This chapter is a revised version of a working paper published by the authors on researchgate.net, see Rauschnabel, Brem and Ro (2015).

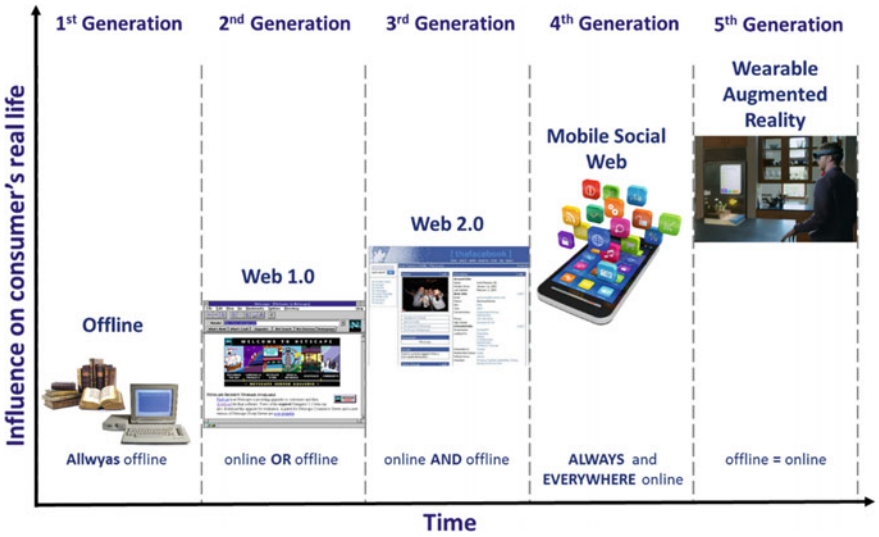

Fig. 1 Evolution of media devices

The first generation of media is termed offline media and includes uni-directional offline media such as newspapers, television and Teletex. These technologies were mostly stationary and digital technologies from that time received their information either from internal storages, cartridges (e.g., game consoles), CD ROMs, or via analog radio frequencies (e.g., TV or Radio). Consumers' role was passive, i.e. they consumed media.

The second generation (1990s), dubbed as Web 1.0, describes early online technologies where static websites structured like digital brochures are prominent examples. Consumers' roles in this generation of media were primarily passive, i.e., consuming content that was mostly produced and published by professional organizations—e.g. companies. Although two-way communications were possible, most of the Web 1.0 technologies were still uni-directional. Broadly speaking, these early websites were 'digital brochures' and most content was produced by professional organizations. Only a few very innovative users created personal websites, primarily by manually programming HTML code, and hosted these websites and offered free web hosting services such as geocities.com.

The third generation, starting in the early 2000s, has been dubbed Web 2.0, or social media (Kaplan and Haenlein 2010). Social media is characterized by complex and multi-directional communications. Users serve both as consumers and producers of content, giving rise to the term 'prosumers'. Faster internet connections, higher user-friendliness among devices, and higher levels of trust and acceptance of the Internet represent examples of why people were more likely to experiment with and use Web 2.0 technologies. Examples of early Web 2.0 technologies are Facebook (at that time 'TheFacebook'), SecondLife, and Myspace.

Staring around 2010, the fourth generation of media extended social media from static devices to mobile device such as laptop computers, tablets, and smartphones.

However, other forms of wearable devices such as smart watches, smart clothes, or smart wristbands, are also covered by this generation of media. These mobile technologies enable users to have access to their 'social media environment' anytime and anywhere. Not surprisingly, social media applications—such as Facebook or Instagram—are the most popular smartphone apps.

The fifth generation of media is the so called wearable augmented reality devices ('WARD') era, i.e., wearable technologies that merge virtual and physical realities. In other words, these technologies meld the real world with virtual elements. One example of this fifth generation of media are augmented reality ARSGs, which are the focus of this article. Wearable augmented reality devices are only made possible due to developments in communication networks. It is now technically feasible to transport data at high rates and ensure shorter latencies (10–100 ms). There are advances in data security, and the communication network is now able to process several devices or several connectivities within the same efficiency range. Networks are also now able to address mobility requirements of new technologies from near field, over short range, local in- and out-door to a global efficiency range.

In this fifth generation, communication reaches a new level concerning human senses involved in media; it is the communication generation that could encompass all human sensory impressions.

The idea of augmented reality is not new; these technologies have been developed and researched during the last few years (Javornik 2016a; Stockinger 2016; Pantano et al. (2017). An example of an established AR technology are the "virtual mirrors" that are often used by fashion retailers (Javornik et al. 2016). Virtual mirrors are displays with integrated cameras that film a consumer, who then can choose the different clothing he/she is wearing on the screen. Mobile AR applications can be used on most mobile devices such as tablets or smartphones. For example, users can capture a famous building in a city with their camera, then use a mobile AR-app, such as Cyclopedia, that recognizes the building and provides the corresponding information about this building from Wikipedia. However, extant AR examples are either just applications for mobile, stationary devices or devices that were specifically developed for professional contexts (e.g., virtual mirrors). ARSGs, in contrast, are conceptualized as a new generation of media since they are (a) specifically developed AR technologies, and (b) also made for the masses.

2.2 *Definition of Augmented Reality Smart Glasses*

Based on our theorizing and prior research, we develop the following definition of Augmented Reality Smart Glasses

(synonym: data glasses, digital eye glasses, or personal imaging system):

> Augmented Reality Smart Glasses (ARSGs) are defined as wearable Augmented Reality (AR) devices that are worn like regular glasses and merge virtual information with physical information in a user's view field.

Most ARSGs are worn like glasses, and few examples (e.g. Google Glass) could also be mounted on regular spectacle frames. Several technologies (e.g., camera, GPS, microphones etc.) capture physical information and augment them with virtual information that can be gathered from the internet and/or stored on the ARSGs memory, primarily accomplished through location-, object-, facial-, and image-based recognition technologies. This virtual information is then presented in real-time on a display, which, in brief, is a transparent screen in front of a user's eye (s). A user can see both the virtual and 'real' world through these displays. Prominent examples of ARSGs are Microsoft HoloLens, Everysight Raptor or Google Glass.

3 Value Creation with Smart Glasses

The core proposition of this article is that ARSGs can be a means to create corporate value for businesses and also for society as a whole. Therefore, it is necessary to distinguish between internal and external value creation factors (see Fig. 2). Internal value creation factors cover aspects where smart glasses can be used by a firm's employees to work more effectively. External value creation means that companies can increase revenues by offering applications for ARSGs that can be used by consumers or for interactions with customers. Important to note is that, due to the novelty of the technology, not all of the potentials have been addressed in

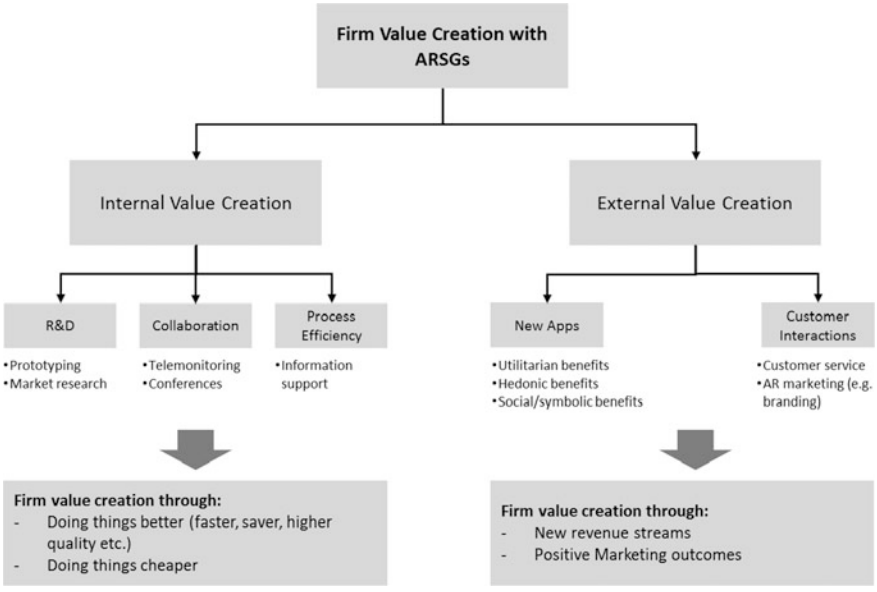

Fig. 2 Firm value creation with augmented reality smart glasses

prior research or practice. Thus, this overview also provides suggestions for future research.

3.1 Internal Value Creation

Research and Development: Traditional research and development activities include a lot of investments into discovery and trial-and-error-processes. This is usually linked with a high investment into hardware such as printers, and into product concepts, usually done with different approaches to prototyping. Even though nowadays 3D printers are becoming more and more prevalent in use, this is still a high investment in terms of financial and time resources. With the use of ARSGs, these processes can be virtualized by using 3D applications—and it even goes further through the usage of social media for the evaluation of new product ideas. Hence, such devices can foster and facilitate the full innovation process within a company and its research and development activities.

Beyond that, ARSGs offer new methods of market research for firms. Consider, for example, survey applications that cover physical information—such as a product or a store—and integrated surveys. Extended versions of ARSGs could combine the advantages of mobile surveys and eye-tracking (as well as other forms of observational data) and provide marketers with new methods and enhanced results/outcomes of market research. Prior research has also focused on new technologies for product testing. For example, the use of virtual 3D-screens have been investigated as a means to test packaging and display its benefits compared to 2D-tests with the limitation of artificial laboratory situations (Berneburg 2007). ARSGs could also be used to present products more realistically. For example, new forms of a bottle could be virtually displayed on a respondent's dining table at home and evaluated in a realistic situation, thus increasing the external validity of product tests.

Collaboration: Early attempts have been made to use ARSGs as a means to promote collaborative work. For instance, Muensterer and colleagues tested the acceptance of Google Glass in a pediatric hospital and used it for telemonitoring with colleagues all over the world (Muensterer et al. 2014). Similarly, manufacturers of ARSGs, such as Microsoft (2015), highlight the benefits of collaborations with varied examples—in a personal setting (a father, who from distance, helps his daughter fix a drain at home) or in a professional setting (researchers in a lab analysing rocks on Mars). Likewise, collaborations in customer-firm interactions are possible, for example, for functions such as customer service and product support. Finally, virtual meetings through services like Skype can be much more efficient if additional information can be shared in real-time and with full visibility through ARSGs. The movie Kingsman provides several fictitious examples how ARSGs can enhance conferences by augmenting conversation partners into a conference room.

Process Effectiveness: Using ARSGs at work could increase an employee's efficiency, as information is always accessible. This is possible, as in times of big data, digitalization, and the 'Internet of Things', products and systems can communicate autonomously with each other and provide employees with relevant information (Lee and Lee 2015). The advantages of ARSGs compared to other forms of devices are threefold: First, only relevant information is displayed. For example, a cook can exclusively take a look at the information about the next ingredients that are necessary for a recipe, rather than being confronted with the whole recipe at once. ARSGs have the ability to recognize in which step of the cooking process the cook is at the moment and what will come next. Besides, ARSGs can help improve the logistical function in supply chains by aiding workers in a retailer's warehouse. Searching for the right products that are requested by a consumer and navigating the worker through the warehouse in the most effective route are just a couple of the popular features associated with ARSGs. Second, information is automatically available when needed and can be enriched with additional online information if desired. For example, designers and engineers can work on collaborative product development projects from virtually any dispersed location around the globe and make changes or alterations to parts of a product or component design in real time, with the changes being made visible to all members of the product development team. If a service technician has problems installing or repairing a machine, additional information can be received by the ARSGs in real-time, or colleagues can join in virtually. Similarly, face recognition could help police officers identify wanted criminals and fugitives and provide themselves with additional information such as criminal records. Third, in contrast to other mobile augmented reality devices, ARSGs can be used hands-free, offering workers greater flexibility. This can be helpful for things such as documentation in medical settings (e.g., forensic medicine), as studied by Albrecht et al. (2014).

3.2 External Value Creation

Companies can also increase value for customers with the help of service functions. Currently, many companies use virtual reality applications. For example, the Swedish furniture chain IKEA offers a 3D kitchen planner on its website in which consumers can plan their purchases virtually. An AR app can extend this experience on tablet computers or smartphones. In a future with ARSGs, this could even go a step further with consumers wearing ARSGs while walking through an empty room and planning their new fittings by placing virtual furniture in a real room. In contrast to mobile AR, ARSGs can provide a much more realistic and hands-free experience. Likewise, consumers with service requests could contact a company via ARSGs. Consider a customer's service request from an automotive company where the customer has problems programming a car's computer. A service representative could then see what the consumer sees and give particular advice on what to do.

3.3 *New Apps as Growth Potentials*

Whereas the aforementioned benefits focused solely on the use of ARSGs in firms, ARSGs also offer the potential for new applications. Consumers tend to be more likely to adopt certain technologies and media when they address particular needs. For example, consumers use social media to obtain gratifications such as entertainment, socialization, self-presentation, information, and others. With regards to ARSGs, there are three clusters of needs that can be addressed by ARSGs applications.

3.3.1 Effectivity Factors

Effectiveness, in this case, describes how 'useful' ARSGs are for consumers by making their life more efficient, and thus address more utilitarian needs and wants. Prior research, such as the widely cited technology acceptance model (Davis 1989), has shown that the perceived usefulness of a new technology is a core determinant of the adoption intention of new technologies (Davies et al. 1989; King and He 2006). In the matter of ARSGs, people who perceive them as a technology that makes their lives more efficient are more likely to adopt them (Rauschnabel et al. 2015a). Other scholars have shown that AR technologies, including ARSGs, can serve as an effective tool to navigate tourists or visitors in museums (Jung et al. 2015; Leue et al. 2015; tom Dieck and Jung 2015). Hein and Rauschnabel (2016) also propose a concept to combine ARSGs with Enterprise Social Networks. Also, consumers who perceive that using ARSGs does not require large mental effort due to their more intuitive and self-explanatory use perceive higher levels of effectivity benefits.

In line with this, commonly discussed applications include navigation systems and organizers. In fact, from a technological perspective, navigation apps could be more effective than common navigation systems since they are able to capture real-world information such as construction-induced speed reductions and detours or provide accurate navigation directions in complex situations.

3.3.2 Hedonic Factors

In simple layman's terms, hedonic factors can be described as 'fun' characteristics. Not surprisingly, people often use a particular form of media for hedonic purposes. These include entertainment, the passing of time, playing games, or escaping from reality. ARSGs offer many opportunities for consumers to receive hedonic benefits. Consider, for example, virtual games that can be played in a real environment. Current computer games are applied in famous environmental contexts depicted in movies such as Tomb Raider or James Bond. Games played on or with ARSGs offer the opportunity to play these games in familiar, real environments. For instance, a

re-launch of the famous Tamagotchi game in the 1990s is possible, where users care about a realistic looking and behaving virtual 'pet'. Likewise, the popular workout smartphone apps could be applied on ARSGs and enhanced to offer additional benefits such as showing joggers the exact directions in the view-field. An important distinction between ARSGs and other technologies (e.g., smartphones or laptop computers) is that they can be used while the user is engaged in some other activity. For example, playing a game on a smartphone or a laptop computer usually requires high levels of a user's physical and mental concentration and thus hinders the development of applications that require a user's physical play. To illustrate, one could consider the idea of an ego-shooter game that can be played in a user's yard or house, in which a user chases enemies in his or her house or garden. Finally, ARSGs can also be used to document one's life and share this content with peers/friends.

3.3.3 Social and Symbolic Factors

Consumer researchers have long known that products or brands that are used in public are linked to social and symbolic aspects (Bearden and Etzel 1982). It is also a well-known finding from fashion marketing that people dress themselves in a manner that allows them to present themselves in a particular way. Augmented reality smart glasses are, as any wearable device, a new form of fashion accessory for users. Thus, psychological similarities between what is known from fashion adoption and ARSGs are very likely, although research in this domain has remained scarce. However, recent evidence suggests that people who believe that their friends and colleagues will adopt the use of ARSGs will also be likely to adopt them (Rauschnabel et al. 2015a).

Also, past experience has shown that users of (new) technologies often form communities, and in these communities, ties between the members are an important determinant of technology adoption (Muñiz and O'Guinn 2001; Felix 2012). In fact, several communities for ARSGs users have already emerged. For example, *EduGlasses.com* is a resource center and online community for educators that use ARSGs in classrooms and other educational settings. GoogleGlassForum.net is another example of an online community that focuses on Google's ARSGs program. These examples enable registered users to engage in discussions about topics related to ARSGs. Research about these online communities has revealed the importance of social factors that drive user participation (e.g., Hennig-Thurau et al. 2004).

Assuming that corresponding apps will be developed in the future, for example, dating apps, ARSGs can be a means to satisfying unmet social needs. These apps offer various benefits as compared to regular online dating websites or mobile apps since users can, for example, see and identify potential partners in real life with ARSGs. Likewise, ARSGs can also help members maintain existing social relationships in a similar manner as social networks. For example, Google promotes the benefits of Google Glass by showing examples where users can identify friends nearby and motivate them to meet in person and by displaying relevant information about their friends (e.g. a person's birthday).

3.4 Customer Interaction

ARSGs also provide numerous opportunities for customer interactions (Javornik 2016b). For example, customers can be supported in after sales service, can review products, and so forth. Consider, for example, a customer entering a showroom at an automobile dealership. This customer can integrate a customer representative in his or her view field (as, for example, discussed in the collaboration section). As in prior stages of the media evolution (see Fig. 1), we propose that apps for ARSGs will arise that allow users to interact with brands—for example, similarly to Facebook brand pages and other forms of social media marketing (Felix et al. 2017). This might probably result in a new discipline 'AR marketing' (Javornik 2016b; Javornik 2016c), and existing offline communication activities (e.g. exhibitions and other marketing events) can be complemented with an AR component.

3.5 Value for Society

When it comes to new technologies, many consumers are sceptical and discuss potential negative consequences of the use of a new technology for society (Fodor and Brem 2015). In the early days of the Internet, it was concluded that using the Internet influenced people negatively, particularly with regards to their social lives and depression (Kraut et al. 1998). Follow-up studies revealed that the initial findings were not as dramatic as proposed (Tyler 2002). Besides potential negative consequences that will be discussed in the next paragraph, various positive effects for society as a whole can emerge.

ARSGs can make rescue teams more efficient, and support medical doctors at work, as discussed above. The use in various settings (e.g. in maintenance and construction work) can decrease user's risks, and thus, contribute positively to public healthcare systems. Although potential privacy concerns exist, ARSGs can be used to record one's environment, and thus help law enforcement personnel with solving crimes. Research has also revealed that ARSGs can facilitate the everyday life of patients with Parkinson's disease (McNaney et al. 2014). Recent discussions about the use of ARSGs in classrooms and education indicate further positive effects on society as a whole.

4 Barriers

Like any technology, the growth of ARSGs might be limited due to some factors. From a technological perspective, the short duration of the batteries, a limited number of applications, missing standards and lack of ubiquitous high-speed internet connection are examples of crucial factors that current are not always

available. However, it is likely that further developments in technology will address these barriers. From a more psychological perspective, users often criticize the design of the extant models, which could be one reason why Google stopped distributing its 'Explorer Program'. Likewise, fear of electro smog, or negative influences on the eyes, are other criticisms that are often discussed among consumers, although current research does not support these fears.

Important to note is also the fact that several legal, ethical and political challenges arise that might hinder the development of ARSGs. For example, wearing ARSGs in public could violate privacy and copyright laws. Both the National Association of Theatre Owners (NATO) and the Motion Picture Association of America (MPAA) have allied themselves in prohibiting the use of ARSGs in cinemas due to concerns regarding movie piracy by illegal recording (Barrie 2014). To reduce potential conflicts with regards to individual privacy concerns, some manufacturers such as Google have announced that they will not develop facial recognition apps, but it might be a matter of time until other developers program such applications.

Manufacturers of ARSGs also advertise the benefits of using ARSGs as navigation systems. Whether this distracts drivers and provides a risk for other traffic participants, however, is yet unknown. Analogous to older technologies, people might criticize that the use of ARSGs could make society less social. For example, the popular Walkman-Effect describes the criticism surrounding Sony's portable cassette player in the 1980s, where people were afraid that Walkman users would become distracted in everyday life. Regarding health issues, potential concerns are addictive ARSGs usage behaviors.

Not surprising is the fact that, due to public criticism (e.g., privacy concerns), not all people perceive ARSGs in a positive manner (Fodor and Brem 2015). In particular, the user image of ARSGs is often expressed in a negative way. In online discussion boards, many users call smart glass wearers 'glassholes'.

5 Conclusion

In this chapter, we addressed an innovative topic that has the potential to be very influential in research, companies, and in general for the creation of new business models: Augmented Reality Smart Glasses (ARSGs). Therefore, we started with a definition and integration of ARSGs into the current media and technology landscape. According to this, ARSGs are the logical next step of media development as they combine wearable devices with AR technologies. In line with this assumption, various forecasts predict high growth rates within the next few years, and thus indicate that ARSGs could be the next 'big thing'. Whereas most research on technology and new media investigates research questions of existing devices or applications, the aim of this research was to discuss a new and promising technology in the very early stage of development. Therefore, we provide relevant definitions, and discussed potential success factors of ARSGs adoption. We hope

that these discussions stimulate managers in considering ARSGs for their business and for scholars to place emphasis on this new and promising technology—both as a research tool and as a research topic. As a research tool, ARSGs can offer new ways for data collection or presentation (e.g. stimuli in experiments). As a study object, ARSGs can make use of theories from numerous disciplines, including marketing, MIS, operations and supply chain management, innovation management, media/communication research, psychology, and so forth. Finally, we conclude with a call for policy makers to be aware of the characteristics of ARSGs and the need for corresponding laws and regulations—ideally, before ARSGs become more ubiquitous in the general population. Policy makers have underestimated the power of former technologies and media, such as mp3 s, cellphones, drones and so forth. Starting to develop regulations for ARSGS in a pre-mass market stage might reduce uncertainty among consumers and legal consequences.

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