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AUGMENTED REALITY SMART GLASSES IN THE CONSUMER SECTOR: CURRENT STATUS AND CHALLENGES

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Abbreviation List

AR	Augmented Reality
ARSGs	Augmented Reality Smart Glasses
CEO	Chief Executive Officer
i.e.	id est
MR	Mixed Reality
n.d.	no date
TAM	Technology Acceptance Model
VR	Virtual Reality

Abstract

This paper addresses the current status and challenges of Augmented Reality Smart Glasses (ARSGs) in the consumer sector. It describes the penetration of the technology in the consumer market, and the prospects of the devices to dominate the market in the long run. While ARSGs are already widely used in industrial contexts, they have not yet been able to establish themselves in the consumer market. A look at the literature, a survey of potential consumers and interviews with experts in this field reveal that the device will not replace the smartphone in the next few years. There is no unanimous view amongst the interviewed experts regarding the breakthrough potential of ARSGs and the timing of its potential breakthrough. The conducted survey shows that the majority of respondents are aware of the technology, but only a minority have used it.

Keywords: Augmented Reality, Augmented Reality Smart Glasses, AR, Consumer Market

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1. Introduction

ARSGs have been present in the media for a couple of years and several big companies are active in the field. In the industrial sector, the advantages of ARSGs have been recognized and they are deployed across multiple use-cases. In the consumer sector, the attempts to establish ARSGs have failed so far. Although discussions on ARSGs are present in the media, empirical research focusing on ARSGs in the consumer sector is scarce. The thesis aims to contribute to the research, addressing the topic across six chapters.

The first chapter of this research introduces the research topic.

The second chapter provides a literature review across two sub-chapters, 2.1 Augmented Reality (AR), and 2.2. Augmented Reality Smart Glasses.

The third chapter covers the methodology of the research. The methodology consists of two research elements, a survey and expert interviews.

The fourth chapter contains the research results and findings from both research elements. First, the author introduces the survey and the results. Second, the author introduces the experts and presents the interview outcomes, in the form of common themes.

The fifth chapter covers the analysis and discussion. It consists of two sub-chapters, 5.1 current state of ARSGs, and 5.2 future development of ARSGs.

Finally, the sixth chapter concludes the research and identifies opportunities for further research.

2. Literature Research

2.1 Augmented Reality

2.1.1 Differentiation between Augmented Reality, Virtual Reality and Mixed Reality

Augmented Reality (AR) is “an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device” (Merriam-Webster, n.d.). It integrates computer-generated virtual objects into the scene and make them appear as if they exist. The objective is to design a system where the user “cannot tell the difference between the real world and the virtual augmentation of it” (Vallino and Brown 1998, 5). It keeps the user in the physical world but overlays the field of vision with digital content through wearable or handheld systems (BCG 2021).

Virtual Reality (VR) “is an advanced, human-computer interface that simulates a real environment” (Zheng et al. 1998). It completely immerses a user inside a virtual environment, where the user cannot see the real world around him or her (Kipper 2013). Unlike VR where the physical world is completely hidden, AR does not create a new world, but expands and enhances the existing environment. AR unfolds its potential when the real environment is to be seen further but extended by digital information (Bitkom 2021a).

Mixed Reality (MR) is everything that lies between a completely real and a completely virtual environment and accordingly represents a combination of the two (Bitkom 2021a). By merging AR and VR, MR enables interaction with digital objects in the physical environment (BCG 2021).

2.1.2 Current State of Augmented Reality

The potential of AR has been hyped for the past years. Recently there have been several AR-related announcements and investments from tech giants like Apple, Microsoft, and Facebook. Research providers expect to see a considerable growth over the next decade. A compound annual growth rate of 50.6% was forecasted for AR and VR. By 2027 this market is estimated to grow from the current $28.2 billion to $165.3 billion (Vynz Research 2021). The largest market size from 2021 to 2026 accounts to the consumer market with 53% (IDC 2020). The thriving gaming, entertainment as well as sports sectors are predicted to advance the utilization of AR technology in consumer applications (MarketsandMarkets 2021).

As computing power and hardware have improved, AR has moved from the theoretical research phase to the industrial application phase (Chen et al.) According to the Gartner's Hype Cycle, AR is no more considered an emerging technology and is set to move from the pilot phase to productivity in the enterprise space (Institute for Immersive Learning 2021). That means that AR and VR are already available on the market as technically mature technologies for commercial use and that companies are generating revenues with them (Panetta 2019).

2.1.3 Consumer vs Industrial Augmented Reality

Current discussions about ARSGs seem to be going in one of two directions. On the one hand, into the consumer direction, and on the other hand in the industrial direction.

In the consumer sector it has the potential to simplify daily activities, such as searching, navigating, or shopping. AR for consumers depends on a good form factor, high comfort, and beautiful design. It is portrayed as cool and fun and is still regarded as a niche product (Liao and Iliadis 2021).

Moreover, several industry experts believe that ARSGs have the potential to replace the smartphone (Leswing 2021).

In the industrial sector, it is a tool for workplaces to complete tasks, analyse data and make decisions. The benefits of industrial AR are rather of practical nature. Industrial AR emphasizes increasing efficiency, saving time, and enhancing effectiveness (Liao and Iliadis 2021). In the industry sector, it has been maturing for several years where the demand is growing steadily.

2.2 Augmented Reality Smart Glasses

ARSGs are "wearable Augmented Reality devices that are worn like regular glasses and merge virtual information with physical information in a user's view field" (Rauschnabel et al. 2015, 6). In 2020, sales of ARSGs reached 20 thousand units. It is expected to increase to 40 thousand units by 2021, before rising significantly to 1.59 million units by 2024 (ARtillery Intelligence 2021). According to Strategy Analytics, global smartglasses revenues will increase by 11% in 2022 (Mawston and Waltzer 2021). Several experts expected 2020 to be the year of ARSGs due to the COVID-19 pandemic (Subin 2021).

In recent years, the smartphone has replaced many products. From MP3 players to navigation devices and digital cameras. Everything is now available in one device, without any lack of quality. Tim Cook, the Chief Executive Officer (CEO) of Apple believes AR is as revolutionary as the smartphone once was (Weddeling 2018). The CEO of Facebook, Mark Zuckerberg expects smartphones to be the primary device most of this decade but believes there will be a breakthrough with ARSGs that will redefine our relationship with technology (Von Musser 2021).

The number of smartphones sold to end users worldwide has continuously declined from 2018 until 2020 but has grown again by 11% in 2021 (Gartner 2021a). While the reason for this could be

explained by the interplay of delayed smartphone replacements due to the COVID-19 pandemic and the availability of 5G smartphones in the lower price segment (Gartner 2021b), others like DJ Koh, the former CEO of Samsung, assume this could be related to the fact that the era of the smartphone is coming to an end and that the smartphone will ultimately be replaced by wearables (Neumann 2021).

2.2.1 Augmented Reality Smart Glasses Players

The first step in the direction of ARSGs for the consumer market came in 2014 when Google Glass hit the market. The hype was huge, but the device failed, and Google took Google Glass off the market after less than a year. There are several reasons why the device failed. Firstly, their clunky design and the camera were perceived as a threat to privacy (Bezmalinovic 2021).

Secondly, Frydenberg, a professor at Bentley University, stated that the device was not ready for the mass market due to technical issues. The device shut itself down, overheated often, had a short battery life and only limited apps available (Bentley University, 2021).

Thirdly, according to the New York Times, the intense promotion of Google Glass and the hype surrounding the product played a big role in the sudden demise of the device (Bilton 2015). Finally, the product price of $1500 was expensive and the use-cases of the glasses were not clear to consumers (Phan 2021).

Two years after the launch of Google Glass, Microsoft and Magic Leap launched their respective ARSGs, Microsoft HoloLens and Magic Leap One. However, they were unable to establish themselves in the consumer market due to their high price and bulky design. Accordingly, they shifted focus towards the industrial market (Bezmalinovic 2021; Roettgers 2019).

To lower the price and make ARSGs appear less bulky, developers started to rely on more minimalist technology. Snap Spectacles sunglasses were launched and are aimed at users of the Snapchat messaging service. They have an integrated camera that films 3D videos from the viewing perspective and adds AR effects. The glasses can take photos, but not much else (Phan 2021). The fact that the glasses cannot do much means they do not need much processing or battery power, which makes them smaller in terms of design and keeps the price down. In 2021, the start-up Nreal launched ARSGs named Nreal Light for around €600. They offer similarly sophisticated technology as HoloLens and Magic Leap, but in a compact form. Nreal Light has been called the first everyday ARSGs for end users on the market (Bitkom 2021b).

Facebook unveiled its smart glasses in partnership with Ray-Ban in September 2021. They are minimalistic in terms of technology and lack AR but can take calls and videos. The partnership with Essilor Luxottica is of great importance as it makes the model stylish which was missing by the rest of the ARSGs on the market. Moreover, they are offered for $300. Monika Perkash, a product director of Facebook said they are “building towards AR glasses as the next computing platform” (Gurman and Nix 2021).

Xiaomi also launched its own smart glasses. Compared to the glasses of Facebook, they can also display messages, and translate text right in real time (TechCrunch 2021). Apple's ARSGs are in development and are expected to launch in 2022. Given Apple's experience in developing compelling wearables in the past and its ability to build ecosystems around these devices, it is believed that they will take the lead in consumer ARSGs. In addition, Apple will also benefit from its large number of engaged users and consumer perception of being more privacy-friendly than many of its competitors (GlobalData 2021).

2.2.2 Benefits of Usage

AR offers several benefits, first and foremost user happiness. According to the research of Mochón, technology can have a positive impact on well-being, although it is important to learn to moderate its use (Mochón 2018). Rauschnabel and Ro analysed that at this early stage of the product life cycle of ARSGs, functional benefits appear to be the primary factor consumers are showing interest in it (Rauschnabel and Ro 2016).

In research conducted in 2017, the top benefits of ARSGs over a cell phone were that the user does not need to look down, one can follow instructions without having the need to hold onto a device, being able to view entertainment in a completely new way, and multi-tasking more efficiently with both hands free at all times. On the other hand, almost one third of respondents answered that none of these benefits appeal to them (Various sources 2017). In the conducted survey of the author, these advantages were included and supplemented by others (see appendix 1).

Moreover, AR can assist customers in getting a more precise picture of how a product will both look and feel. By being able to show products with AR in greater detail, customers can already more clearly see what they are buying before they make a purchase. This makes it easier to meet customer expectations, which ultimately leads to high customer satisfaction, customer loyalty, and positive word of mouth (Berman and Pollack 2021, 622; Bulearca and Tamarjan 2010).

Poushneh and Vasquez-Parraga found out in their research, that AR can considerably influence user experience (UX) in a positive way (Poushneh and Vasquez-Parraga 2016). As Berman and Pollack put it together, benefits of AR are functional in the sense of time saving, practical, convenient, a short response time, high quality of information and interactive but also emotional

through increased trust, aesthetic quality, media enjoyment and user satisfaction and thus create an increased willingness to purchase (Berman and Pollack 2021, 622).

2.2.3 Barriers to Adoption

According to Chen et al., size and price of ARSGs do not meet the demand of the public yet. As stated in a survey by Perkins Coie et al. in 2020, the top obstacles to mass adoption of AR are a poor UX through bulky hardware, lack of quality content, the consumer reluctance to embrace the technology, financing and investment, cost to consumers, and the government oversight. Moreover, for ARSGs to be used in everyday life, they need to be comfortable and offer clear added value which was not the case so far on the mass market (Bezmalinovic 2021).

The ordinary consumer does not realize the impact this technology can have on his or her daily life. There are also technological barriers like a limited battery power, accuracy of sensor function, and field of view (Van Krevelen and Poelman 2010). In addition, legal, ethical, and policy challenges may arise that could constrain the movement of ARSGs, e.g., wearing ARSGs in public could violate privacy and copyright laws (Rauschnabel et al. 2017).

2.2.4 Technology Acceptance Model

The technology acceptance model (TAM) is a framework to describe the intentions and actions of prospective consumers regarding the acceptance of technologies. Davis developed scales for the variables “perceived ease of use” and “perceived usefulness” of technologies (Davis 1989). The model predicts that the perceived ease of use of a technology influence the users’ attitude towards the acceptance of the technology. This in turn affects the willingness to adopt to the technology (Davis 1989; Rauschnabel and Ro 2016). In 2016, Rauschnabel and Ro analysed the technology acceptance drivers based on the TAM regarding ARSGs. They wanted to find out how ARSGs are

perceived from potential users and what the driving forces and obstacles of potential users are. They found out that knowledge about ARSGs is relatively high and that male participants have higher knowledge of ARSGs. They describe that the technology is still in the "early stages of technology diffusion." Therefore, they assume that the likeliest adopters are innovators and early adopters (Rauschnabel and Ro 2016).

2.2.5 Five Media Framework

To understand the difference between ARSGs and other media devices, the framework of media generations is used. According to the framework, media devices have gained more influence on the consumer's life over the years. A distinction between five generations is made: offline, Web 1.0, Web 2.0, Mobile Social Web, and wearable AR (see appendix 2).

The framework starts with the first generation termed as offline media such as newspapers and television. This generation is characterized by its focus on stationary technologies. The second generation, referred to as Web 1.0, describes the early online technologies. The role of consumers in this media generation was rather passive, i.e., they usually consumed content produced and published by companies. The third generation, which began in the early 2000s, is called Web 2.0 where social media is defined "by complex and multi-directional communications". An example of Web 2.0 is Facebook where users act as both consumers and producers of content. The reason users were willing to experiment with Web 2.0 was a faster internet connection, higher device usability, and higher levels of trust and acceptance of the Internet. With the fourth media generation, social media moved from static devices to mobile devices such as smartphones, and smartwatches. These mobile technologies allow users "to have access to their 'social media environment' anytime and anywhere" (Rauschnabel et al. 2015).

The difference between the Web 2.0 and the Mobile Social Web is that it is no longer stationary, but users could take the device with them. The fifth generation under which ARSGs fall are wearable AR devices, i.e., wearable technologies that merge virtual and physical realities. According to the framework, ARSGs are the logical next step of media development, because they combine mobility with AR technology (Rauschnabel et al. 2015).

3. Methodology

Since the research topic is rather new and only limited research is available, an inductive research approach is utilized. Consequently, the motivation of the research is to create new insights into the field of ARSGs (Saunders et al. 2009). To leverage the benefits of both qualitative and quantitative methods, the author conducts two separate research pieces, a survey, and a set of expert interviews. A quantitative method is applied for the survey and a qualitative method is applied for the expert interviews. The survey focuses on potential consumers and the interviews are arranged with corporate experts in the field of ARSGs. The author conducts the survey first and the expert interviews afterwards, a research design referred to as explanatory sequential mixed methods (Creswell and Creswell 2018). The research design allows the author to get a clear understanding of the research question, combining information from both sources.

4. Results and Findings

4.1 Survey Results

84 people participated in the survey. The following tables give an overview of the findings of the survey. First, the results on the general findings are shared: (1) what is your gender, (2) how old are you, (3) where do you live, and (4) what is your highest high school or college degree. Followed

by the results regarding the ARSGs specific findings, covering (5) knowledge of what ARSGs are, (6) usage of ARSGs, (7) benefits, (8) barriers and (9) the willingness to pay.

4.1.1 Demographic Findings

Question	Response					
(1) What is your gender?	Male	Female	Diverse	/	/	/
	37	47	0			
(2) How old are you?	11-25 (Gen Z)	26-41 (Gen Y)	42-56 (Gen X)	57-75 (Baby Boomers)	/	/
	11	35	19	19		
(3) Where do you live?	Europe	North America	South America	Africa	Asia	Australia
	83	1	0	0	0	0
(4) What is your highest high school or college degree?	Less than a high school diploma	High school diploma or equivalent	Bachelor's/ Master's degree	PhD degree	Prefer not to say	Other
	0	18	61	1	3	1

Table 1 General Findings | own table based on survey data in number of participants

4.1.2 AR Specific Findings

Question	Response		
(5) Did you know (before watching the video) what augmented reality smart glasses are?	Yes	No	/
	55	29	
(6) Have you ever used augmented reality smart glasses?	Yes	No	Not sure
	15	67	2

Table 2 AR Specific Findings | own table based on survey data in number of participants

When dividing the age groups in Generation X, Y, Z, and Baby Boomers, it turns out that more than 70% of Gen X, Y and Z have known before doing the survey what ARSGs are. Compared to Baby Boomers where only 32% knew prior to the research what ARSGs are. If one goes a step further and looks at who has already used ARSGs, you find that the two youngest generations Gen Y and Gen Z are the most likely ARSG users, with a share of over 25%. Behind them comes Generation X with 16% and at the very back Baby Boomers with 0% (see appendix 3). A survey

on statements about technology affinity and knowledge in 2020 also found that younger generations prefer to try out new technical devices and are more familiar with them than older generations which could explain these results (VuMA 2020).

(7) Do you see any benefits for yourself in using augmented reality smart glasses?

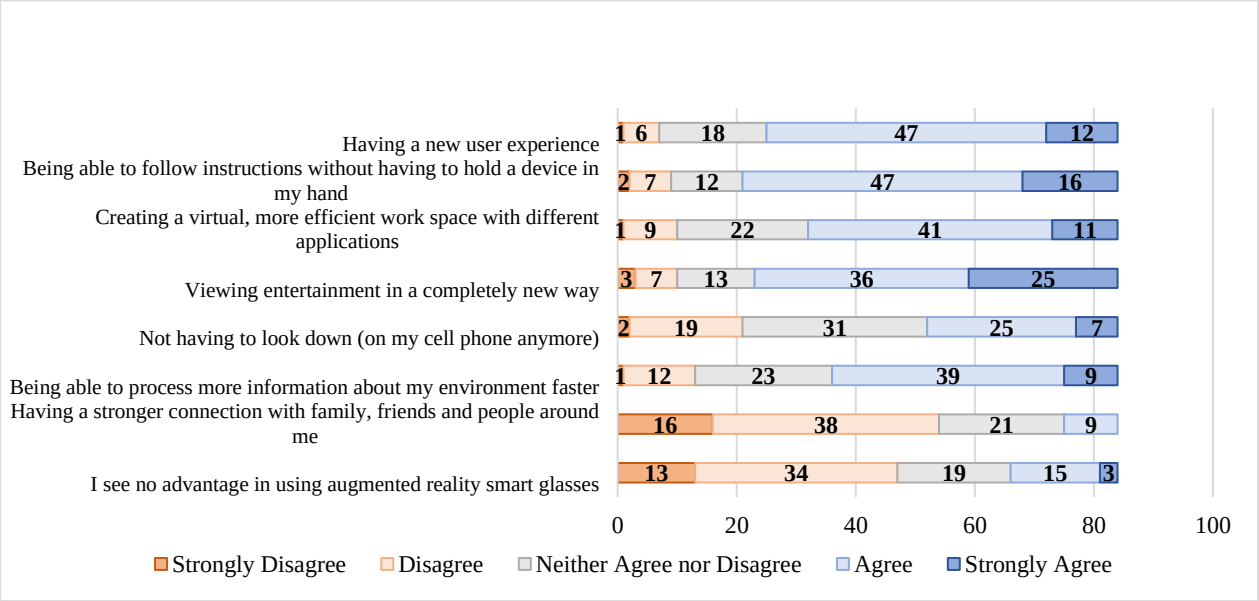

Figure 1 Benefits of Augmented Reality Smart Glasses | own figure based on survey data in number of participants

The Likert scale was used to measure the respondents' attitude towards the usage of ARSGs to find out in detail where they rather see benefits and barriers for themselves. There are five aspects that the participants rather see as benefit for themselves in using ARSGs: (1) viewing entertainment in a completely new way, (2) being able to follow instructions without having to hold a device in my hand, (3) creating a virtual, more efficient workspace with different applications (4) having a new user experience and (5) being able to process more information about my environment faster.

It turns out that viewing entertainment in a completely new way is especially important as almost 30% strongly agree here. On the other hand, the majority does not see it as a benefit that one could have a stronger connection with family, friends, and people around oneself. Also, the advantage of no longer having to look down on a device is not considered a strong advantage.

(8) Are there any reasons why you would not buy augmented reality smart glasses?

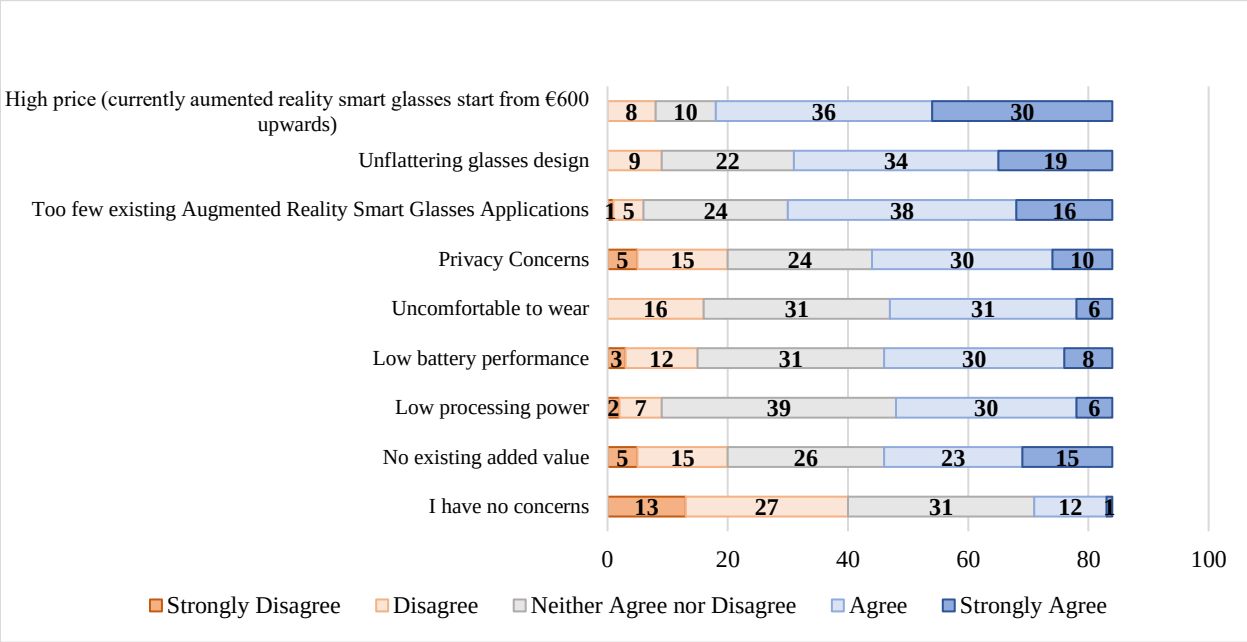

Figure 2 Barriers of Augmented Reality Smart Glasses | own figure based on survey data in number of participants

The most important aspects of why participants would not buy ARSGs is the price of €600. It is considered as too expensive. Also, more than 50% believe that the glasses have an unflattering design and that they have too few existing AR applications. 45% assume that the glasses provide no added value.

(9) How much would you be willing to pay for augmented reality smart glasses?

Figure 3 Willingness to pay for Augmented Reality Smart Glasses | own figure based on survey data in number of participants

When asked how much they would be willing to pay, it emerged that 7% would not be willing to pay anything. 28% answered that a price up to €200 is reasonable. 38% perceive a price between €200-€400 as appropriate. 18% would be willing to pay between €401-€600, 2% are willing to pay between €801-€1000 and only 1% would be willing to pay more than €1000.

4.2 Expert Interview Results

The second research element is a set of five qualitative expert interviews. The experts are from the telecommunication industry and the AR manufacturer industry.

4.2.1 Introduction to the Experts

The author spoke to Michael R. (M.R.), Yiwen W. (Y.W.), Christopher L. (C.L), Gordon R. (G.R.) and Sebastian K. (S.K.). A detailed overview of the experts, including their institution and job title can be found in appendix 4.

4.2.2 Interview Results

The expert interviews reflect the state of ARSGs at the current moment and the future. In many areas, the industry is in the early stages of an expanding development, in which the experts expect further large innovative leaps over the coming years. The results span across seven categories: (1) ARSGs in the consumer sector vs. industrial sector, (2) AR vs. VR, (3) benefits of ARSGs, (4) barriers of ARSGs, (5) target groups, (6) ARSGs as replacement of the smartphone, and (7) outlook into the future. The detailed questionnaire can be found in appendix 5.

4.2.2.1 ARSGs in the Consumer Sector vs. Industrial Sector

There is widespread agreement among the interviewed experts that ARSG technology makes an important contribution in the industrial sector in machine maintenance and in the context of warehousing (C.L.; G.R.; S.K.). Less skilled workers can be successfully guided and used more efficiently in this way (Y.W.). Its use is also valuable in health care (C.L.). Necessary measures become more transparent, the repairs more efficient and it exists high savings potential (G.R; S.K.). An estimated one million devices are used in the enterprise sector. Many companies operate

predominantly traditionally and use the ARSGs at best on a trial basis in certain sectors. The volume of business is therefore limited (G.R.). All experts believe that the device has not established itself at all in the consumer sector yet. Nreal established itself as a pioneer in the AR industry for the consumer market. In the consumer-oriented sector, Nreal does not only compete with AR headsets, but also with VR headsets (Y.W.).

4.2.2.2 AR vs VR

The field of VR is very popular among consumers. The devices have great image quality but are primarily for stationary use; in terms of their target direction, they are primarily geared toward the gaming and training sectors. The AR sector offers significantly more creative application possibilities due to its mobility. Mobile communications companies also have an interest in offering consumers a larger volume of data via 5G, which they can and want to access at any time (S.K.).

4.2.2.3 Benefits of ARSGs

Compared to smartphones, ARSGs provide more information with a better three-dimensional display on a larger screen. There is also the possibility of interacting with the environment. ARSGs combine the real with the virtual; the device offers the possibility not only to look at the virtual objects, but also to interact with them. The user can give a lot of room to creativity when using them (Y.W.). If one has ever used ARSGs, a user will quickly realize that the device offers great advantages because one does not have to look at the smartphone all the time. The user also has his hands free, and the use and processing of information is simple (S.K.).

The advantages associated with the use of the glasses must be made clear to the consumer. An example in this context is the dedicated cooking application, called Vodafone Giga AR. Another advantage of the glasses is the 2D-Screen content where one can watch movies with the ARSGs.

It is better to see a 2-meter-screen in front of you than to watch a movie on your smartphone (S.K.). ARSGs bring an improvement in the daily life and make it more efficient e.g., through letting appointments pop up without having to look at a watch or a smartphone. In the sport sector, various athletes and sports coaches have said this is the factor they need to ensure the focus on the sport. The Head of the Red Bull Athletes Performance Centre said she would even classify the technology as "technical doping" because it gives the user an advantage (M.R.).

4.2.2.4 Barriers of ARSGs

All experts believe that the devices are not attractive to end consumers due to the clunky and unwieldy hardware, the high price, the limited functionality, and the neglected design. There are deficits in computing power, display technology, connectivity, and power supply. Using a huge helmet that guarantees a sufficient power supply for good computing performance is not practical. The format of a Ray-Ban would be considered progress since the external impression is not disturbing. In this context, the problem remains that not all consumers wear glasses. It is doubtful whether the use of a contact lens can be considered as an alternative since a three-dimensional reproduction cannot be safely guaranteed in this way.

Furthermore, various manufacturers have closed ecosystems for their glasses. It is necessary to adapt the apps so that they run on different systems. Since the input systems differ from each other, the transfer remains problematic. Especially as a developer one has to decide whether to build for the one or the other provider (S.K.). Potential users need to get the opportunity to try out innovations to get them to rethink. Most people have smartphones whose potential they are not exploiting. Henry Ford's quote "If I had asked people what they wanted, they would have said faster horses" still holds true. Providers would have to allow customers to try ARSGs out for a short time

before they would have to commit to them, but this comes with a big investment. On the example of smartwatches one can see that they did not catch on initially because the battery life was short, and the added value was not readily apparent. Investments are only made once people are convinced that the product has an advantage. The price for the ARSGs should therefore be under €400. Furthermore, the constant concentration on the display can impair the eyesight in the long run (G.R.).

It can also lead to attention deficiency, e.g., if a consumer is driving a car and at the same time reading text messages, this is distracting and can lead to dangerous situations that should be avoided by imposing strict conditions. Moreover, the user will spend even more time online. With the smartphone, the barrier is that the user has to get it out of the pocket first and then look at it, but with glasses, it would be even more normal to constantly wear them (S.K.). ARSGs are not comfortable to wear for a long period of time. Currently, there are no comfortable ARSGs whose design is appealing to consumers. There are serious obstacles to overcome: Housing a powerful battery, an operating system and the necessary sensors in a headset leads to weight problems. Supply chains have to be maintained. In addition, there is no cross-platform support between different devices. Institutes are needed that connect manufacturers and enable cross-platform use (Y.W.). Moreover, the existing glasses are still dependent on smartphones (C.L.). There is the concept of "distracted reality", meaning that if the user is wearing these glasses all the time, things might blend in. The user could say he or she does not want to see certain things. In the worst case, someone could blend out certain population groups and make them as he or she want (M.R.).

4.2.2.5 Target Group

All experts agree that at present, the main target are early adopters with an affinity for technology. The consumers predominantly have the desire to try something new (Y.W.; M.R.). The broad mass market is not yet involved however, the number of applications will increase (C.L.). The market for Nreal products is likely to be primarily in Asia for the time being. The company is not big enough to have a global presence at the same time. Nreal Light is more of a device for high-tech enthusiasts. In contrast, Nreal Air is primarily intended for the public. Sales in the consumer segment will therefore be much greater (Y.W.).

4.2.2.6 ARSGs as Replacement of the Smartphone

The market for ARSGs is tricky. It is important not to get too far ahead of the trend. When Google announced Google Glass in 2014, consumers were just getting to smartphones. Meanwhile, the right time has already approached. Within the next five years, the Asian market should be ready for the new high-tech products (Y.W.). Whether ARSGs can and will replace the smartphone remains to be seen over the next few years. Smartwatches, for example, have become established as a product over time after initial problems (C.L.).

Smartphones today are sophisticated, similar to each other and determine the everyday life of individuals. Consumers are therefore open to new products with creative aspects. If Apple launches ARSGs, it will have a major impact on the industry. However, ARSGs will probably not be able to replace the smartphone within five years; the latter will continue to be needed for power supply and data processing. The device is not yet a replacement for a smartphone; rather, it provides additional and more intense experiences. However, ARSGs could become mainstream without completely displacing the smartphone (Y.W.).

The smartphone will lose its dominant position in the next few years and be replaced or at least supplemented by other media. In the next 5 to 10 years, technology will move away from the smartphone (G.R.). In the long run, the glasses will replace the smartphone if the functions are completely covered. This could be made possible via a cloud that provides the computing power within the framework of 5G, the glasses could then look quite normal (S.K.). Vodafone was the first company to show a handheld AR application in the stadium and that can track soccer players. It is an unnatural scenario for someone sitting in the stadium holding a smartphone in front of them and looking at the real world through that smartphone. At the end of the day the user wants to improve what he would see. This is not possible with a smartphone, but with ARSGs to make the improvement liveable. Otherwise, it is not an improvement, but something that stands between the user and reality (M.R.).

4.2.2.7 Outlook into the Future

There is agreement that the influence of the companies dominating the market on further developments is extraordinarily great. The behaviour of Apple, Google and Facebook will be decisive in determining whether a new technology will prevail on the global market. The price of the glasses will play an important role. €600 is too high for the youthful target group. In the future, it is important to create a platform that develops cases in the areas of entertainment, sports, and education that enhance the experience of the user (C.L.). Strategically, one should not focus on the form factor "glasses". Not every consumer wear glasses (G.R.). When Facebook introduces its new project to the market, big companies like Apple and Google will join and increase the general acceptance. Apple, as the market leader, will place a pair of glasses on the market in five years at the latest and ensure the breakthrough as they will eventually offer an interesting “total package” for its users. (S.K.; Y.W.).

This year, Nreal Air will be launched on the market. The product will have fewer functions than the Nreal Light model. Nreal Light was intended to show what was possible with ARSGs. Nreal Air, on the other hand, is intended for a wider audience, i.e., the real end user. The price is lower and is intended to encourage consumers to try a new product. Nreal created a fashionable design at an affordable price. Not using cameras has nothing to do with the privacy aspect, but mainly to improve the design. The glasses are easier to wear outside as they resemble regular sunglasses (Y.W.).

In 2025 we will no longer be operating with a flat display but will be equipped with a new tool that will change the smartphone. In a stadium, for example, you will no longer want to look at a cell phone or tablet to check game situations. In this situation, it makes sense to use glasses that can enrich the real image with additional information (M.R.). In the long run, ARSGs should be wearable anytime and conveniently, provide users with more information and innovative experiences, and enable more efficient work (Y.W.).

5. Analysis and Discussion

This chapter contains the analysis and discussion of the theoretical background from chapter 2 and the results and findings from chapter 4. The chapter is divided into two parts: (1) current state of ARSGs, and (2) future development of ARSGs.

5.1 Current State of Augmented Reality Smart Glasses

ARSGs are an innovative technology, which is still in the early stage of its development. Although the first ARSGs were initially launched in 2014 as a consumer device, ARSGs have disappeared from the consumer market in the meantime and have mainly been used for industrial use-cases

since. By now, several ARSG players have emerged on the consumer market and further ones are to come.

One key driver, making AR a promising technology is its ability to keep the user in the physical world but overlays the field of vision with digital information. This makes it a technology that has an advantage in everyday life and is not solely focused on a stationary context like VR devices. Experts agree that the application focus should be in the field of AR, as these products are mobile and offer more application possibilities. They also agree that the current group of ARSG-users consists of early adopters and tech geeks who like to try new things. This has also emerged from the research of the TAM. Back in 2015, it was assumed that only early adopters would be interested in the technology, which is still the case today. All experts see great potential in the AR sector due to the mobility factor. In comparison to AR, it must also be considered that VR is already relatively mature and highly developed, especially in the gaming sector. So, there is also more potential in the AR sector in that sense, because it is still quite at the beginning of its maturity in the consumer sector. The five media framework describes the usage of media generations and the influence on the consumer's life. It is precisely the factor of mobility that is significant. It is questionable whether we have already arrived in the fifth generation. According to the interviews and the survey, the answer to this is no. So far, there are still too many barriers to advancing into the fifth generation.

Like every new technology, ARSGs entail a set of benefits and challenges. The benefits of ARSGs from literature include increased happiness, functional benefits, getting a more immersive and realistic UX. Moreover, the top benefits of ARSGs over smartphones were not to have the need to look down, following instructions without having the need to hold onto a device, being able to view entertainment in a completely new way, multi-tasking more efficiently with both hands free at all

times. According to the conducted survey, especially the aspect of viewing entertainment in a completely new way is seen as important. Not having to look down on a smartphone is not considered to be a game changer by survey participants.

The challenges of ARSGs from literature include size, price, bulky hardware, lack of quality content, the consumer reluctance to embrace the technology, regulation and legal risks, financing and offer a clear value to consumers. According to the conducted survey, the most important aspects of why participants would not buy ARSGs is the high price of €600. It is considered as too expensive. Also, more than 50% believe that the glasses have an unflattering design. The younger the generation, the more they seem to value the look of the glasses. Over 70% of Gen Z sees it as a reasoning why they would not buy ARSGs compared to only 50% of the Baby Boomers.

5.2 Future Development of Augmented Reality Smart Glasses

In recent years, the smartphone has replaced many products from navigation devices to digital cameras. Several influential business leaders assume that AR is the next big thing. Smartphones are mainstream now but there will be a breakthrough with ARSGs that will redefine our relationship with technology. It is no longer a matter of offering what is technologically possible but offering a version of ARSGs that brings the right density of functionality and battery. When comparing ARSGs players, it is noticeable that the scope of function influences the scope of form. ARSGs will be equipped with less technology in the future to address other aspects that are important for the mass market. This can be shown with the example of Nreal. The new product Nreal Air will have fewer features than the first model Nreal Light. Nreal Light was intended to show what is possible with ARSGs. Nreal Air, on the other hand, is intended for a broader audience, considered to be 'the real end user'. The price is lower and should encourage consumers to try a

new product. The question whether the glasses can and will replace the smartphone unveiled different views and is not to be answered with certainty today. Some of the interviewed experts believe the glasses will replace the smartphone, while others think they will always coexist next to the smartphone and that the smartphone will continue to play a supporting role. There is also a discussion whether the form factor is the right one, or whether the technology would have to evolve from glasses to contact lenses to become mainstream. Most of the interviewed experts share the view that Apple will play a major role in determining whether the glasses become mainstream.

6. Conclusion and Future Research

The survey showed that especially the older generation does not know what ARSGs are and only 17% of all participants have used ARSGs before. This aligns with the view of the interviewed experts, who assume a small interest group of early adopters. While the interviewed experts do not agree on the timing of the ARSG breakthrough, they share the view that there are still many barriers to overcome before ARSGs reach wide adoption on the consumer market and that Apple has the potential to play a big role in shaping the future of ARSGs.

There is a current pattern of ASRG players decreasing the scope of their glasses to tackle two of the main challenges, the high price point, and the unattractive, sometimes chunky form factor driven by computing and battery power. The interviewed experts and the majority of survey participants agree that the price of €600 is too high and that a price below €400 would be more appealing to consumers. Yet, regardless of product pricing a large amount of the potential users does not understand the value of ARSGs today and will have to be educated about the benefits of the technology in order to be won over.

From a development perspective, during the first phase when Google Glass, Microsoft Mesh and Magic Leap launched their products, the devices were still too expensive for the consumer market, there was not enough content and potential users did not see the benefit in ARSGs. As a result, the strategy of many players changed and therefore in a second phase, players focused on reducing the scope of functionalities to be able to offer cheaper devices, such as Snap Spectacles. These glasses can be purchased at a low price and thus give the user a small insight into the new technology. In the third phase, players launched devices that offer a good scope of functionality for a reasonable price, moving them somewhat in the middle of the first two phases.

Nevertheless, the price appears to be rather high to do justice to the consumer market and the benefits must be better presented to potential users. That is why Nreal has decided to launch Nreal Air as a new model, which has less technology and can therefore have a rather discreet design and a cheaper price. As early as 2016, in the research of Rauschnabel and Ro, it was stated that only early adopters were interested in the technology. The conducted survey and the interview experts seem to still see it that way at the present time in 2021. The challenges are still existing, with users not understanding the added value and the price point is too high to try something new. ARSGs are still mostly targeted at early adopters to build brand recognition and demonstrate the technology's capabilities in the consumer sector.

The presented research has a couple of limitations that can be addressed in future research. The survey results are focusing on European consumers. Same is true for the conducted interviews. In addition, the survey and the expert interviews only reflect a point-in-time analysis and do not provide insights into a change of ARSG implementation over time. Given the fact, that the economic impact of COVID-19 is still significant, it could be interesting to revisit some of the research contents when the effects of the pandemic have toned down.

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Appendix

Appendix 1: Survey Questions

Current Status of Augmented Reality Smart Glasses in the Consumer Market:

Dear participant

this survey is part of my master thesis of the management master program at NOVA School of Business and Economics in Lisbon, Portugal. The purpose of this survey is to gather insights into consumer perceptions regarding augmented reality smart glasses. The survey will take approximately 3 minutes to complete. Participation in the survey is voluntary. All information provided will be kept strictly confidential and used for research purposes only. If you have any questions about this study, please feel free to contact me at 45812@novasbe.pt.

Thank you in advance for taking part in this survey!

In case you don't know was augmented reality (mixed reality) smart glasses are, please watch the following short video: https://www.youtube.com/watch?v=cjpaNQFojAc (There are several augmented reality smart glasses providers. Here is a short video for illustration).

1. Did you know (before watching the video) what augmented reality smart glasses are?

- Yes
- No

2. Have you ever used augmented reality smart glasses?

- Yes
- No
- I'm not sure

3. Do you see any benefits for yourself in using augmented reality smart glasses?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Having a new user experience					
Being able to follow instructions without having to hold a device in my hand					
Creating a virtual, more efficient workspace with different applications					
Viewing entertainment in a completely new way					
Not having to look down (on my cell phone anymore)					
Being able to process more information about my environment faster					
Having a stronger connection with family, friends, and people around me					
I see no advantage in using augmented reality smart glasses					

4. How much would you be willing to pay for augmented reality smart glasses?

- €0
- €1-€200
- €201-€400
- €401-€600
- €601-€800
- €801-€1000
- >€1000

5. Are there any reasons why you would not buy augmented reality smart glasses?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Higher price (currently Augmented Reality Glasses start from €600 upwards)					
Unflattering Glasses Design					
Too few existing augmented reality applications					
Privacy concerns					
Uncomfortable to wear					
Low battery performance					
Low processing power					
No existing added value					
I have no concerns					

6. What is your gender?

- Male
- Female
- Diverse
- Prefer not to say

7. How old are you?

8. Where do you live?

- Europe
- North America

- South America
- Africa
- Asia
- Australia
- Prefer not to say

9. What is your highest high school or college degree?

- Less than high school diploma
- High school diploma or equivalent
- Bachelor’s/Master’s degree
- PhD degree
- Prefer not to say
- Others

Appendix 2: Evolution of Media Devices

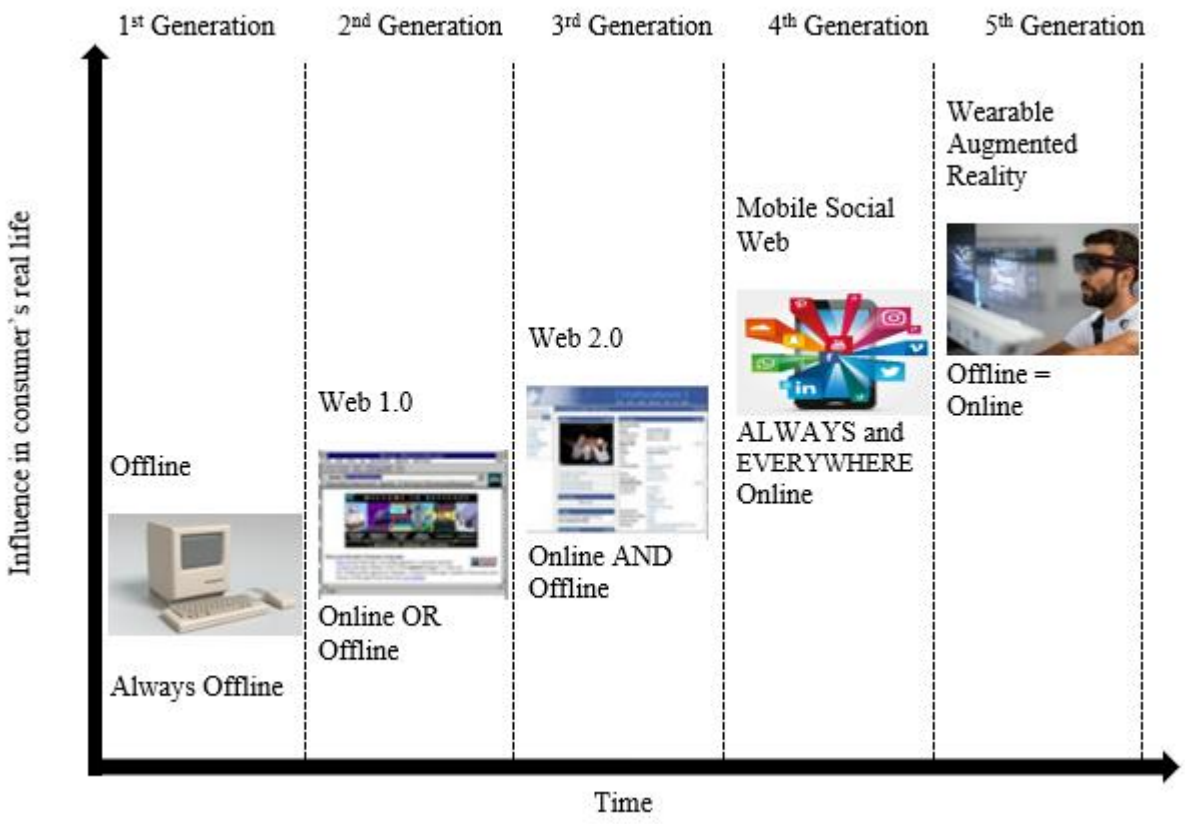

Figure 4 Evolution of Media Devices | own figure based on source Rauschnabel et al. 2015

Appendix 3: AR Specific Findings Based on Age

Question	Response	11-25 (Gen Z)	26-41 (Gen Y)	42-56 (Gen X)	57-75 (Baby Boomers)
Did you know (before watching the video) what augmented reality smart glasses are?	Yes	8 (73%)	27 (77%)	14 (74%)	6 (32%)
	No	3 (27%)	8 (23%)	5 (26%)	13 (68%)
Have you ever used augmented reality smart glasses?	Yes	3 (27%)	9 (26%)	3 (16%)	0
	No	7 (64%)	26 (74%)	16 (84%)	18 (95%)
	I am not sure	1 (9%)	0	0	1 (5%)
Total	/	11	35	19	19

Table 3 AR Specific Findings based on Age | own table based on survey data

Appendix 4: Introduction to the Experts

Key	Name	Institution	Job Title
M.R.	Michael R.	Vodafone Germany	Director Consumer Services and Innovation
Y.W.	Yiwen W.	Nreal	Solution Manager that launched Nreal Light in Germany and will launch Nreal Air in Japan this year
C.L.	Christopher L.	Vodafone Germany	Innovation Group Lead with focus on AR consumer side strategy
G.R.	Gordon R.	Vodafone Germany	Product Marketing Manager for Wearables
S.K.	Sebastian K.	Vodafone Germany	AR Evangelist and Manager for industrial clients and end consumers

Table 4 Expert Overview | own table based on the information of the conducted interviews

Appendix 5: Interview Questions

The interview questions changed depending on the interview partner.

1. Augmented Reality Smart Glasses (ARSG) are already widely used in the enterprise sector. What are the major use cases in the enterprise sector?
2. What is the reason, Nreal chose to produce for the consumer market instead? So far, the competition like Microsoft or Magic Leap decided to produce for the industrial market. What differentiates your product?
3. Currently, ARSGs have not yet become established in the consumer sector. What are the reasons for this?
4. Why did Vodafone/ Nreal opt for AR and not VR? Why do you see more potential here? What are key differences between AR and VR?
5. In recent years, there have been many companies like Facebook, Microsoft, and Apple, moving into the VR and AR space - are we on the verge of a breakthrough? What do you expect to change in the next 1-3 years?
6. Some devices like Magic Leap work all by themselves, some are supported by the smartphone. How do you see the role of smart glasses in the long term? Do they have the potential to replace the smartphone in the long run?
7. Is the strategy of Nreal to launch glasses with less capabilities so that it is possible to make them lighter and cheaper?
8. What is your main market country wise? What is your target group?
9. How does Nreal position itself to the competition? Do you think there will be an extreme change when Apple launched a product?

10. What do you think consumers want from AR glasses? What is the main reason people buy ARSGs nowadays?
11. The new version, Nreal Air, will not have any outward facing cameras. They can display videos and phone apps, but they cannot see what is around, which means they do not have spatial awareness and hand tracking features like Nreal Light. What was the reason for that decision?
12. Nreal Air gets promoted as a “portable movie theatre.” Do you think Nreal is a playful device rather than a device that increases productivity? Where does Nreal position itself?
13. I read that Nreal is the first pair of glasses on the consumer market that could gain foothold based on design and price. Would you say this is true? Or what would you say is still missing for Nreal to establish itself?
14. Vodafone has a cooperation with Nreal. What is Nreal's customer group and what are the key use cases? How is the product distributed? What is the vision?
15. What are the strengths and weaknesses of ARSGs today and in the future?
16. AR is still relatively in its early stages: does Vodafone already see AR adding value in the next 2-3 years or only in the long-term future and wants to position itself strategically?
17. How do the sales figures look regarding the cooperation with Nreal?
18. What makes the Giga AR Cooking App special and has there already been customer feedback?