Public Perceptions on Psychological and Social Impacts of Virtual and Augmented Reality

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Figure 1: The axes identify potential psychological and social implications of ongoing developments in Virtual and Augmented Reality that have already been discussed at large in the scientific community. These radar graphs show how much a representative sample of the public is concerned about these identified implications concerning the two technologies.

Abstract

Virtual Reality (VR) and Augmented Reality (AR) technologies have gained prominence in scientific and industrial contexts over the last decade. While extensive evaluations of their potential benefits and challenges exist, public perceptions of the psychological and social issues associated with VR and AR remain less explored. This study addresses this gap by examining public attitudes toward these issues and the broader impact of such technologies through a two-part online survey (N=150). Our findings reveal that participants hold a nuanced perspective, clearly distinguishing between VR and AR, expressing optimism about potential applications yet voicing concerns regarding their effects on health, social interactions, and overreliance. This study contributes empirical evidence on public perceptions of VR and AR, offering valuable insights for developers, designers, and policymakers.

CCS Concepts

• **Human-centered computing** → **HCI theory, concepts and models**; **Empirical studies in HCI**.

Keywords

Public Perceptions, Ethical Concerns, Psychological Implications, Social Implications, Mixed Reality, Extended Reality

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1 Introduction

Virtual Reality (VR) and Augmented Reality (AR) are expected to become increasingly integrated into various aspects of society in the coming years [42]. These technologies, collectively referred to as XR henceforth (see Section 2.1 for more information regarding the terminology), offer the potential to revolutionize domains such as entertainment [10, 25] and education [1, 2] to the medical sector [5, 23, 33], the producing industry [7, 36], transportation [26, 32, 45], and more [54]. However, alongside their transformative possibilities come significant ethical, psychological, and social challenges. As XR technologies continue to evolve, addressing these concerns, particularly those surrounding privacy, security, and safety [20], has become a crucial responsibility.

Understanding public perceptions and expectations regarding XR technologies can provide valuable insights into their social acceptance and ethical implications. Although public opinion offers only a snapshot in time, these perspectives illuminate the broader impact of VR and AR technologies from a non-academic vantage point, thereby complementing the ongoing scientific and industrial evaluations presented in Section 2 regarding related work.

Ethical considerations, such as privacy, identity theft, data protection, or content manipulation represent just a few of the novel challenges associated with the broader use of XR [19, 42, 48]. It can be assumed that these implications significantly influence the public opinion on XR next to already identified barriers to social acceptance of XR devices [51]. This work aims to take a closer look at this assumption by answering the question posed in "The Ethics of Realism in Virtual and Augmented Reality" [48, Sec. 'Scientific Questions']: "What, if any, are public perceptions of these issues today?" Through an online survey, a total of 150 participants representing the general public were first asked to envision the potential positive and negative impacts of VR and AR on their lives and society separately. Following this, the implications highlighted in the aforementioned work were evaluated, allowing a deeper understanding of the public's awareness and consciousness of these technologies' broader psychological and social dimensions identified and discussed by the scientific community.

Contribution Statement: This work aims to contribute to understanding public perceptions regarding VR and AR technologies, particularly in the context of their psychological and social implications. By addressing an open question raised in "The Ethics of Realism in Virtual and Augmented Reality" [48], it provides empirical evidence derived from a two-part online survey. These insights are intended to guide developers, designers, and policymakers in navigating the societal integration of VR and AR technologies. Specifically, this research seeks to answer the following two research questions:
RQ1: What *potential impacts* does the public perceive from VR and AR technologies *on their lives and on society*, respectively?
RQ2: How does the public perceive *psychological and social implications* surrounding VR and AR technologies, respectively?

Table 1 provides a summary of the two parts of the survey that were conducted to answer these two research questions. Detailed explanations of this survey will follow in the subsequent sections. The findings revealed a clear distinction in how participants perceive VR and AR. While participants expressed optimism about the potential benefits of both technologies, they were more apprehensive about VR, citing concerns such as health effects, social isolation, and overreliance. These results provide valuable empirical data on public awareness, attitudes, and concerns regarding the psychological and social implications of XR technologies.

2 Related Work

XR technologies, while offering immense potential across various sectors, also come with significant risks that need to be addressed to achieve widespread acceptance and integration into everyday life. Previous research has extensively focused on analyzing and evaluating the possibility and impact of these risks, identifying potential threats, and examining their implications. However, alongside these technical and systemic evaluations, it is equally crucial to consider the apprehensions and perspectives of users and bystanders. Understanding their concerns and general opinions is essential for addressing barriers to acceptance and ensuring the responsible development of XR technologies. Its broad acceptance still faces numerous challenges that must be addressed to reach a certain degree of pervasiveness [24]. This section reviews threats that have already materialized, consolidates existing user concerns highlighted in prior studies, and provides an outlook on potential issues that may arise as XR continues to evolve.

2.1 Distinguishing Terminologies

The field of XR technologies encompasses a wide array of terms, definitions, and frameworks used to describe its various components. Among these, Milgram and Kishino's "Reality-Virtuality Continuum" [35] remains one of the most prominent frameworks, positioning Mixed Reality (MR) as an umbrella term for anything between "true" reality and "true" virtuality. In recent years, however, the term Extended Reality (and the related abbreviation XR) has gained traction as a broader and potentially more encompassing umbrella term. Despite this, differing approaches to categorization persist. For example, some consider MR (more or less) synonymous with AR [13], while others define it as an entirely separate category of technologies [16, 17]. Numerous other classifications exist, ranging from slightly to significantly different, though this section does not aim to provide an exhaustive overview.

For the purposes of this work, the authors chose to focus exclusively on distinguishing between AR and VR, guided by two key reasons. First, the foundational work on which this study builds explicitly differentiates between AR and VR. Second, the recently introduced xReality framework [40] provides a unified approach to consolidating previous frameworks and resolving many associated terminological debates. In this framework, XR is the abbreviation for xReality and serves as the overarching term, with AR and VR defined as distinct entities based on their most critical differentiator. AR emphasizes local presence, extending and/or diminishing the physical environment. VR, in contrast, focuses on telepresence, replacing the user's physical surroundings (entirely) with a virtual

Table 1: A summary of the survey conducted herein. Both parts were held online consecutively.

Part	Type	Short Description	Dependent Variables
I (Impact)	Qualitative	Envisioning both positive and negative impacts of XR on their life and its broader societal influence.	• What potential positive impacts do you envision [...]? (free text) • What potential negative impacts do you envision [...]? (free text)
II (Implications)	Quantitative	Rating of concern about and prior engagement with hypothetical implications of XR technologies.	• I am concerned about this happening to me. (5-point Likert scale; strongly disagree - strongly agree) • I have thought about this aspect before the study. (yes/no question)

environment. Within this framework, more minute differentiations and descriptors of subcategories can be found, yet for this work, the focus was kept on this distinction.

2.2 Social and Health-Related Issues of XR

An important aspect is the perception of social context. Several studies offer insights into social hesitations around XR devices [18, 27, 51]. A major obstacle is the social discomfort linked with using current XR devices publicly, resulting in reduced confidence and hesitancy. Thus, the device's design and appearance are pivotal in its acceptance.

In a study with a questionnaire regarding AR glasses, participants expressed worries about potential legal consequences associated with using technology that could track and collect data about others without their consent, ethical doubts about recording others, and how the threat to others' privacy could lead to altered social interactions, with peers potentially behaving in less authentic or communicative. Further concerns include fear of being socially stigmatized and a sense of responsibility to protect others' privacy, potential adverse reactions from peers, and even escalation to extreme cases of physical confrontation [41].

Next to privacy concerns (more on that in Section 2.3) and given the large amount of data XR devices collect, it seems realistic that VR and AR environments can invoke profound emotional, psychological, and social effects. These effects range from inhibiting real-world social interactions, possibly causing social withdrawal, to the potential for users to neglect their health [48] (more on that in Section 2.5).

Long usage sessions might also lead to physical discomfort and further health issues [29]. Next to that, Serino et al. [47] and Guo et al. [21] highlight potential dangers associated with playing immersive location-based XR games. Users engrossed in the game may lose awareness of their surroundings, inadvertently entering private property and/or getting themselves into hazardous situations. Lastly, a recent review highlights that the number of physical injuries increased with the number of VR consumer products sold [11].

2.3 Security and Privacy Issues of XR

The social context of technology has shifted to not only include users' personal privacy [9, 14] but also extend to the privacy of others, as users share information concerning other individuals [37, 41]. When using AR glasses, factors such as the presence of people, the usage context of AR, and the immediacy of consequences following privacy breaches influence people's reactions to the technology [41]. For XR in general, multiple areas of concern can be identified where users' privacy or security could be compromised. Privacy risks that stem from applications' needs to gather input from the numerous sensors on XR devices, such as cameras [34, 44, 50] and display XR output to modify the user's view of the user's surroundings [39, 43]. Further challenges arise with using XR controllers and headsets, notably the potential for unauthorized observation, as the headset obscures the user's field of vision [55].

Further limitations in these devices and applications in XR include the absence of multi-factor authentication and the lack of clear mechanisms for users to delete their profiles. Privacy policies regarding data sharing with third parties are often ambiguous and fail to protect sensitive user data [38]. Casey et al. showed how OpenVR-compatible systems respond to various attacks, and further protection across all aspects of XR systems was recommended. Proposed solutions include encrypting sensitive data, implementing stricter application control measures, and integrating permission-based access for XR features [8]. Additionally, frameworks are recommended to enforce regulations overseeing XR output.

2.4 (Mis-)Using XR for Malicious Purposes

Yet another aspect of XR research is "immersive attacks" [3, 8, 56], aiming at users' psychological and physiological safety through perceptual tricks rather than typical hardware or software vulnerabilities. These attacks manipulate parts of the system to create disorienting, deceptive, or harmful experiences for users. For instance, altering visual or auditory cues can lead to motion sickness, confusion, or even panic, leveraging the immersive nature of XR to amplify their impact.

Tseng et al. explored the risks of malicious manipulation of perceptual manipulations and demonstrated how the potential for physical harm could be caused in VR [53]. Even though virtual-physical perceptual manipulations, such as redirected walking or enhanced haptics, can be used in beneficial ways, their speculative design workshop explored the potential threats of such approaches if used maliciously. They emphasize the need for awareness and careful application of these perceptual manipulations to prevent their misuse and protect users from malicious exploitation of perceptual vulnerabilities.

Table 2: Statements that were to be assessed by the participants during the second part.

Shortcode	**Implication** (cf. [48])	**Statement**
SocIso	Social Isolation	Increased usage of this XR system could lead to reduced face-to-face interactions.
PrefVirt	Preference for Virtual Social Interactions	Due to this XR system, people might withdraw from meetings in real life.
BodyNeg	Body Neglect	This XR system's immersive nature could lead to neglecting your physical well-being and daily responsibilities.
ImitBehav	Imitative Behavior	With this XR system, it might become increasingly hard to maintain a clear distinction between virtual behavior and real-life behavior.
Pers	Persuasion	This XR system could influence your emotions and behaviors in ways that could be detrimental to your well-being.
UnexHorr	Unexpected Horror	The possibility of being disturbed by encountering unexpected horror content within XR environments of this system.
PornViol	Pornography and Exposure to Violence	That XR experiences with this system might become so realistic, that the consumption of explicit or violent content could have a lasting impact on your well-being.
ExtrViol	Extreme Violence and Assault	XR experiences on this system might blur the line between fantasy and reality.
LackCommon	Lack of Common Environments	XR environments of this system could lead to the potential loss of a common sense of reality and shared experiences.
LackGround	Lack of Ground Truth	The persuasive power of this XR system might lead to situations where people believe these experiences to be true.
PersAds	Persuasive Advertising	Using this system could limit your freedom to engage with XR content without constant commercial influence.

Even without those advanced perceptual tricks, XR technologies have the potential to draw people into unhealthy and dangerous amounts of use. Barreda-Ángeles and Hartmann [4] explored the compulsive use of VR in an online survey with 752 participants. Their results show that a significant number of participants are potentially addicted and may lose touch between real and virtual worlds in the long term.

Through a design fiction approach, Eghtebas et al. [15] estimated dark scenarios in AR use, including situations with physical, psychological, and societal harm. Herein, laypeople created hypothetical AR scenarios, environments, or narratives, which allowed them to engage with technologies in a simulated context, encouraging them to reflect on their expectations and perceptions. Many of these align with the potential implications given in the following section, such as a lack of ground truth with specific parts of the real world being removed and/or manipulated.

2.5 The Ethics of Realism in Virtual and Augmented Reality

Through technical advancements in XR, increasingly realistic virtual worlds allow for potential misuse, abuse, and neglect. The publication of the same name as this section by Slater et al. [48] is the impetus for this work and conveys essential concerns related to XR's psychological and social implications.

Some of these potential implications include, but are not limited to, individuals prioritizing virtual experiences over their physical well-being. XR technologies could hinder people's ability to engage with the physical world, potentially resulting in extreme cases of social withdrawal. Additionally, exposure to violent or harmful content in XR environments may desensitize individuals or encourage imitative behaviors, leading to real-world consequences. Furthermore, the absence of shared social norms within XR spaces could disrupt the public sphere and undermine societal cohesion. The consequences of XR experiences extend beyond the immediate experience to after-effects and potential long-term consequences, considering their highly immersive and personal nature. A short overview of the implications of this work is given in Table 2. In their conclusion, the authors infer that public perceptions should be studied and a code of conduct for XR should be established.

2.6 Assessing User Perceptions of XR

Gaining user feedback and assessing their opinions is pivotal for technological evolution, including XR. While numerous surveys and questionnaires have been crafted to gauge user experiences with technologies, many focus on specific user aspects and might not cover the broader spectrum of potential concerns. Recently, the Mixed Reality Concerns (MRC) Questionnaire was published to assess users' apprehensions and concerns regarding XR artifacts and applications [28]. A conceptual framework of potential concerns was also introduced, giving an overview of related work and categorizing some of the more well-researched dangers of XR. Studies on the public perception of VR exist, though they are primarily concerned about more specific use cases, such as in medicine [30, 31], in therapy [46], or for use in public libraries [12]. For the field of AR, Thompson et al. [52] assessed mental models of the general public regarding AR. Furthermore, Stockinger [49] evaluated users' perception, acceptance, and attitude of AR in publicly available social media posts, and Harbor [22] analyzed 12 laypeople interviews about concerns regarding AR, presenting a first broader understanding of the public consciousness of potential downsides of AR. While studies evaluating public perceptions exist, previous research has

rarely considered user perceptions and concerns for XR applications. More specifically, the literature lacks a direct comparison of user perceptions of VR and AR using consistently applied and comparable metrics.

3 Research Approach and Setup of the Online Study

The previous section has shown the current state of research regarding the potential impact and (mis-)use of XR technologies. Public perceptions of XR extend far beyond the operational efficiency of current-generation devices and published research. These views are not solely grounded in the technology's present functionality or limitations but are also heavily influenced by expectations for its future development and implications. Therefore, understanding public perceptions includes recognizing people's many points of contact with relatively new technologies such as XR. In addition to hands-on experiences with such devices, many other factors play a role, including media reports, expectations based on portrayals in media like movies and games, general cultural influences, socioeconomic background, and more.

Public perceptions of XR comprise current experiences with the technology, speculative expectations for its development, and broader considerations of its societal impact. We decided not only to evaluate the concerns surrounding the recognized implications of previous work but also to explore how the public currently perceives VR and AR. This dual focus stems from the understanding that perceptions of these technologies are shaped not only by the risks identified in academic and industry contexts but also by how individuals evaluate the benefits and downsides of VR and AR in their own lives and society. By capturing these perceptions, we aim to gain a broader and more nuanced view of how these technologies are understood and categorized by the general public.

Current XR devices are rapidly being introduced to the market, making it likely that public attitudes will evolve as exposure to and familiarity with these technologies increase. This study, therefore, provides a snapshot of perceptions at this moment in time.

Our research is divided into two parts to address these objectives comprehensively. First, we examine how people evaluate the potential positive and negative effects of VR and AR on their lives and society. This approach seeks to show whether VR and AR are perceived as distinct technologies or if they are viewed as a unified group under the XR umbrella. Second, we aim to understand the public awareness of the potential implications that emerge with the continued development of these devices. Ultimately, this work hopes to bridge the gap between the academic discourse on XR technologies and real-world public perceptions, providing a foundation for future research and development to address public expectations and concerns.

Table 1 shows the two parts of the online study conducted to answer research questions posed in the contribution statement. Both parts were conducted one after another to facilitate participant recruitment. The qualitative text-based questions of *Part I* were posed before the quantitative evaluations of *Part II* to minimize the influence of the concern-based statements on the participants' perceptions of impacts. Due to this having been a joint online questionnaire, the participants' demographic data and details about the study procedure are the same for both parts; see Section 3.2 and Section 3.3 for this information.

3.1 Phrasing of Statements to Represent the Implications Posed in Previous Work

Initially, two researchers formulated four one-sentence statements for each of the eleven identified implications [48, Sec. 'Psychological and Social Implications']. Then, six experts from the fields of privacy, security, XR, and HCI were invited to review and provide feedback on these statements. The statement that received the highest expert ratings was selected from each implication as one of the 11 statements later evaluated by participants. They are given in Table 2. All other statements were discarded from further consideration.

3.2 Study Procedure

Participants were first briefed on the procedure and gave informed consent. They were then presented with a neutral, text-based introduction to AR and VR technologies, illustrated using examples of current-generation headsets. Three of the authors collaboratively developed these descriptions, drawing on publicly available information about representative devices. Namely, the *Microsoft Hololens 2*[1] for AR see-through glasses and the *HTC Vive 2*[2] for immersive VR glasses. Care was taken to avoid relying solely on promotional material from the manufacturers, which often contains a certain bias. By synthesizing multiple sources and focusing on factual, device-agnostic characteristics, we aimed to provide an accessible yet impartial foundation. To reduce carry-over effects in responses, the order in which VR and AR were assessed was randomized so that half of the participants started with a different technology than the others.

First, participants were prompted to identify VR and AR's potential positive and negative impacts on various aspects of life, including leisure, work, and broader societal influences. They were required to think of at least three impacts for each technology, but were free to give more as well. The results of this *Part I* are given in Section 5. Then, the participants were instructed to rate the statements of Table 2 on two different aspects. Participants were asked to indicate their level of agreement with the statement "I am concerned about this." in response to each implication statement, using a 5-point Likert scale ranging from "strongly disagree" to "strongly agree". Afterward, we chose to ask participants whether they had considered each implication before the study instead of inquiring about the perceived likelihood of each statement. This decision was influenced by the fact that even experts from the related publication on social and psychological implications did not evaluate the probability of these scenarios occurring. The focus of this study was not primarily on these probabilities. Rather, our objective was to gauge the extent to which the public is aware of these potential dangers. The results to both questions of this *Part II* are given in Section 5.

[1] https://www.microsoft.com/en-us/hololens, last accessed on 2025-05-31.
[2] https://www.vive.com/us/product/vive-pro2/overview, last accessed on 2025-05-31.

3.3 Participants

The questionnaire evaluation is based on a sample of 150 participants, of whom 73 (48.67%) identified as female, 75 (50%) as male, and 2 as non-binary or preferred not to disclose their gender. Participants' ages ranged from 19 to 75, with an average age of approximately 40 years ($\bar{x} = 40.48$, $s = 14.7$).

To ensure a broad and balanced perspective, participants were recruited via the online research platform Prolific[3], which allows for the construction of samples representative of current demographic distributions. This approach was deliberately chosen to approximate the diversity of the general population, rather than focusing on specific cohorts or professional groups. While we recognize that no sample of this size can capture the full spectrum of public opinion, our goal was to provide generalizable insights by drawing randomly from a representative pool. In contrast to cohort-based studies, this broader strategy was intended to reflect the general public's attitudes toward XR technologies, offering a snapshot of prevailing perceptions within Western populations.

The majority of our participants (84.67%) were employed in sectors unrelated to computing or technology, and most had moderate (approximately 20 hours) to no prior experience with XR technology. Specifically, around 60% reported no previous use of AR devices, while roughly one-third had not used VR devices, as defined in our survey instrument. Participation was entirely voluntary, with participants free to withdraw at any time. On average, the survey took approximately 15 minutes to complete, and participants received compensation corresponding to an hourly rate of roughly £9.

4 Results of Part I: Qualitative Assessment of Assumed Impacts of VR and AR

Responses were systematically analyzed and categorized based on recurring themes by two researchers. Following the methodology recommended by Blandford et al. [6], a thematic analysis was applied to the qualitative data. Initially, two authors independently coded 15% of the responses in an open-coding process. These preliminary codes were then refined during a code adjustment session. Given the similarity of the initial codes for VR and AR, they were merged into a single coding tree. The remaining responses were then coded using this consolidated tree. For clarity, the descriptions of positive and negative impacts are divided into separate sections.

4.1 Overarching Themes of Assumed Positive Impacts

In total, the following six principal topics could be identified during the analysis of the detailed participants' answers to the following question: *"What potential positive impacts do you envision for the use of this presented technology across various aspects of life, such as leisure, work, and its broader societal influence? [...]"*

A detailed breakdown of the distribution of codes in principal topics and associated subcategories is given in the Appendix with Table 3.

4.1.1 *Immersion and Visualization*. The number of participants mentioning positive impacts in "Immersion and Visualizations" was relatively equal in both AR (~18%) and VR (~14%). Participants note that AR offers novel immersive interactions by merging the real world with digital elements, while VR mainly seems to provide full immersion in gaming environments. They further mention that advanced immersive visualizations can provide visual aids and enhance visualization for various purposes. It finds applications in architecture and healthcare, allowing for realistic visual representations and training simulations. Multiple answers include the fact that AR maintains a connection to the real world so that users can distinguish between virtual and real-life details.

> *"The fun of being able to be part of something that, although not real, seems so."* (P053)

> *"Learning can become fun - interactive and being immersed in something will help people with wanting to learn."* (P049)

4.1.2 *Assistance and Training*. The number of participants mentioning positive impacts regarding "Assistance and Training" was similar for AR (~20%) and VR (~16%). Participants mentioned that both AR and VR can provide task-based assistance in the workplace, providing quick access to information and further assistance. This could be particularly beneficial for professions in medicine and the automotive industries; participants described these opportunities as follows:

> *"Training - this would be great in training situations for a wide variety of industries. Users will be able to practice difficult or dangerous tasks with no risk."* (P147)

AR could also provide a hands-on learning experience that assists in developing users' practical skills. VR technology could make viewing educational content both in person and remotely possible. It could offer opportunities to "visit" places for educational purposes. Additionally, both AR and VR could present themes and ideas in creative, tangible ways, benefiting students through hands-on experiences.

4.1.3 *Access and Availability*. Many more answers fit into the "Access and Availability" category for AR (~17%) than for VR (~3%). Participants remarked on AR's potential capability to access various information during real-life tasks, being a huge benefit for practicality. As see-through glasses usually retain part of the surrounding reality in the user's vision, they could utilize AR devices while simultaneously completing other tasks.

> *"It can be used for socializing hands-free. For example, you could have a video call with a loved one whilst cooking hands-free."* (P102)

In contrast, participants viewed "Access and Availability" in VR differently, perceiving it as less flexible since current devices seem primarily stationary. However, they recognized the potential for VR and AR equally in remote working, as individuals could remain in one location while engaging in virtual environments:

> *"Remote collaboration with colleagues with virtual overlays of diagrams, instructions, or live video feeds as workers can receive real-time guidance from anywhere in the world."* (P106)

4.1.4 *Enjoyment*. "Enjoyment" shows the biggest difference in frequency, as roughly 15% of positive answers for AR fall into this

[3] https://www.prolific.com, last accessed on 2025-05-31.

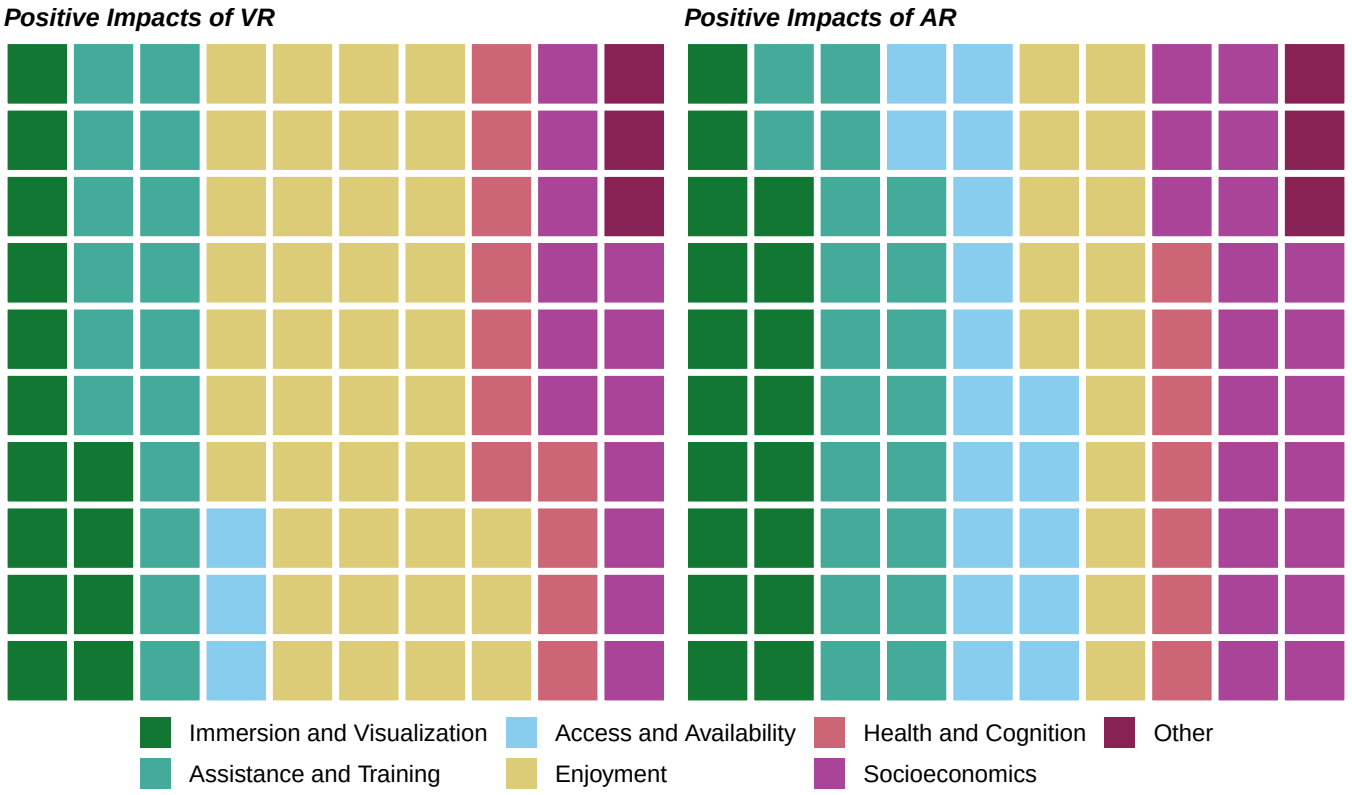

Figure 2: These two waffle graphs show the overarching themes of perceived positive impacts identified during the qualitative assessment of *Part I*. The impacts were defined jointly for both VR and AR. With a total of 100 boxes, each box roughly indicates a 1% rate of occurrence for VR on the left and AR on the right.

category, but around 40% of all positive impacts for VR match this category. Both AR and VR may revolutionize entertainment, as per the participants' answers, especially in gaming applications, as users would feel like being completely immersed in the virtual environment. This could further encourage creativity and relaxation; one participant describes it as follows:

> *"The ability to instantly escape one's environment. This could be beneficial if the simulated environment is a peaceful or intellectually stimulating one. [...]"* (P009)

It could also encourage connectivity for individuals separated by states or vast distances and provide more social aspects to people. It also opens doors to remote exploration of tourism destinations, cultural landmarks, and historically significant sites, offering access to otherwise inaccessible experiences.

4.1.5 *Health and Cognition*. "Health and Cognition" related answers came up at a rate of 7% for AR and 11% for VR. Participants note that both technologies could make active physical movement in virtual space possible, providing users with a sense of participation in a realistic-seeming virtual experience, which could encourage a healthier lifestyle than stationary gaming and thus improve their physical and mental health:

> *"This gives people something to do and can improve the well-being of people who use it to have fun."* (P146)

In conjunction with the improved "Assistance and Training" mentioned before, VR could offer realistic training in certain critical fields, like the medical field, improving safety conditions and minimizing risks in real-life scenarios.

> *"VR technology could be used as a therapeutic tool. You might be able to use it for relaxation, or for confronting fears, or any number of psychological uses that immerse the patient."* (P058)

> *"Psychology. People can use these to overcome or treat certain phobias that they deal with in their everyday lives."* (P108)

AR could extend this safety concept to everyday life by reducing distractions. One example would be for pedestrians through hands-free access to real-time information, thereby offering safer interactions with infotainment devices during travel.

4.1.6 *Socioeconomics*. Answers regarding socioeconomic impacts were mentioned more often for AR (~20%) than for VR (~13%). Regarding positive long-term cost-effectiveness, participants again describe AR and VR as assisting tools. Through reduced human error, enhanced productivity, and improved accuracy in accessing and utilizing information, these could ultimately boost efficiency by always being in use:

> *"Ease of use means it can be integrated with daily life."* (P008)

Both AR and VR devices may increase productivity and enable advancements in science and the economy, especially in health care and engineering. Expanding opportunities for individuals with disabilities, instructional support for senior citizens, and assistance for neurodivergent individuals or those with other cognitive disabilities were mentioned multiple times as well.

4.2 Overarching Themes of Assumed Negative Impacts

In total, the following six principal topics could be identified during the analysis of the detailed participants' answers to the following question: *"What potential negative impacts do you envision for the use of this presented technology across various aspects of life, such as leisure, work, and its broader societal influence? [...]"*

A full breakdown of the distribution of codes across the major topics and their subcategories is likewise provided in the Appendix, as is shown in Table 4.

4.2.1 *Withdrawing From Reality*. The topic of "Withdrawing From Reality" was mentioned at around 15% for AR and around 27% for VR. Participants described a spectrum ranging from reduced real-life interaction to more extreme forms of isolation from social commitments and full disengagement from the real world. Herein, some described that "reduced real-life interactions" may occur as follows:

> *"[AR] may potentially lower the need to meet with other people. As you would have the ability to speak with others as and when you choose, the need to physically meet up with others would be reduced."* (P120)

Here, many participants came up with some of the potential impacts of hyperrealism in XR, as the ones in Section 5, even though these would only be introduced to them later on in the joint online study:

> *"Some individuals may be so caught up in the AR world that they neglect their real-world responsibilities."* (P094)

> *"Isolation. People could become too focused on the technology and neglect interactions with actual people."* (P010)

AR could also interfere with the development of social interaction skills, including non-verbal communication and emotional connection, as well as the practice of social skills. Described as a worst-case scenario, full disengagement from their real-life experience was often anticipated and was more of a concern due to VR technology:

> *"Potential for people to retreat into [their] own realities and lose external interaction with real people or situations."* (P122)

4.2.2 *Excessive Use*. The number of participants mentioning "Excessive Use" was higher for AR (~16%) than it was for VR (~11%). XR technologies could blur the lines between physical and virtual reality, causing confusion about what is real and what is virtual, creating an inaccurate perception of reality. The underlying danger of not being able to perceive differences long-term and how it could affect people is described by one participant:

> *"VR technology could psychologically hurt those who can't tell the difference between what is real and what is not."* (P058)

Consequently, individuals could mistake virtual experiences for real-life scenarios, disregarding the physical risks involved and ignoring real-life and societal responsibilities. AR could confuse users and have long-term effects on their cognitive capabilities to differentiate digital elements from "real" physical ones:

> *"[AR] blurs the lines between reality more because you can see your real-time surroundings at the same time as the digital content."* (P117)

Furthermore, participants were concerned that overreliance and trust in the XR technology for work practices could result in a decline in the individual's ability to perform tasks without the technology.

4.2.3 *Privacy, Security, and Crime*. "Privacy, Security, and Crime" came up at roughly the same rate for AR (~10%) and VR (~7%). Privacy concerns surrounding XR technology include storing and protecting personal data, the potential for unauthorized access to personal information in public spaces, and the risk of data misuse or intrusive advertising. The recording and transmission capabilities of see-through AR glasses could raise significant privacy issues regarding intrusion on individuals' privacy during social interactions. Participants describe various misconducts that could potentially be caused by XR technology.

In AR, participants were more focused on how incorrect data displayed with the devices could lead to errors that could impact people's lives, whether it happened intentionally or accidentally:

> *"People could use AR technology to propagate misleading or false information."* (P058)

AR devices collect sensory input in everyday life, often including personal data such as voice or video recordings. This raises concerns about the potential misuse of these data by the wearer or third parties:

> *"It would be easy to make malicious and degenerate software for such a device, and also if this device were hacked, they could interrupt your entire vision. This literally means this device can be used in any situation where obstacles or distractions in your vision could be harmful (for example, driving)."* (P038)

> *"People will be able to spy on their surroundings by using the [AR] headse"* (P110)

In VR, participants expressed greater concern about attacks due to VR users being unaware of their real surroundings. Additionally, there is a general worry about exposing individuals to negative experiences and thus influencing illegal actions, particularly given the high level of realism in VR:

> *"Due to the much more immersive nature of VR compared to traditional digital content, experiencing disturbing or graphical content could cause mental health stress or other issues on the user."* (P125)

> *"Exposure to violence or strange behaviors which might influence users."* (P046)

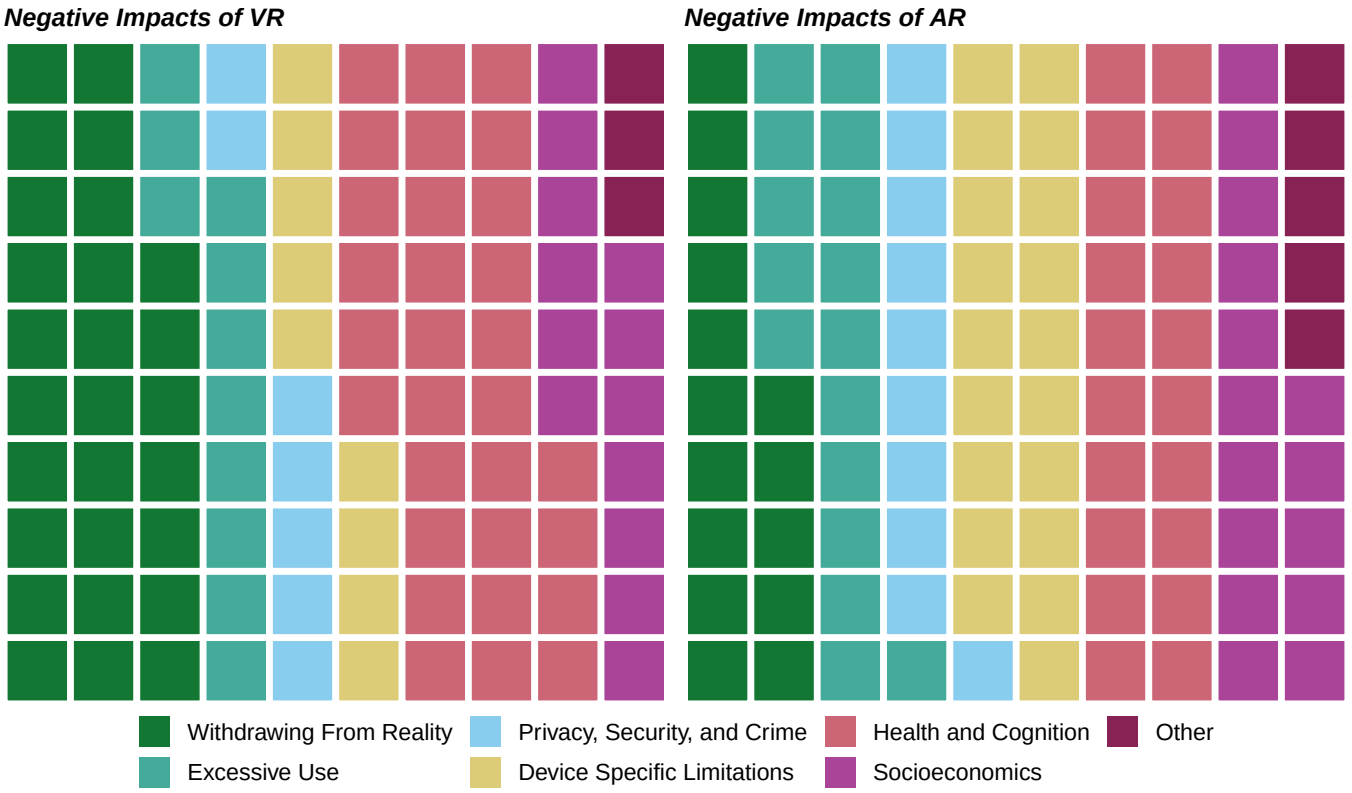

Figure 3: These two waffle graphs show the occurrence of the overarching themes of perceived negative impacts identified during the qualitative assessment of *Part I*. The impacts were defined jointly for both VR and AR. With a total of 100 boxes, each box roughly indicates a 1% rate of occurrence for VR on the left and AR on the right.

> *"I would worry about people using this to act out violently, like they may not in real life."* (P060)

4.2.4 *Device Specific Limitations*. The category "Device Specific Limitations" is different from the rest of the negative categories in the way that it is less about exploitations, attacks, or social and psychological impact, but about the devices failing for the users and being unreliable. Around 19% of all answers mentioned this in relation to AR and 9% in relation to VR.

The potential for physical harm could especially exist when using AR glasses, especially if movement in the real world is not restricted, as users may get disorientated or distracted by virtual objects.

> *"Using while driving, walking, etc. Increase dangers with distractions."* (P085)

Due to limited visibility caused by wearing a headset, more accidents may occur, including tripping over objects, colliding with obstacles, and road collisions:

> *"Dangerous. Although less dangerous than fully-immersive VR, people could still be distracted by the virtual elements presented in real-life surroundings."* (P021)

Moreover, the practicality and usage of XR technology could further be constrained by potential malfunctions, bulky equipment, reliance on stable wifi and electricity, and inconveniences such as wearing glasses:

> *"The experience is only as good as the wifi connection."* (P084)

4.2.5 *Health and Cognition*. "Health and Cognition" also came up when asked about negative impacts, with roughly 20% occurrence for AR and around 30% occurrence for VR. Constant use could have adverse effects on mental health due to the XR device's immersive nature, leading to disruptions in personal life, cognitive overload, and individuals' overall well-being, behavior, and mood.

Additionally, concerns have been raised about increased addiction tendencies, especially among vulnerable demographics like youth and individuals already struggling with addiction:

> *"Could potentially be detrimental to young people. The new class of entertainment enabled by these devices could draw youths away [...] too strongly. Could be a stronger source of addiction for people who are already vulnerable e.g. video game addicts."* (P125)

This potential addiction could lead individuals to prioritize virtual experiences over real-world responsibilities and relationships as a form of escapism, resulting in neglect of work, partners, and other important aspects of life. Anticipated consequences of prolonged indoor usage of XR technology include a decline in physical

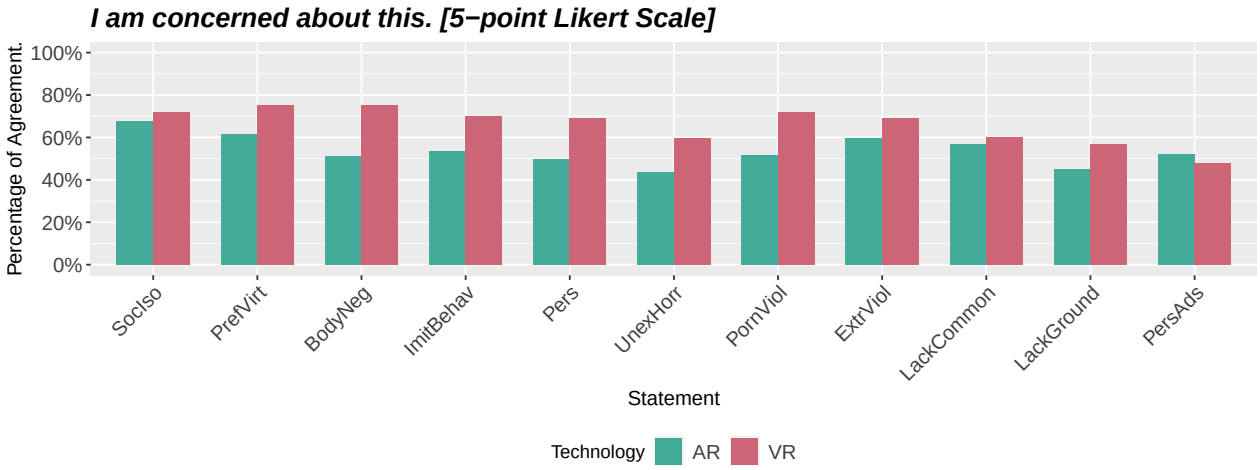

Figure 4: This bar chart shows the percentage of participants agreeing (5-point Likert scale, only "Agree" and "Strongly agree" counted) to the following question of Part II: "I am concerned about this." The statements were assessed twice by each participant, once in the context of AR and once in the context of VR.

health due to reduced physical activity, potentially resulting in deteriorating eyesight, headaches, and motion sickness, thereby discouraging engagement in physical activities.

Furthermore, the long-term impact of XR on brain stimulation and sensory responses remains uncertain for many participants, raising concerns about long-term health implications.

This collectively led to "Health and Cognition" being mentioned by 29.65% of all participants in VR (compared to 20.02% in AR).

4.2.6 *Socioeconomics*. Similarly, some negative answers also fell into the category of "Socioeconomics", this being the case for around 15% of all AR answers and 13% of all VR answers. The inclusion of XR technologies into the workplace has the potential for certain job roles to become redundant, a shift in job functions, and significant job losses. This is attributed to MR technology's ability to provide the necessary information and training, reducing the need for jobs with human assistance:

> *"Potentially reduced job opportunities - in the previously mentioned case of customer support [with AR], this may eliminate the need for on-site support, which could lead some businesses to cut staff and only rely on remote support teams"* (P115)

A risk of further widening the Social Gap is present, given the XR device's high cost and its inaccessibility to senior citizens and marginalized groups, particularly individuals with visual impairments.

> *"[VR] would completely change the dynamic of how the world works if heavily utilized, effectively segregating those who do not have access to the technology - further increasing societal gaps such as social classes"* (P153)

5 Results of Part II: Quantitative Assessment of Agreement With Psychological and Social Implications of VR and AR

On average, more participants expressed concern about the statements when framed in the context of VR compared to AR. While over half of all participants found the statements concerning both technologies, there was a 16% higher agreement on the concerning nature of the implications in VR (66.08%) than in AR (53.88%).

Talking about AR, statement *SocIso* (Social Isolation) was rated as concerning by the highest amount of participants (67.54%), statement *UnexHorr* (Unexpected Horror) by the least (43.71%). In comparison, statements *PrefVirt* (Preference for Virtual Social Interactions) and *BodyNeg* (Body Neglect) both had the most people being concerned about them in a VR context, with three-fourths indicating agreement. For VR, the fewest people rated the statement *PersAds* (Persuasive Advertising) as concerning. Curiously, this statement is also the only one where participants rated it to be more concerning in the context of AR than in VR. All other statements showed less concern about the social and psychological implications in the context of AR; on average 12.20% fewer participants indicated this. With a difference of 24.01%, the biggest difference could be seen for statement *BodyNeg* (Body Neglect), and statement *LackCommon* (Lack of Common Environments) showed the most overlap with a difference of just 3.3%. A graphical representation of these results is shown in Figure 4.

In addition to rating the concerns, participants were instructed to indicate whether they had considered the potential implications of further developments of the two XR technologies before participating in the study. Figure 5 shows the distribution of answers as a bar chart. As with the previous question, participants agreed more when within the realms of VR, with 61.07% having considered the statements in the context of VR before and 46.12% in the context of AR before, on average.

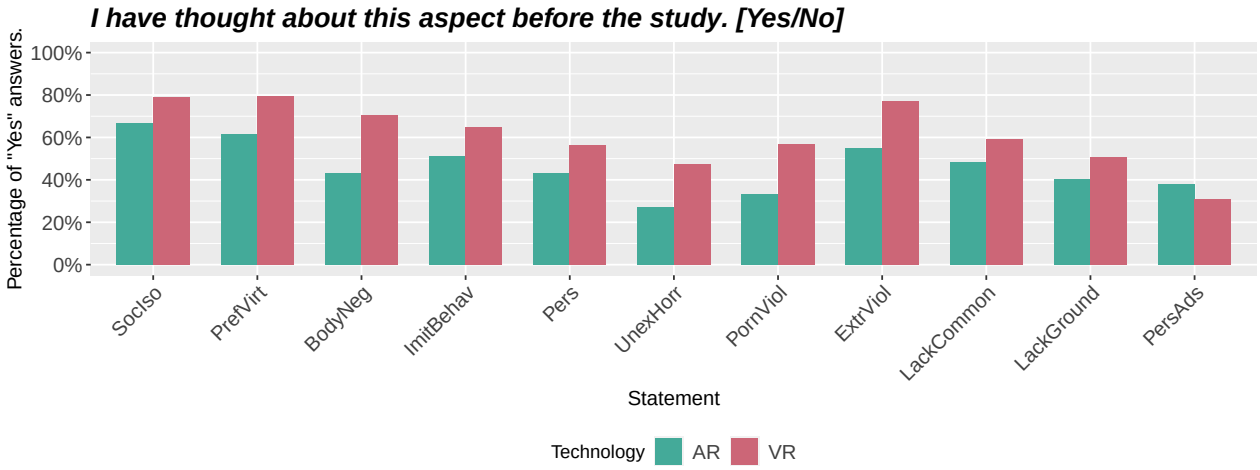

Figure 5: This bar chart shows the percentage of participants agreeing (yes/no question) to the following question: "I have thought about this aspect before the study." The question was answered twice by each participant, once in the context of AR and once in the context of VR.

For AR, the highest proportion of participants (66.89%) had previously considered the implications of statement *SocIso* (Social Isolation), while the fewest (27.15%) had considered statement *UnexHorr* (Unexpected Horror). Conversely, in the context of VR, statement *PrefVirt* (Preference for Virtual Social Interactions) had the highest prior consideration (79.49%), whereas statement *PersAds* (Persuasive Advertising) received the least attention, with only 30.77% of participants considering it concerning. Notably, statement *PersAds* was also the only one where the level of concern was higher for AR than for VR.

For both technologies, the agreement in relation to the concern and previous consideration of the statements highly correlates. The statements with the most (*SocIso*) and least (*UnexHorr*) agreement for AR and the most (*PrefVirt*) and least (*PersAds*) agreement for VR are the same for both questions. Figure 6 in the Appendix furthermore gives the detailed Likert-scale results.

6 Discussion

We conducted a two-part online study to understand the public's perception of XR technologies. We discuss the two research questions stated in the contribution statement.

6.1 Revisiting RQ1: What *potential impacts* does the public perceive from VR and AR technologies *on their lives and on society,* respectively?

Although the frequencies of the implications vary between VR and AR, the underlying sentiments and considerations are similar across both technologies. AR was predominantly viewed as a functional tool rather than an entertainment device. Participants specifically emphasized the convenience of AR devices for their accessibility, availability, and versatility in accessing diverse information, likely because they primarily associate AR with productivity enhancement and real-time information delivery. VR devices were often viewed in different contexts, as participants described them as less flexible due to their stationary nature. One exception could be remote working, where they could effectively function within a single room. VR devices were primarily perceived as a gaming and entertainment tool similar to other gaming devices, prompting concerns about addiction. This aligns with the current marketing strategies for these technologies, where VR is primarily advertised for gaming while AR is promoted as a tool for enhancing productivity. **This gap between the capabilities of current XR devices and public perceptions highlights the need for better alignment between device design, marketing, and user education.** While modern VR and AR devices are increasingly versatile, they are still perceived as serving distinct purposes: AR for productivity and VR for entertainment. Researchers and developers should address these misconceptions by showcasing the multifunctionality of XR technologies and designing features that emphasize flexibility and adaptability. The industry can help reshape public understanding and encourage broader adoption by promoting use cases that challenge these perceptions. One example could be the continuous adjustment from a VR to an AR environment made possible by the Apple Vision Pro[4], but its usefulness, and therefore its impact, has yet to be seen.

As outlined in Section 2, previous work explored novel challenges of XR [18, 37], including potential surveillance risks and bystander privacy concerns arising from an unintentional recording by XR sensors. Participants voiced similar concerns for both AR and VR, expressing worries about both their safety and the privacy of others, particularly regarding hacking risks and susceptibility to data breaches, which could compromise various types of personal data and lead to misuse and privacy violations. Additionally, VR raises greater concerns regarding overall health, yet it also offers the added benefit of positively impacting physical

[4]https://www.apple.com/apple-vision-pro/, last accessed on 2025-05-31.

activity. Generally, participants viewed XR as a dual-natured technology, which is evident from the similar categories of its positive and negative effects. They believed that XR could significantly enhance health and cognitive functions but recognized its potential drawbacks. Similarly, while XR could enable greater socioeconomic opportunities by allowing individuals to work and socialize in ways previously inaccessible, it also risks marginalizing those unable to use such technologies due to health, economic, or ethical reasons. Participants observed that individuals prone to abuse and addiction could be significantly affected by the advent of more realistic and widespread XR technologies. Frequently, they did not view the progression of XR strictly in terms of positive or negative outcomes. Instead, they highlighted its potential to widen the social gap, enabling some people to find new ways of working and entertaining while simultaneously disenfranchising others. Companies selling XR devices and applications must ensure that these remain affordable for a wide spectrum of society, with low-tier devices potentially being one option to remedy this. **Particularly in educational and professional settings, it's crucial to offer viable alternatives to ensure that individuals who cannot or choose not to engage in XR are not excluded.** Both VR and AR remain simultaneously transformative and potentially divisive technologies, and the public image of these technologies supports this. Their capacity to enhance accessibility, enable remote work, and foster creative innovation goes strictly hand-in-hand with the high cost of entry, reliance on advanced hardware, and digital literacy requirements that can create barriers for economically or socially disadvantaged groups, potentially deepening inequalities.

Participants expressed concerns about encountering violence or strange behaviors in both VR and AR environments, mirroring the findings of the upcoming section and emphasizing the consequences of exposure to violence or harmful actions leading to desensitization or imitative behavior in XR environments. For cases of misuse in AR, participants were more focused on the concentration of unverified, biased, or false data, particularly concerning how incorrect data displayed on AR devices could lead to errors that may impact people's lives, whether intentionally or accidentally propagated. For VR, the primary concern expressed was the theft of private and personal data. Ultimately, a greater number of participants expressed concerns about AR devices malfunctioning during use, particularly in work settings, which could pose risks to the user. Many noted AR glasses' current bulkiness and size, while the unclear quality of realism associated with current VR devices was noted often. We recommend that XR designers use the distinct functionalities and sentiments associated with VR and AR technologies. Incorporating robust protection mechanisms, such as privacy and security measures, is a given. **Yet, more education on how these devices work, what sensors they require, and proactively providing information on what data is acquired, processed, used, and shared might help to reduce or at least situate these concerns better.**

All in all, to maximize their transformative potential while minimizing their divisive effects, it is essential to address accessibility, privacy, and security concerns proactively and inclusively. Equally important is ensuring that alternatives to XR remain viable and accessible, allowing individuals to opt out of XR experiences without being excluded from essential aspects of life. Maintaining this choice is crucial to ensuring that XR enhances societal progress without becoming a mandatory or exclusive element of participation in education, work, or social engagement. Additionally, public education and understanding of these technologies need significant improvement, with greater emphasis placed on showcasing the versatility of current XR devices to challenge the currently assumed narrow use cases and promote their broader adoption, where applicable and wanted.

6.2 Revisiting RQ2: How does the public perceive *psychological and social implications* surrounding VR and AR technologies, respectively?

With "The Ethics of Realism in Virtual and Augmented Reality" [48] identifying potential psychological and social implications of anticipated advancements in XR, the question of current public perceptions regarding them remained. Our observation aligns with the longer availability of VR devices to consumers despite their relatively low market share compared to ubiquitous technologies like smartphones. Over half of the participants had previously contemplated the implications presented in the study, particularly the ones involving detachment from reality and the blurred lines between real and virtual worlds. Although the percentage of prior consideration varies, even the least contemplated VR implication (i.e., persuasive advertisement) had been considered by about a third of the participants. **XR developers and policymakers must ensure that the advantages of AR are not overshadowed by the aim of interested third parties to capture users' attention through their pervasive nature.**

The implication of persuasive advertisements is the only one that was more frequently considered in the context of AR, suggesting that commercial influence raises greater concerns when it occurs in the real world as opposed to a virtual setting. Although AR devices are usually designed to facilitate normal interactions within the real world, social isolation has emerged as the most frequently considered and concerning implication among participants. Next to VR's potential to isolate users by replacing their real surroundings, AR may, therefore, also face greater societal resistance than previously anticipated. Aside from persuasive advertisements, VR currently evokes more concerns among participants. However, there are variations in the implications; about two-thirds and half of the participants, on average, express concern for VR and AR, respectively. **This indicates that most of the public recognizes the potential negative implications of the continued development of XR technologies.**

Yet, it remains uncertain how many people would consider these implications without being directly prompted. The results in our study are mixed, with all implications having been thought about before being asked about them by parts of the participant pool, but none were unanimously considered or rejected. Furthermore, as new devices are introduced, these findings represent only a snapshot in time and could shift in various directions in the coming years. XR designers can leverage these insights by prioritizing the transparency, user empowerment, and ethical considerations of their interface designs. **Understanding that the public is already concerned about XR systems in their surroundings,**

even if just in parts, designers must strive to address these apprehensions through clear communication, intuitive interfaces, and mechanisms that empower users to control their XR experiences transparently.

6.3 Limitations and Future Work

Regarding *Part I*, perceptions could shift significantly if people experience XR technologies firsthand rather than reading about them in an online survey. As such, this research can only provide a snapshot of current opinions that will likely change as more devices approach market readiness. Future work could look into the difference that hands-on experiences make with XR devices. Future studies could also explore whether attitudes towards AR and VR converge as cross-reality systems within the XR spectrum become more prevalent.

For *Part II*, participant responses were likely influenced by the phrasing and overall framing of the questions and statements. While the findings provide insight into general public perceptions, further detailed investigations are necessary to clarify responses to particular use cases and devices.

In general, while the online research platform Prolific offers access to a typically broader and more diverse participant pool than relying on local recruitment, it still has limitations, such as self-selection bias and an overrepresentation of individuals familiar with online research platforms. These factors may influence the generalizability of findings to the wider public. While the sample size of 150 participants provides only a rough estimate of current perceptions and represents just a snapshot in time, the results were kept broad enough to avoid overclaiming. In the same vein, we did not conduct more fine-grained demographic-based analyses, as this would require a much larger sample size to ensure rigor and reliability. However, exploring how factors such as age or general technical savviness might influence perceptions could offer valuable insights in future research. Attention checks were implemented to ensure that participants engaged with the survey as intended, and initial introductions to the technologies were provided to reduce reliance on prior knowledge. If feasible, leveraging a broader participant pool and conducting longer-term studies would enhance the reliability and depth of insights gathered in potential future works.

7 Conclusion

This work explored current public perceptions of XR technologies and applications, drawing insights from qualitative and quantitative data to understand the societal reception and concerns associated with these technologies. Our findings highlight a complex mix of both opportunity and caution expressed by the participants. The results show that VR technologies are more familiar to the public, possibly due to their earlier introduction into the market and prevalent use in gaming. This familiarity has led to a higher level of contemplation among participants regarding the implications of realism within XR, particularly around issues such as social isolation and the blending of virtual with real life. Conversely, AR is perceived more as a tool for productivity, aligning with its current market positioning. However, the potential for AR to cause issues in distinguishing the real from the virtual was stated as a major concern by our participants, suggesting that public perceptions could affect its future adoption and societal integration. Concerns such as data privacy, the risk of addiction, and the potential for increased socioeconomic disparities were prominent. These issues highlight the dual-edged nature of XR technologies, capable of both enhancing human capabilities and exacerbating existing societal issues. Future research might aim to take a closer look at the specific contexts and scenarios where XR could have significant impacts. Such studies will be essential for developing guidelines and frameworks to ensure that the advancement of XR technologies aligns with ethical standards and meets public expectations. As XR continues to grow and will reach ubiquity, understanding and addressing public concerns will be key to unlocking the full potential of these technologies in a manner that benefits all parts of society.

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References

[1] Abdullah M. Al-Ansi, Mohammed Jaboob, Askar Garad, and Ahmed Al-Ansi. 2023. Analyzing Augmented Reality (AR) and Virtual Reality (VR) Recent Development in Education. *Social Sciences & Humanities Open* 8, 1 (Jan. 2023), 100532. https://doi.org/10.1016/j.ssaho.2023.100532

[2] Cecilia Avila-Garzon, Jorge Bacca-Acosta, Kinshuk, Joan Duarte, and Juan Betancourt. 2021. Augmented Reality in Education: An Overview of Twenty-Five Years of Research. *Contemporary Educational Technology* 13, 3 (April 2021), ep302. https://doi.org/10.30935/cedtech/10865

[3] Mahdi Azmandian, Mark Hancock, Hrvoje Benko, Eyal Ofek, and Andrew D. Wilson. 2016. Haptic Retargeting: Dynamic Repurposing of Passive Haptics for Enhanced Virtual Reality Experiences. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. Association for Computing Machinery, New York, NY, USA, 1968–1979. https://doi.org/10.1145/2858036.2858226

[4] Miguel Barreda-Ángeles and Tilo Hartmann. 2022. Hooked on the Metaverse? Exploring the Prevalence of Addiction to Virtual Reality Applications. *Frontiers in Virtual Reality* 3 (Nov. 2022), 9. https://doi.org/10.3389/frvir.2022.1031697

[5] Nuri Basoglu, Muge Goken, Marina Dabic, Dilek Ozdemir Gungor, and Tugrul U. Daim. 2018. Exploring Adoption of Augmented Reality Smart Glasses: Applications in the Medical Industry. *Frontiers of Engineering Management* 0, 0 (2018), 0. https://doi.org/10.15302/J-FEM-2018056

[6] Ann Blandford, Dominic Furniss, and Stephann Makri. 2016. Qualitative HCI Research: Going Behind the Scenes. *Synthesis Lectures on Human-Centered Informatics* 9, 1 (April 2016), 1–115. https://doi.org/10.2200/S00706ED1V01Y201602HCI034

[7] Sebastian Büttner, Henrik Mucha, Markus Funk, Thomas Kosch, Mario Aehnelt, Sebastian Robert, and Carsten Röcker. 2017. The Design Space of Augmented and Virtual Reality Applications for Assistive Environments in Manufacturing: A Visual Approach. In *Proceedings of the 10th International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '17)*. Association for Computing Machinery, New York, NY, USA, 433–440. https://doi.org/10.1145/3056540.3076193

[8] Peter Casey, Ibrahim Baggili, and Ananya Yarramreddy. 2021. Immersive Virtual Reality Attacks and the Human Joystick. *IEEE Transactions on Dependable and Secure Computing* 18, 2 (March 2021), 550–562. https://doi.org/10.1109/TDSC.2019.2907942

[9] Song Chen, Zupei Li, Fabrizio Dangelo, Chao Gao, and Xinwen Fu. 2018. A Case Study of Security and Privacy Threats from Augmented Reality (AR). In *2018 International Conference on Computing, Networking and Communications (ICNC)*. IEEE, Maui, HI, 442–446. https://doi.org/10.1109/ICCNC.2018.8390291

[10] Adrian David Cheok, Michael Haller, Owen Noel Newton Fernando, and Janaka Prasad Wijesena. 2009. Mixed Reality Entertainment and Art. *International Journal of Virtual Reality* 8, 2 (Jan. 2009), 83–90. https://doi.org/10.20870/IJVR.2009.8.2.2729

[11] Daniel J. Cucher, Melissa S. Kovacs, Clarence E. Clark, and Charles K. P. Hu. 2023. Virtual Reality Consumer Product Injuries: An Analysis of National Emergency Department Data. *Injury* 54, 5 (May 2023), 1396–1399. https://doi.org/10.1016/j.injury.2023.01.030

[12] Negin Dahya, W.E. King, Kung Jin Lee, and Jin Ha Lee. 2021. Perceptions and Experiences of Virtual Reality in Public Libraries. *Journal of Documentation* 77, 3 (Jan. 2021), 617–637. https://doi.org/10.1108/JD-04-2020-0051

[13] Jeremy Dalton. 2021. *Reality Check: How Immersive Technologies Can Transform Your Business*. Kogan Page Publishers, London, United Kingdom.

[14] Jaybie A. De Guzman, Kanchana Thilakarathna, and Aruna Seneviratne. 2019. Security and Privacy Approaches in Mixed Reality: A Literature Survey. *Comput. Surveys* 52, 6 (Oct. 2019), 110:1–110:37. https://doi.org/10.1145/3359626

[15] Chloe Eghtebas, Gudrun Klinker, Susanne Boll, and Marion Koelle. 2023. Co-Speculating on Dark Scenarios and Unintended Consequences of a Ubiquitous(Ly) Augmented Reality. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23)*. Association for Computing Machinery, New York, NY, USA, 2392–2407. https://doi.org/10.1145/3563657.3596073

[16] Mana Farshid, Jeannette Paschen, Theresa Eriksson, and Jan Kietzmann. 2018. Go Boldly!: Explore Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) for Business. *Business Horizons* 61, 5 (Sept. 2018), 657–663. https://doi.org/10.1016/j.bushor.2018.05.009

[17] Government Accountability Office. 2022. *Gao-22-105541.Pdf*. Technical Report GAO-22-105541. Government Accountability Office, Washington, D.C.

[18] Jan Gugenheimer, Christian Mai, Mark McGill, Julie Williamson, Frank Steinicke, and Ken Perlin. 2019. Challenges Using Head-Mounted Displays in Shared and Social Spaces. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, Glasgow Scotland Uk, 1–8. https://doi.org/10.1145/3290607.3299028

[19] Jan Gugenheimer, Mark McGill, Samuel Huron, Christian Mai, Julie Williamson, and Michael Nebeling. 2020. Exploring Potentially Abusive Ethical, Social and Political Implications of Mixed Reality Research in HCI. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/3334480.3375180

[20] Jan Gugenheimer, Wen-Jie Tseng, Abraham Hani Mhaidli, Jan Ole Rixen, Mark McGill, Michael Nebeling, Mohamed Khamis, Florian Schaub, and Sanchari Das. 2022. Novel Challenges of Safety, Security and Privacy in Extended Reality. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems (CHI EA '22)*. Association for Computing Machinery, New York, NY, USA, 1–5. https://doi.org/10.1145/3491101.3503741

[21] Yuntao Guo, Shubham Agrawal, Srinivas Peeta, and Irina Benedyk. 2021. Safety and Health Perceptions of Location-Based Augmented Reality Gaming App and Their Implications. *Accident Analysis & Prevention* 161 (Oct. 2021), 106354. https://doi.org/10.1016/j.aap.2021.106354

[22] David Harborth. 2019. Unfolding Concerns about Augmented Reality Technologies: A Qualitative Analysis of User Perceptions. In *Wirtschaftsinformatik 2019 Proceedings*. Univ. Siegen, Siegen, 15.

[23] Min Chai Hsieh and Jia Jin Lee. 2018. Preliminary Study of VR and AR Applications in Medical and Healthcare Education. *Journal of Nursing and Health Studies* 03, 01 (2018), 5. https://doi.org/10.21767/2574-2825.100030

[24] C.E. Hughes, C.B. Stapleton, D.E. Hughes, and E.M. Smith. 2005. Mixed Reality in Education, Entertainment, and Training. *IEEE Computer Graphics and Applications* 25, 6 (Nov. 2005), 24–30. https://doi.org/10.1109/MCG.2005.139

[25] Shiu-Wan Hung, Che-Wei Chang, and Yu-Chen Ma. 2021. A New Reality: Exploring Continuance Intention to Use Mobile Augmented Reality for Entertainment Purposes. *Technology in Society* 67 (Nov. 2021), 101757. https://doi.org/10.1016/j.techsoc.2021.101757

[26] Christopher Katins, Sebastian S. Feger, and Thomas Kosch. 2023. Exploring Mixed Reality in General Aviation to Support Pilot Workload. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems (CHI EA '23)*. Association for Computing Machinery, New York, NY, USA, 1–7. https://doi.org/10.1145/3544549.3585742

[27] Christopher Katins, Jannis Strecker, Jan Hinrichs, Pascal Knierim, Bastian Pfleging, and Thomas Kosch. 2025. Ad-Blocked Reality: Evaluating User Perceptions of Content Blocking Concepts Using Extended Reality. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–18. https://doi.org/10.1145/3706598.3713230

[28] Christopher Katins, Paweł W. Woźniak, Aodi Chen, Ihsan Tumay, Luu Viet Trinh Le, John Uschold, and Thomas Kosch. 2024. Assessing User Apprehensions about Mixed Reality Artifacts and Applications: The Mixed Reality Concerns (MRC) Questionnaire. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24)*. ACM, New York, NY, USA, 13. https://doi.org/10.1145/3613904.3642631

[29] Mara Kaufeld, Martin Mundt, Sarah Forst, and Heiko Hecht. 2022. Optical See-through Augmented Reality Can Induce Severe Motion Sickness. *Displays* 74 (Sept. 2022), 102283. https://doi.org/10.1016/j.displa.2022.102283

[30] Michelle Sophie Keller, Hannah J. Park, Maria Elena Cunningham, Joshua Eleazar Fouladian, Michelle Chen, and Brennan Mason Ross Spiegel. 2017. Public Perceptions Regarding Use of Virtual Reality in Health Care: A Social Media Content Analysis Using Facebook. *Journal of Medical Internet Research* 19, 12 (Dec. 2017), e7467. https://doi.org/10.2196/jmir.7467

[31] Rebecca Kirkham and Caitlin Batten. 2020. Public Perceptions on Using Virtual Reality and Mobile Apps in Anxiety Treatment: A Cross Sectional Analysis. *Reinvention: an International Journal of Undergraduate Research* 13, 2 (Oct. 2020), 37. https://doi.org/10.31273/reinvention.v13i2.625

[32] Thomas Kosch, Andrii Matviienko, Florian Müller, Jessica Bersch, Christopher Katins, Dominik Schön, and Max Mühlhäuser. 2022. NotiBike: Assessing Target Selection Techniques for Cyclist Notifications in Augmented Reality. *Proceedings of the ACM on Human-Computer Interaction* 6, MHCI (2022), 1–24.

[33] Lan Li, Fei Yu, Dongquan Shi, Jianping Shi, Zongjun Tian, Jiquan Yang, Xingsong Wang, and Qing Jiang. 2017. Application of Virtual Reality Technology in Clinical Medicine. *American Journal of Translational Research* 9, 9 (2017), 3867.

[34] Richard McPherson, Suman Jana, and Vitaly Shmatikov. 2015. No Escape From Reality: Security and Privacy of Augmented Reality Browsers. In *Proceedings of the 24th International Conference on World Wide Web*. International World Wide Web Conferences Steering Committee, Florence Italy, 743–753. https://doi.org/10.1145/2736277.2741657

[35] Paul Milgram and Fumio Kishino. 1994. A Taxonomy of Mixed Reality Visual Displays. *IEICE TRANSACTIONS on Information and Systems* 77, 12 (Dec. 1994), 1321–1329.

[36] Thomas Moser, Markus Hohlagschwandtner, Gerhard Kormann-Hainzl, Sabine Pölzlbauer, and Josef Wolfartsberger. 2019. Mixed Reality Applications in Industry: Challenges and Research Areas. In *Software Quality: The Complexity and Challenges of Software Engineering and Software Quality in the Cloud (Lecture Notes in Business Information Processing)*, Dietmar Winkler, Stefan Biffl, and Johannes Bergsmann (Eds.). Springer International Publishing, Cham, 95–105. https://doi.org/10.1007/978-3-030-05767-1_7

[37] Helen Nissenbaum. 2009. Privacy in Context: Technology, Policy, and the Integrity of Social Life. In *Privacy in Context*. Stanford University Press, Redwood City, USA. https://doi.org/10.1515/9780804772891

[38] Naheem Noah, Sommer Shearer, and Sanchari Das. 2022. Security and Privacy Evaluation of Popular Augmented and Virtual Reality Technologies. https://doi.org/10.2139/ssrn.4173372 social science research network:4173372

[39] Chamath Rathnasekara, Tharindu Athukorala, Lahiru Dikwellage, Udith Wickramasuriya, Amila Senarathne, and Sandunika Elvitigala. 2017. Securing Corporate Data in Mobile Devices in a COPE Environment. In *2017 6th National Conference on Technology and Management (NCTM)*. IEEE, New York, NY, 120–125. https://doi.org/10.1109/NCTM.2017.7872839

[40] Philipp A. Rauschnabel, Reto Felix, Chris Hinsch, Hamza Shahab, and Florian Alt. 2022. What Is XR? Towards a Framework for Augmented and Virtual Reality. *Computers in Human Behavior* 133 (Aug. 2022), 107289. https://doi.org/10.1016/j.chb.2022.107289

[41] Philipp A. Rauschnabel, Jun He, and Young K. Ro. 2018. Antecedents to the Adoption of Augmented Reality Smart Glasses: A Closer Look at Privacy Risks. *Journal of Business Research* 92 (Nov. 2018), 374–384. https://doi.org/10.1016/j.jbusres.2018.08.008

[42] Holger Regenbrecht, Sander Zwanenburg, and Tobias Langlotz. 2022. Pervasive Augmented Reality—Technology and Ethics. *IEEE Pervasive Computing* 21, 3 (July 2022), 84–91. https://doi.org/10.1109/MPRV.2022.3152993

[43] Franziska Roesner and Tadayoshi Kohno. 2021. Security and Privacy for Augmented Reality: Our 10-Year Retrospective. In *1st International Workshop on Security for XR and XR for Security (VR4Sec)*. USENIX, Berkeley, CA, 5.

[44] Kimberly Ruth, Tadayoshi Kohno, and Franziska Roesner. 2019. Secure Multi-User Content Sharing for Augmented Reality Applications. In *Proceedings of the 28th USENIX Conference on Security Symposium (SEC'19)*. USENIX Association, USA, 141–158.

[45] Adrian Sarbach and Thierry Robin Weber. 2025. Next-Generation Navigation: Evaluating the Impact of Augmented Reality on Situation Awareness in General Aviation Cockpits. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*. Association for Computing Machinery, New York, NY, USA, 1–18. https://doi.org/10.1145/3706598.3713597

[46] Robert Segal, Maneet Bhatia, and Martin Drapeau. 2011. Therapists' Perception of Benefits and Costs of Using Virtual Reality Treatments. *Cyberpsychology, behavior and social networking* 14 (Jan. 2011), 29–34. https://doi.org/10.1089/cyber.2009.0398

[47] Maeve Serino, Kyla Cordrey, Laura McLaughlin, and Ruth L. Milanaik. 2016. Pokémon Go and Augmented Virtual Reality Games: A Cautionary Commentary for Parents and Pediatricians. *Current Opinion in Pediatrics* 28, 5 (Oct. 2016), 673. https://doi.org/10.1097/MOP.0000000000000409

[48] Mel Slater, Cristina Gonzalez-Liencres, Patrick Haggard, Charlotte Vinkers, Rebecca Gregory-Clarke, Steve Jelley, Zillah Watson, Graham Breen, Raz Schwarz, William Steptoe, Dalila Szostak, Shivashankar Halan, Deborah Fox, and Jeremy Silver. 2020. The Ethics of Realism in Virtual and Augmented Reality. *Frontiers in Virtual Reality* 1 (March 2020), 1. https://doi.org/10.3389/frvir.2020.00001

[49] Hanna Stockinger. 2015. Consumers' Perception of Augmented Reality as an Emerging End User Technology: Social Media Monitoring Applied. *KI - Künstliche Intelligenz* 29, 4 (Nov. 2015), 419–439. https://doi.org/10.1007/s13218-015-0389-5

[50] Robert Templeman, Mohammed Korayem, David Crandall, and Apu Kapadia. 2014. PlaceAvoider: Steering First-Person Cameras Away from Sensitive Spaces. In *NDSS '14*. Internet Society, Fredericksburg, VA, 15. https://doi.org/10.14722/ndss.2014.23014

[51] Derianna Thomas and Lars Erik Holmquist. 2021. Is Functionality All That Matters? Examining Everyday User Opinions of Augmented Reality Devices.

In *2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. IEEE, Lisbon, Portugal, 232–237. https://doi.org/10.1109/VRW52623.2021.00050

[52] Alexandra Thompson and Leigh Ellen Potter. 2020. Overlays and Goggles and Projections, Oh My! Exploring Public Perceptions of Augmented Reality Technologies. In *Proceedings of the 31st Australian Conference on Human-Computer-Interaction (OzCHI '19)*. Association for Computing Machinery, New York, NY, USA, 295–301. https://doi.org/10.1145/3369457.3369482

[53] Wen-Jie Tseng, Elise Bonnail, Mark McGill, Mohamed Khamis, Eric Lecolinet, Samuel Huron, and Jan Gugenheimer. 2022. The Dark Side of Perceptual Manipulations in Virtual Reality. In *CHI Conference on Human Factors in Computing Systems*. ACM, New York, NY, 1–15. https://doi.org/10.1145/3491102.3517728 arXiv:2202.13200 [cs]

[54] Dafnis Cain Villagran-Vizcarra, David Luviano-Cruz, Luis Asunción Pérez-Domínguez, Luis Carlos Méndez-González, and Francesco Garcia-Luna. 2023. Applications Analyses, Challenges and Development of Augmented Reality in Education, Industry, Marketing, Medicine, and Entertainment. *Applied Sciences* 13, 5 (Jan. 2023), 2766. https://doi.org/10.3390/app13052766

[55] Karthik Viswanathan and Abbas Yazdinejad. 2022. Security Considerations for Virtual Reality Systems. https://doi.org/10.48550/arXiv.2201.02563 arXiv:2201.02563 [cs]

[56] Graham Wilson and Mark McGill. 2018. Violent Video Games in Virtual Reality: Re-Evaluating the Impact and Rating of Interactive Experiences. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '18)*. Association for Computing Machinery, New York, NY, USA, 535–548. https://doi.org/10.1145/3242671.3242684

A Appendix

Table 3: Category Distributions for Positive Impacts.

Category Label	AR		VR	
	Percentage	**n**	**Percentage**	**n**
Immersion and Visualization	**17.25 %**	**80**	**14.14 %**	**65**
Immersive Virtual Interactions	5.82 %	27	8.70 %	40
Advanced Immersive Visualizations	7.33 %	34	5.22 %	24
Fusion of Reality and Virtuality	4.10 %	19	0.22 %	1
Assistance and Training	**19.63 %**	**91**	**15.66 %**	**72**
Task-Based Assistance	10.78 %	50	0.22 %	1
Training in the Workfield	4.75 %	22	10.22 %	47
Education in General	4.10 %	19	5.22 %	24
Access and Availability	**17.05 %**	**79**	**3.05 %**	**14**
Remote Access to Workplace	4.75 %	22	3.05 %	14
Data Availability in General	6.04 %	28	0.00 %	0
Improved Multitasking	4.32 %	20	0.00 %	0
Practicability	1.94 %	9	0.00 %	0
Enjoyment	**15.12 %**	**70**	**39.59 %**	**182**
Entertainment and Gaming	8.63 %	40	18.48 %	85
Gaining New Experiences	0.87 %	4	10.66 %	49
Improved Social Connections	5.18 %	24	6.53 %	30
Escaping Reality for Relaxation	0.44 %	2	3.92 %	18
Health and Cognition	**6.69 %**	**31**	**10.45 %**	**48**
Mental Health Improvements	1.94 %	9	2.83 %	13
Physical Health Improvements	1.51 %	7	2.83 %	13
Improved Safety at Work	3.24 %	15	4.79 %	22
Socioeconomics	**20.71 %**	**96**	**13.49 %**	**62**
Catalyst for More Innovation	5.61 %	26	2.18 %	10
Efficiency in the Workplace	11.86 %	55	3.70 %	17
Improved Accessibility	3.24 %	15	7.61 %	35
Other	**3.67 %**	**17**	**3.70 %**	**17**
Total		***464***		***460***

Table 4: Category Distributions for Negative Impacts.

Category Label	AR		VR	
	Percentage	n	Percentage	n
Withdrawing From Reality	**15.17 %**	**69**	**26.82%**	**123**
Reduced Real-Life Interactions	10.33 %	47	12.21 %	56
Isolation from Social Commitments	2.42 %	11	5.89 %	27
Full Disengagement	2.42 %	11	8.72 %	40
Excessive Use	**16.28 %**	**74**	**10.68 %**	**49**
Issues to Distinguish Reality From Virtuality	4.62 %	21	7.19 %	33
Overreliance and Overtrust	8.14 %	37	2.18 %	10
Procrastination and Distraction	3.52 %	16	1.31 %	6
Privacy, Security, and Crime	**9.68 %**	**44**	**7.20 %**	**33**
Reduced User Privacy	4.18 %	19	1.09 %	5
General Misuse by Third Parties	5.50 %	25	6.11 %	28
Device Specific Limitations	**18.48 %**	**84**	**9,38 %**	**43**
Disorientation, Fall/Accident Risk	8.14 %	37	5.45 %	25
Technical Limitations in General	8.36 %	38	3.49 %	16
Challenging to Use	1.98 %	9	0.44 %	2
Health and Cognition	**20.02 %**	**91**	**29.65 %**	**136**
Mental Health Decline	5.50 %	25	6.11 %	28
Physical Health Decline	5.94 %	27	10.46 %	48
Addiction to the Virtual World	3.08 %	14	8.72 %	40
Loss of Skills	4.40 %	20	1.09 %	5
Motion Sickness	1.10 %	5	3.27 %	15
Socioeconomics	**15.18 %**	**69**	**13.30 %**	**61**
Loss of Jobs	3.52 %	16	2.18 %	10
Reinforcing Social Disparities	5.06 %	23	4.80 %	22
Excessive Cost and Maintenance	6.60 %	30	6.32 %	29
Other	**5.28 %**	**24**	**3.06 %**	**14**
Total		***455***		***459***

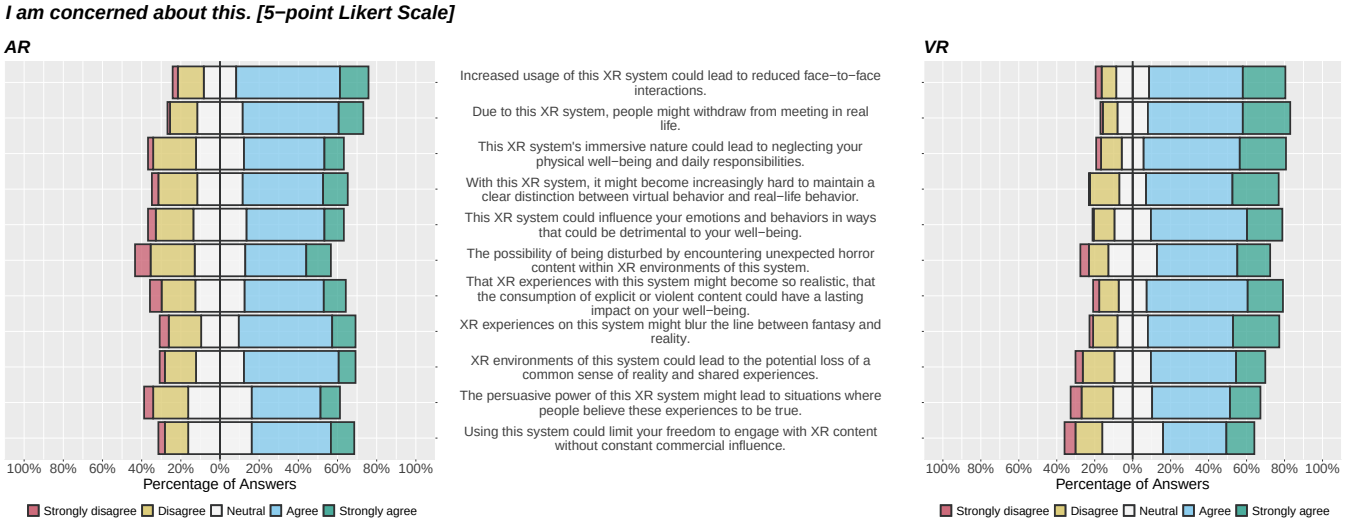

Figure 6: The full results of the 5-item Likert scale evaluated agreement of the participants with the statements as described in Table 2.