Identifying Manipulative Advertising Techniques in XR Through Scenario Construction

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ABSTRACT

As Extended Reality (XR) devices and applications become more mainstream, so too will XR advertising — advertising that takes place in XR mediums. Due to the defining features of XR devices, such as the immersivity of the medium and the ability of XR devices to simulate reality, there are fears that these features could be exploited to create manipulative XR ads that trick consumers into buying products they do not need or might harm them. Using scenario construction, we investigate potential future incarnations of manipulative XR advertising and their harms. We identify five key mechanisms of manipulative XR advertising: misleading experience marketing; inducing artificial emotions in consumers; sensing and targeting people when they are vulnerable; emotional manipulation through hyperpersonalization; and distortion of reality. We discuss research challenges and questions in order to address and mitigate manipulative XR advertising risks.

CCS CONCEPTS

• **Security and privacy** → *Social aspects of security and privacy*; • **Human-centered computing** → **Mixed / augmented reality**; **Virtual reality**; **Scenario-based design**.

KEYWORDS

Extended reality, mixed reality, advertising, virtual reality, augmented reality, scenario construction, privacy, computer ethics.

1 INTRODUCTION

Extended Reality (XR) devices and applications, such as Virtual Reality (VR) headsets and Augmented Reality (AR) smartphone apps, are becoming increasingly popular, with many predicting that in just a few years these sort of devices will become ubiquitous and widely used [92]. For context about the growth of XR technologies,
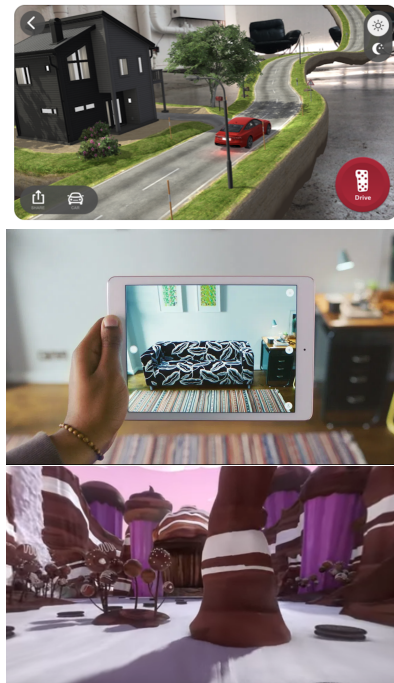
Figure 1: Current examples of XR advertising. From top to bottom: (1) Screenshot of an Audi AR ad that allows consumers to drive an Audi car in their own living room [34]. (2) AR experience marketing from IKEA that allows a consumer to superimpose furniture onto their living room, so they can preview what furniture would look like in their home [63]. (3) Screenshot of a VR ad from Oreo that allows consumers to explore a fictional, fantastical cookie factory where Oreo cookies are made [112].

the global VR market size was valued at $10.3 billion in 2019, and is predicted to reach $62.1 billion in 2027 [48]. Similarly, the global AR market size was valued at $8.0 billion in 2020, and is predicted to reach $100.2 billion in 2024 [47].

Alongside the proliferation of XR, advertising has become a common monetization model in XR applications [17]. Examples of XR ads include placing designs on beverage bottles that consumers can scan with their smartphones to augment the bottle in playful and interactive ways [89]; games that allow a consumer to pretend they are driving a luxury car in their living room [34]; and mirrors that allow a consumer to preview what they might look like with certain makeup or clothing on [105] (see Figure 1 for more examples). Currently, the XR advertising market is small compared

to more traditional advertising markets, such as TV or online advertising [17, 116]. However, there are signs that this market will soon grow, with many companies exploring and developing XR advertisements and respective technology [66].

XR advertising will present new and exciting ways for businesses to promote their products and services to consumers. Promised features of XR technologies, such as increased immersivity and interactivity of XR environments; the ability to render photorealistic graphics in front of and around consumers; and the sensing capabilities of XR devices all promise to usher in a new era of business-consumer interaction [127]. However, these same characteristics could also result in XR advertising posing unprecedented risks to consumers. New forms of XR advertising could pave the way for new types of *manipulative advertising* — tricking consumers into buying products they do not want or need, potentially convincing consumers to buy products that are actively detrimental to their health and well-being.

The increased immersivity and interactivity of XR environments could be used to make dangerous products seem playful and fun. Realistic three-dimensional experiences in future XR generations could alter a consumer's perception of reality, changing what products they want to purchase. The numerous sensors and data collection capabilities of XR devices present new and dangerous privacy risks for consumers, which may be leveraged for advertising. Advertisers could know sensitive information about consumers that renders them susceptible to certain advertisements, such as inferring consumer's emotional state to gauge when they are emotionally vulnerable. Some of these harms are unique and novel to XR advertising; others have already existed in other forms of advertising, but XR technologies offer unprecedented scope and scale to these harms.

A conundrum of studying such future consumer risks is that today's XR technologies may be a poor proxy of near-future capabilities. To overcome this problem, we utilize *scenario construction* — analyzing current technologies and trends to construct informed narratives, or scenarios, regarding how a technology could be used in the future [33, 78, 100, 128, 132]. This method is often used in predicting and imagining the future [14, 78], as well as for surfacing ethical tensions and impacts of various technologies [91, 128]. Scenario construction is, therefore, well suited for exploring potential future incarnations of manipulative XR advertising and their harms.

In this paper, we use this method to construct scenarios that project out from current XR capabilities, XR research, and documented harms of other advertising techniques to illustrate ways in which future XR advertising is likely to be manipulative. We describe seven scenarios for manipulative XR advertising. From these scenarios, we identify five techniques of XR advertising manipulation: misleading experience marketing; inducing artificial emotions in consumers; targeting people when they are vulnerable; emotional manipulation through hyperpersonalization; and distortion of reality. Following from these scenarios, we discuss research challenges in the further investigation and mitigation of manipulation in XR advertising.

2 BACKGROUND

We introduce XR technologies and XR advertising. We first discuss definitions of Extended Reality and associated terms. We then talk about XR advertising by walking through examples of current XR advertising techniques.

2.1 What is Extended Reality (XR)?

Extended Reality (XR) has emerged as a catch-all term encompassing technologies that augment or create realities [5, 93, 120], predominantly Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). The XR Safety Initiative defines XR in the following way:

> "Extended Reality (XR) is a fusion of all the realities – including Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) – which consists of technology mediated experiences enabled via a wide spectrum of hardware and software, including sensory interfaces, applications, and infrastructures. XR is often referred to as immersive video content, enhanced media experiences, as well as interactive and multi-dimensional human experiences." [95]

Virtual Reality (VR) refers to technologies that attempt to block out or hide reality and replace it with a virtually generated world, such as through digital graphics [76]. The most widely-used consumer VR device is the VR headset; a head-worn apparatus that immerses the user in a three-dimensional experience, by covering the user's eyes and displaying a 3D environment instead [120].

Augmented Reality (AR) refers to technologies that aim to enhance, or augment, a real environment through digital displays and computer graphics [84], often by superimposing these graphics as overlays onto the physical world. One common AR technology are AR smartphone apps [25]. These apps overlay digital images onto a live video feed from the smartphone's camera. Thus, if one is looking at the smartphone screen, it seems that the digital elements that are created by the app are part of or attached to real-world objects. Another type of AR device is the AR headset, such as the Microsoft Hololens [81] or the Magic Leap One [75]. Similar to VR headsets, a user wears an AR headset over their eyes. The user can still view the world around them, with the headset overlaying digital graphics onto real-world objects the user is seeing. Though popular in fiction, AR headsets have not yet found mainstream adoption.

Mixed Reality (MR) is more difficult to define [114]. Milgram and Kishino popularized the idea of MR being a virtuality continuum with the two extremes being completely real environments and completely virtual environments [84] — mixed reality is anything that lies along this continuum.

Thus, XR technologies encompass any VR, AR, or MR technology. VR headsets, AR smartphone apps, AR headsets, all are part of XR. For the purposes of studying XR advertising, our focus will be on XR technologies that are aimed at consumers; though there are numerous XR devices with industrial applications (e.g., heads-up displays for pilots [35], or VR experiences that simulate work environments in order to train employees [120]), these are not likely to include advertisements due to their context of use, and are therefore of low relevance to our investigation.

2.2 What is XR Advertising?

XR advertising is any form of advertising that takes place in an XR context or is shown on an XR device. There is a variety of ways in which XR has already been used for advertising and marketing [40, 108, 127, 135]. Currently, common XR ad formats include 360° videos and photos [135]; apps that allow users to project products into their real-world environment to preview them (e.g., projecting furniture onto their living room floor) [135]; product placement within XR experiences [135]; location-based AR advertisements, also known as geo-layer (AR applications that require consumers to go to a specific physical location to access content) [108, 135]; projection mapping (projecting images or videos onto already existing surfaces) [40]; magic mirror (using AR mirrors or TV screens where a user sees themselves or their surroundings, but with digital graphics that augment the scene) [108]; active print packaging (AR applications that scan a pattern or item in the real world to unlock digital content on a phone screen) [108]; and AR lenses (using a smartphones camera to place images and brand logos onto the user's surroundings) [135].

So far, XR advertising is still in its infancy compared to other advertising markets [17, 116] but there are signs that XR advertising is growing. 75% of Forbes' "World's Most Valuable Brands" have already developed some form of XR advertising [66], including companies such as Pepsi [121], Glenlivet [130], and Audi [34]. A recent survey showed that over 30% of XR apps are monetized through advertising [72]. As XR devices become more ubiquitous, it stands to reason that XR advertising will become ubiquitous as well.

3 RELATED WORK

While research on the prospect of manipulation in XR advertising is scarce, we discuss relevant related work on manipulation in advertising generally, on XR advertising techniques and their effectiveness, and on general ethical issues regarding XR. Few prior work explicitly connects these three realms to the extent we do in our assessment of manipulation potential in XR advertising.

3.1 Manipulation in Advertising

Before studying manipulation in XR advertising, one first has to ask: what constitutes manipulation, especially in the context of advertising? If a business uses an ad to convince you to buy a product, were you manipulated into buying it, or were you persuaded into doing so? Is there anything wrong with a company convincing a consumer to purchase a product?

Scholars have answered this question by separating persuasion from manipulation [12], with the former being considered an acceptable practice and the latter being considered morally objectionable [110]. Persuasion occurs when an advertiser presents their message (i.e., an advertisement) to the consumer, and the consumer rationally debates and evaluates the message, coming to a conclusion on whether to purchase the product or not. Manipulation occurs when advertisers use techniques and methods to make consumers do something involuntarily or something that goes against their best interests [110] — actions which may end up harming the consumer. For example, if an ad succeeds at manipulating a consumer, the consumer could purchase foods that are unhealthy for

them (e.g., eating at fast food restaurants) [118]; engage in habits detrimental to their well-being (e.g., gambling) [51]; lose money by spending on products that end up not being useful to their lives [60, 83]; and in the case of *political* ads that are manipulative, voting for policies and politicians that go against their best interests [28].

Elaborating on the question of manipulation and persuasion, Danciu notes that a single advertisement can have some features that are informative, some features that are persuasive, and some features that are manipulative [30]. Informative features are any factual features of the product that are objectively true (e.g., the name of the product or its price). Persuasive features are rational, logical arguments as to why the consumer should buy the product (e.g., this medicine will alleviate headaches, and so by buying this medicine you will have fewer headaches and a greater quality of life) [30]. Manipulative features are features that encourage consumers to buy a product, but not through rational and logical arguments that characterize persuasive features [30].

There are many types of manipulative advertising features [97]. These features include the use of emotive persuasion (appealing to a consumers emotions, such as by falsely promising extremely high levels of satisfaction or threatening with danger) [30]; outright deception and lying (which sabotages the possibility of rational and logical deliberation) [30]; fallacious arguments (arguments that have erroneous reasoning and logic) [30]; and associative advertising (falsely associating desirable traits with products) [97]. These manipulative features can be accomplished through the use of language, the message content, or by carefully altering visual images that are shown to consumers (e.g., by enhancing images) [30].

Scholars have created taxonomies of manipulative techniques advertisers employ [6, 30]. Armstrong [6] describes general persuasive techniques in advertising in his book; however, some techniques he describes could be classified as manipulation, such as associating products with things that are favorable, inducing emotions such as guilt or fear in consumers, or the use of distraction [6]. In a similar vein, other work has examined the use of dark patterns, i.e, techniques companies use to encourage behaviors users' otherwise might not engage in [20, 49, 74], and nudging, i.e., the alteration of small details, such as the order in which products are displayed or determining which option is the 'default' choice, that significantly impact consumers' behavior [119, 129]. Other work has surveyed and analyzed ads in order to identify the prevalent manipulative advertising techniques [4, 86, 102], finding that manipulative techniques are prevalent in various advertisements and websites. Most of the work in this area has focused on non-XR advertising, such as TV ads, print ads, or digital ads — little attention has been placed on manipulative techniques in XR advertising.

3.2 XR Advertising

The literature that has focused on XR advertising can be broadly divided into two areas: XR advertising techniques and their effectiveness.

Research on XR advertising techniques focuses on the current and future state of XR advertising, hypothesizing about what XR

advertising techniques are possible and studying what XR advertising techniques are currently being used. In Section 2.2 we described numerous papers that described current XR advertising tactics [40, 108, 127, 135]. Other work has focused on the future of XR advertising, looking at the potential that XR advertising can offer to industries. Qin and Lei studied the features of VR advertising, identifying how VR advertising is characterized by increased immersion, interaction, and imagination [98]. Tourism is an area that has received particular attention for XR advertising (e.g., see [53, 69, 77]). Given how XR advertising can recreate reality, XR has the potential to simulate tourist destinations and preview experiences. For instance, allowing consumers to be shown a VR 'tour' of a place before going there, or enhancing tourist spots with AR displays [69].

Other research has focused on the effectiveness of XR advertising at stimulating purchases, with a particular focus on how XR ads compare to traditional, non-XR ads. Here the results are mixed. Some papers suggest XR ads are more effective [111, 127] and others that they are not. For example, Leung at al., [69] find that VR ads were more effective in the short term than traditional video ads, but suffered significant decreases in purchase intention over time. Berki [13] found that two-dimensional banner ads performed better when placed in a virtual, 3D world than compared to being displayed on a traditional computer screen. Wedel et al. [127] highlight that this question of whether XR ads are more effective than non-XR ads remains an open question that needs to be tackled by the research community.

3.3 XR User Harms

Scholars have identified a range of consumer harms in XR technologies. One is that of physical harms, such as nausea or motion sickness caused by headsets [1, 64, 107] or epileptic seizures caused by XR graphics [1]. Another is that of mental harms, such as addiction to alternative realities that are 'better' than actual reality [90, 115]; distress caused by XR experiences that are upsetting and that the user may think are real [15]; how XR experiences allows users to recreate anti-social behaviors (such as violence or murder) in a realistic, immersive virtual environment and the psychological harms this may cause; as well as how the enactment of these behaviors could change how users perceive these behaviors and how likely they are to engage in them (e.g., could committing murder in an XR experience affect one's likelihood of committing murder in real life?) [1, 19].

One harm that has received particular attention are the privacy risks that XR technologies pose [31]. XR devices have vast data collection capabilities, being able to capture information about a user's surroundings such as the layout of the room the user is in [31]; gestures, movements, and activities by the user wearing the XR device [31]; physiological data such as a user's gaze, facial expressions [8], or eyeball movement [31]; and even the data of bystanders [32]. Scholars have investigated not only what are the data collection capabilities of these devices, but also what can be inferred from this data and potential consequences. Miller et al. find that five minutes of body motion data is enough to identify individual consumers [85]. Similarly, VR activity could be used to identify medical conditions such as autism [61] or dementia [117].

OBrolchain et al., in studying social networking sites in virtual reality, hypothesized that the collection of sensitive information could be used to discriminate against certain users [90].

Although XR advertising has sometimes been mentioned, the ethical harms of XR advertising have so far not been explored in depth. If scholars mention the harms of XR advertising, it is often described as an extension of another harm. For example, Obrolchain et al. [90] briefly mention XR advertising, but only as one of the harms within the context of VR social networking sites. Similarly, Adams et al. [1] talk about advertising, but only in one subsection in their broader consideration of XR privacy risks. Specifically, Adams et al. note that one of the privacy risks of XR is that data could be leaked to, among other entities, advertisers, which may in turn affect XR advertising. Similarly, in papers focused on XR advertising techniques, harms are rarely mentioned; and when they are mentioned, it has often come as a subpoint in a discussion section or a concluding thought to the paper without properly engaging with those harms. For example, Barnes et al., in studying the consumer experiences of VR advertising, shortly discuss problems and consumer harms of VR, but only discuss motion sickness [11]. Similarly, Lombard and Snyder-Duch, in studying interactive advertising, mention the ethical dilemmas of immersive advertising and how it "gives new meaning to the term 'deceptive advertising'" but do not unpack it further [73].

Thus, although there has been research on ethical issues and harms of XR technologies and a few mentions of the harms of XR advertising, to our knowledge issues with XR advertising have not been explored more deeply. By unpacking and analyzing the unique and nuanced potential harms of manipulation in the context of XR advertising, we provide insight into these harms and the challenges in mitigating them.

4 METHOD

Our approach for understanding what manipulative XR advertising will look like in the future was inspired by methods such as design fiction [78] and value sensitive design [44] that critically examine future technologies and their ethical implications. After careful consideration, we chose *scenario construction* as our method.

Scenario construction is a process by which, through analyzing current technologies and broader societal and historical trends, narratives (i.e., scenarios) are created describing how a technology could be used in the future [33, 78, 100, 128, 132]. It is a common tool used to both prototype the future [78] as well as analyze the ethical impacts of technologies. Scenario construction is effective at surfacing ethical tensions, impacted stakeholders, and abusive usage of technologies [71, 100, 128].

In our case, scenarios are used to highlight potential instantiations of manipulative XR advertising. For the purpose of identifying what manipulative advertising will look like in XR, we consider scenario construction an ideal method given the future-oriented objective of our work. We conjecture that while XR manipulative advertising may not be a pronounced issue currently, it will be an issue in the near future. Through the developed scenarios, we can explore what different manipulative techniques are likely to emerge in XR advertising.

In constructing scenarios, we aimed to construct narratives that were meaningful, informed, and reflective of future manipulation risks in XR scenarios; moving beyond simple prediction or guess-work into something more accurate and useful [132]. To this end, we ground our research in current XR advertising techniques. However, existing techniques alone are not sufficient to identify future manipulative XR advertising scenarios. Given the relative novelty of XR advertising and the speed at which XR technologies are evolving and changing, new XR advertising techniques are likely to appear and existing ones may become antiquated.

Therefore, we first analyze what features, enabled by XR technology and research, constitute opportunities for XR advertising by carefully studying the literature, current XR devices, advertising techniques, and advertising trends. The identified defining characteristics help ground our scenario construction in development trajectories that manipulative XR advertising techniques are likely to follow.

Second, we construct the manipulative XR advertising scenarios. Despite scenario construction being used by many different researchers and practitioners, there is no universally agreed on process on how to create scenarios, with many different approaches being used. Our scenario construction process takes inspiration from several approaches, namely the SATORI Project [128], Wright et al., [132], and Betten et al. [14], and proceeded as follows. We first searched the literature and popular media to gain an understanding of manipulation in current advertising mediums, consumer-available XR technologies, and current XR advertising examples. With this knowledge, and the previously identified XR advertising features, we asked a series of questions such as:

- Could this existing manipulative advertising technique be replicated in XR?
- How could each of the features of XR advertising exacerbate this manipulative technique?
- How could an already existing XR advertising technique be used by bad actors to manipulate consumers?
- A given XR advertising feature is enabled by a certain XR technology characteristic. How could this be leveraged to manipulate consumers?

Using these prompts, we developed an initial set of scenarios of users interacting with XR ads that were manipulative. We revised and iterated on these scenarios, ensuring that the scenarios were properly grounded and consistent with prior knowledge about advertising, manipulation, and XR, as well as the identified XR advertising features. Once the scenarios were finalized, we chose the subset of distinct scenarios described in Section 6 by removing redundant or overlapping scenarios.

As a way of summarizing and synthesizing the scenarios, we condensed them into the specific ways in which the scenarios were manipulative. We identified five key ways that XR advertising can be manipulative: misleading experience marketing; inducing artificial emotions in consumers; targeting consumers while they are vulnerable; emotional manipulation through hyperpersonalization; and distorting reality. Based on these techniques, we describe research challenges for mitigating associated risks.

5 DEFINING FEATURES OF XR ADVERTISING

We identified the defining characteristics XR advertising by examining the current and proposed capabilities of XR technologies; current examples of XR advertising; relevant literature; and studying trends in how advertising techniques have developed over time. We identify five traits that we anticipate will define future XR advertising and differentiate it from previous forms of advertising. These traits are: (1) greater immersivity (2) extreme realism, (3) previewing products, (4) hyperpersonalization, and (5) pervasive advertising.

5.1 Greater Immersivity — Feeling as Though You Are in the Ad

Immersivity is the feeling of presence and of 'being there' [11]. In the context of XR technologies, this means feeling that one is part of the virtual world being presented, and that the graphics being displayed shape reality. The digital world or enhancements are said to be immersive if the generated sensory stimuli are compelling enough to make the user believe the displays are real and seem to be physically present alongside the user [104].

The immersivity of an experience is not a binary construct; instead, it can be imagined as a point on a spectrum, with some experiences being more or less immersive depending on various traits, such as the level of interactivity, or how well the experience can obscure and make the user ignore the 'real world,' thus presenting the experience as the only reality [73]. XR technologies enable expanding this spectrum, allowing unprecedented forms of immersivity that go far beyond what can be achieved in traditional computer screens by maximizing these traits [73]. For example, XR devices allow greater forms of interactivity; most MR and VR headsets track a user's pose and gaze direction and change what the user is seeing accordingly, which is vastly more interactive than using a mouse to manually move the viewport on a computer screen [73]. Similarly, VR headsets often completely cover a user's eyes, hiding the real world from them; unlike a traditional 2D screen, where a user can simply look away, it is much harder to do so with a VR headset, thus making the experience more immersive [73].

Since XR is more immersive than non-XR mediums, it stands to reason that XR advertising will be more immersive than advertising in other mediums. For example, instead of seeing a product on a TV or computer screen, with XR technologies a user could interact with a digital version of that product by picking it up, rotating it, using it, throwing it, or examining it in detail. An ad shown in a virtual reality headset could potentially surround the user, making it difficult to ignore or look away and making the world presented in the ad to be real and make the consumer feel they are really there.

This increased immersivity and interactivity is important in the context of advertising, given that interactivity and immersiveness make advertising more effective [73]. Scholars have hypothesized that interactivity and immersiveness make ads more effective by two key mechanisms. The first is that increased immersivity and interactivity generate positive feelings by the user which may inhibit the user's resistance strategies to the advertising's arguments [52, 73] — this is especially true if the ad is interactive in a

playful manner [62]. Secondly it has been suggested that the increased cognitive load of being in an immersive and interactive environment (having to respond to and interact with an ad, perhaps engage in tasks as part of the ad) means that fewer cognitive resources can be spent critically evaluating the ad's message and enacting resistance strategies to counter the ad's message [52].

5.2 Extreme Realism — Hard to Tell Advert From Reality

Related to immersivity is the idea of extremely realistic ads — ads that are so photorealistic and subtle that they are potentially mistaken for reality. This differs slightly from immersivity. An immersive ad is one where the user feels they are in the ad and that they are present in the world the ad is presenting. A *realistic* ad, though, would have consumers believe the ad they are seeing is the real world, and may not notice that it has been artificially created. For example, if consumers are using AR to enhance or augment reality, they might have difficulty discerning if something they see is an ad or if it is part of reality. Though current AR and VR graphics are not photorealistic, we anticipate that over time the sophistication of devices will lead to photorealistic graphics.

There are many ad techniques that attempt to be subtle, such as product placement (when a business pays a media company to insert into their media content a branded product [110]) or native advertising (when an ad appearing in an online or print publication *looks* like an article in that publication medium, but is actually an ad [113]). In the context of XR advertising, if an advertiser wants to make their ad subtle and the graphics used to display an ad are photorealistic, the consumer may think the ad exists in reality. Using the example of product placement in XR, if an AR application overlays a digital softdrink can on a user's field of vision, if that digital overlay is realistic enough, the consumer may not know if that can is real or not.

5.3 Previewing Products — Try Products Before Buying Them

A new opportunity XR advertising presents is the chance to show and let consumers experience the goods they want to purchase before a purchase [18] — a phenomenon known as experience marketing [11]. XR technologies can recreate digital three-dimensional representations of products, and consumers can then see if they are interested in purchasing that product.

While consumers can already preview goods and services before buying them (e.g., going to a physical store to see the product before buying it, or looking at pictures and customer reviews of a product online), XR enables people to preview more complete and higher quality representations of items (3D-digital recreation instead of a photograph) from the convenience of their own homes. Additionally, XR technologies allow users to preview products in real contexts. For example, let us assume a consumer wants to buy a new table for their house; without XR technologies, they can visit the store, look at the table, perhaps take pictures and measure its dimensions, but they wouldn't truly know what the table looks like in their living room until they buy the table. But through XR technologies this problem could be easily overcome: an AR app could project a digital recreation of the table onto the consumer's living room, allowing the consumer to see what the table looks like.

Beyond products, XR advertising could allow for previewing experiences. For example, a hotel resort could offer a VR tour of its premises [53, 69, 77]. The National Hockey League (NHL) created an experience that allowed fans to experience watching a hockey game at a crowded stadium through the use of a VR headset [67]. Potentially, as XR devices evolve, senses such as smell, touch, and taste could be incorporated, changing how consumers can preview a product or experience.

5.4 Hyperpersonalization — An Ad Made Just For You

Personalized advertising, sometimes referred to as targeted advertising or online behavioral advertising, is an advertising technique whereby ads are selectively delivered and targeted to those consumers who are more likely to engage with that ad [38]. This is accomplished by advertisers gathering data about individuals such as their age, gender, location and search queries [37], and then matching ads to users who are most likely to engage with the ad based on their characteristics (e.g., only showing ads for restaurants in Paris to individuals who live in Paris) [38]. Companies such as Facebook and Google thrive in selling targeted advertisements and allowing advertisers to target consumers based on demographics, location, and inferred interests.

Hyperpersonalized advertising would be personalized advertising but on a much larger scope and granularity, where ads are not targeted to groups of consumers who share a characteristic (e.g., all females who live in Madrid), but ads are tailor-made and customized for individuals so that no two people see the same ad; and much more data is collected by advertisers to hyperpersonalize the ads. For example, a person who really likes dogs might be shown an ad for a product with a fictional dog as a spokesperson for the product. A different person who dislikes dogs and prefers cats would be shown the same advertisement, but with a fictional cat as a spokesperson for that product.

There are two reasons why XR is likely to enable and feature hyperpersonalized ads. First, there has been an advertising trend towards more and more personalized advertising [125], which inevitably leads to hyperpersonalized advertising. Netflix has already premiered a primitive type of hyperpersonalized ads, algorithmically selecting what thumbnail image for a movie gets shown for individual users; thus, different users see different thumbnails for the same movie [59]. As algorithms become more and more sophisticated, it is possible that they will able to generate custom advertisements for each individual.

The second reason that hyperpersonalization will likely be present in XR advertising is the vast data collection and sensing capabilities of XR technologies. Current XR devices can capture consumer's biometric and physiological data. For example, VR headsets are worn on a user's head, and controllers are held by the user: the positioning of these devices and their orientation can be used to track a user's gait, height, body posture, and gaze-direction [8]. Cameras that are integrated into XR devices can capture a user's facial expressions [8]. These expressions, coupled with biometric and physiological data, may give insights into a user's emotional state

at that time [8] and may disclose sensitive user information, such as how gaze-direction can be used to infer a user's sexuality [101].

XR devices may also collect data about the users surroundings — for example, smartphone AR apps require the user to use the smartphone's camera to film the real world before digital images can be superimposed on the real world. Not only does this allow data collection of the user, but it can capture data about bystanders standing next to the user (e.g., if a smartphone camera films another person in the frame). Similarly, some VR headsets have accessories that track a user's location and their movements — these movements may be used to predict the layout of a room [31].

As XR devices develop further, it is not hard to imagine additional sensors being integrated into these devices to aid in device functionality. For example, the Virtual Reality horror game "Bring to Light" [45] comes with a heart rate sensor, to detect when a user's heart rate is elevated (and therefore when they are most scared) to change the course of gameplay. Thus, there exists the possibility that future XR devices incorporate a wide range of sensors to measure and react in realtime to physiological information about the user.

Additionally, XR technologies capture the consumer's behavior within an XR experience. For example, if a consumer is using a VR headset to use a social media application to talk to friends, who that consumer is talking to and what they are saying can be collected.

5.5 Pervasive Advertising — Ads Are Everywhere

Pervasive advertising refers to advertising that is ubiquitous, frequent, and embedded within an individual's daily life and environment, to the point where an individual would be surrounded by advertising [87]. Some XR technologies, by their design, enable pervasive advertising. For example, some AR glasses and AR contact lenses are designed to be worn by users constantly throughout their daily life, as evidenced by the ways they are marketed. Mojo Lens is a company that designs AR contact lenses, and advertises its product by saying "Mojo Lens uses unique, purpose-built microelectronics and the world's densest microdisplay to layer digital images and information seamlessly into your life. By providing critical information through smart software that understands your context, Mojo Lens empowers you to be your best self in any situation." [58]. We see from this text how the goal of this technology is to be used constantly, throughout everyday life. While current AR lenses and glasses may not yet be fit for continuous use, it is conceivable that this technology will mature to the point where they are comfortable and desirable to be worn throughout the day.

By being worn constantly at all times, and being the lens through which users see the world, AR glasses and lenses could display advertisements constantly, and design the ads to blend seamlessly into the user's view of their environment. Since the user is looking through the AR glasses to see the world, they would essentially be surrounded by these advertisements.

6 MANIPULATION IN XR SCENARIOS

Following our scenario construction approach, we developed seven scenarios of manipulative XR advertising. Our scenarios vary in severity and negative impact or harm on consumers; what XR devices or experiences they are likely to appear in (e.g., VR versus AR versus MR); and the actors behind the manipulation in the scenario. Some of these scenarios are unique to XR, in that the scenario would be difficult to exist outside the XR context. Other scenarios are not exclusive to XR, but the manipulative features are exacerbated by XR technology. All our scenarios have in common that they are instances of a consumer being tricked, deceived, or otherwise sabotaged through XR advertising in their ability to rationally evaluate the claims of an ad, and make an informed decision of whether to purchase a product.

For each scenario, we first present the scenario, and then elaborate on how the scenario was constructed and on its manipulative characteristics.

After listing the constructed scenarios, we synthesize them into five mechanisms through which manipulative XR advertising can occur: misleading experience marketing; inducing artificial emotions in consumers; targeting consumers while they are vulnerable; emotional manipulation through hyperpersonalization; and distorting reality. Figure 2 shows the links between the XR advertising features identified in the previous section, our scenarios, and the manipulative XR advertising mechanisms.

Note that we do not consider our set of constructed scenarios to be a comprehensive representation of any or all possible types of manipulation in XR advertising. Scenario construction is about providing reasonable estimates of scenarios that are likely to play out in the future, but they are not meant to be exclusive. We anticipate that novel manipulation risks and techniques beyond our set of scenarios will emerge as XR capabilities and other technologies continue to develop. The contribution in our work lies in identifying and describing a first set of potential risk and consumer harm scenarios and in articulating associated research challenges. By doing so we create opportunities to consider and mitigate identified issues already in the design of XR technologies and experiences and facilitate reflection on ethical issues in XR design and XR advertising by developers, consumers, as well as policymakers.

6.1 Scenario 1: Military Games

The U.S. army creates a VR experience that allows people to "live a day in the life of a soldier." The experience itself is highly gamified and punctuated with achievements, fun, excitement, and a play-like atmosphere. The U.S. military uses this as a recruitment tool and markets it heavily to teenagers. John, a sixteen-year-old teen, sees the experience and decides to try it out. Although apprehensive at first, John finds he is having fun. He likes running around, fulfilling missions around base camp, and outshooting other players in the shooting range makes him feel pretty good about himself. John slowly becomes enamored with the military, and now convinced, applies to become a member of the armed forces.

6.1.1 Construction Process. To construct this scenario, we first identified a current advertising practice — that of the military advertising job positions through videogames. The U.S. military has a history of using videogames to recruit participants, having released a series of videogames titled "America's Army", a collection of

first-person shooters used as a recruitment tool [7, 82]. In a recent scandal, it was revealed that the U.S. military maintains a presence on Amazon's online gaming platform Twitch and has allegedly used the platform to target teenagers (some as young as 13) for recruitment [9, 70].

Given how the U.S. military uses video games as recruitment tools, it is reasonable to imagine that they would create similar experiences in VR; several military-style VR games exist already (e.g., Pavlov VR [46]).

We then asked ourselves: if these games existed in XR, could the XR features identified in Section 5 make this experience manipulative? If so, how? We imagined the experience leveraging the Greater Immersivity of XR and the Extreme Realism of XR, leading to an experience that is highly immersive and realistic — much more so than traditional games.

This could lead to manipulative advertising in two key ways. First, given the realism and immersivity of the experience, teenagers would not be playing the game, they would be *living* the experience. The experience may seem more convincing and realistic, and teenagers may think that what is presented is a realistic depiction of what life in the armed forces is like — almost like a preview of what military life is like.

Second, the emotions felt in the VR experience could be more intense than felt in a traditional marketing experience, which could impact the ad's effectiveness. Ads that generate positive emotions in consumers are generally more effective than ads that do not [10, 24]. The excitement, adrenaline, engagement and fun that an immersive, realistic experience generates in the user could be more intense than when viewed through a 2D screen. If powerful enough, teenagers may associate these feelings of positivity with the military — an association that might be so powerful that it biases the decision of whether to apply to the armed forces.

These two features combined create a situation where a user is being misled and swayed on an emotional level to react positively to the ad — which constitutes manipulation. This led to the creation of a scenario where a teenager plays the game, succumbs to the realism and immersivity of the medium, and joins the armed forces as a result.

6.2 Scenario 2: Ugly Furniture

A furniture company releases a new AR app that allows customers to place 3D renderings of furniture into their home, to see how the furniture would look like in their home. Unbeknownst to the consumer, the preview is altered in ways that make the photorealistic rendering of the furniture seem brighter and more colorful than real life, whilst still seeming realistic. An unsuspecting customer uses the app to "try out" a new sofa in their living room; satisfied with how it looks, they buy the sofa, only to find that the actual sofa is much duller, uglier, and of vastly lower quality than the preview had suggested.

6.2.1 Construction Process. We first identified a common XR advertising practice (and a feature of XR advertising); that of Previewing Products. Many furniture companies (e.g., IKEA) have already developed AR apps that allow consumers to place 3D models of furniture

in their home [63]. As discussed in Section 5.3, this form of experience marketing is a big draw for advertisers, since it allows consumers to preview and interact with products before purchasing them.

We asked, how could this advertising practice be used by bad actors? We imagined that it could be possible for these previews to be fake and misleading. It is well known that advertisers often doctor images of their products to make them seem better than they actually are [29]. Techniques used include using image- and video-editing to hide imperfections in products, to make models appear thinner and more conventionally beautiful, or using props and subtle photography tricks, such as using eyeliner to create artificial grill marks on food [43]. It can be reasonably deduced that advertisers will similarly attempt to alter and enhance XR previews of their products.

Combining these two ideas led us to imagine a scenario in which a furniture company misleads a consumer about the product they are selling through a doctored preview. At first it may seem like this scenario is not that revelatory; advertisers have been doctoring images of their products for a long time, how could it be different in XR? However, these manipulations could be *more convincing*, and thus more manipulative, in XR advertising. Consumers would see the furniture right in front of them and be able to interact with it, instead of seeing a 2D image on a screen or in a print ad. Consumers may think that the sofa they are interacting with is real, and not be aware (or not take into account) that they are fictional representations. Research shows that XR ads can lead to high feelings of presence [136]. In the cases of previewing experiences, consumers will not just see an experience through a photo or video: consumers will actually live through that experience. While currently rendered objects are often still recognizable as such in XR experiences, if a preview takes advantage of the Extreme Realism feature of XR, the sofa could be rendered photorealistically in realtime, and incorporate an environment's actual lighting and shadows; making the deception difficult to notice.

6.3 Scenario 3: Fake Relatives

Carolina gets a video call from her brother, which she picks up in her VR chat app. The call is not unexpected — they chat regularly, and him calling out of the blue is no big deal. The conversation starts the usual way with their jokes, asking about each other's lives. Eventually, the call turns to her financial situation; with her new job, Carolina is looking for ways to invest her money. Her brother convinces her to invest in a profitable stock portfolio, which she readily agrees too — she trusts her brother. Too late, it transpires that Carolina was tricked: the person she thought was her brother was actually a holographic recreation of him in the form of an ad. The profitable stock portfolio was actually a very high risk investment that does not pan out, and Carolina loses thousands of dollars on the deal.

6.3.1 Construction Process. One manipulative technique used with current technologies is bad actors pretending to be family members, relatives, or other trusted parties, to convince people to transfer money to unknown accounts. Although this is a form of scamming,

and not a legitimate form of advertising, we felt it appropriate to include here for two reasons. First, because it shares many of the same traits with manipulative advertising (convincing a user to carry out an action against their better interests). And second, because despite its illegality, this type of scam is prevalent right now, with particular danger when older adults are targeted. Millions of adults fall victim to this form of scam every year [39]: the FBI even has a special page dedicated to detecting and preventing financial fraud of the elderly [39].

Then we asked, what could this look like in XR? First, it could leverage the Extreme Realism of XR to create photorealistic avatars of trusted loved ones. Through the rise of deepfake technologies [106], it will be possible to create realistic XR avatars of anyone from a small amount of video footage or photos. The data collection capabilities of XR devices mean that it could be relatively easy for would-be scammers to scrape data such as the identity of their victim and pictures of relatives, and perhaps have them act in realistic ways (e.g., having the avatar use the same idiosyncratic phrases that the person they are replicating will use). We already know that such recreations are possible in XR; researchers in South Korea managed to reunite a mother with her dead child, by recreating an avatar of the child in VR [3]. Recreating a living relative is therefore conceivable. Thus, we imagined a scenario in which a person is reunited with a realistic avatar of a loved one (who they believe to be real); and are then scammed.

This form of scam is dangerous, and millions fall victim every year; how would the scale increase in a world where this is happening in XR? How will consumers differentiate between a genuine call and an avatar created by a scammer if the avatar looks exactly like the person the consumer is attempting to reach?

6.4 Scenario 4: Political Alternate Reality

A politician, struggling to win their re-election bid, hires an obscure political ads firm that specializes in XR advertising. The firm releases a series of ads meant to display on consumer's head-worn AR glasses. These ads are fairly sophisticated and subtle; the ad simply analyses a building and overlays graphics to leave a slightly modified version of the building. The ad is conveniently geolocated in places of extreme poverty. The targeting is so specific, and the ad so sophisticated, that if a consumer with AR glasses turns to look at evidence of poverty, such as a closed-down store or a homeless encampment, the ad kicks in; the modifications it makes aim to erase any evidence of poverty. A closed down store is edited to seem simply closed for the day. Graffiti is "erased," broken windows are "fixed." An alleyway with a homeless person in it is redrawn, but without the homeless person. This erasure of poverty creates the impression that the economy is booming.

6.4.1 Construction Process. To construct this scenario, we first imagined manipulative ads in the context of politics. Politicians will sometimes create deceptive ads in order to get re-elected; for instance, in the 2020 U.S. presidential campaign, both candidates

have released ads that outwardly lie and contain deceiving statements [26, 65]. There have even been cases of explicit image tampering in campaign images, such as one ad released by the Trump campaign to make it seem like his opponent Joe Biden is in a basement [65]. Thus, it is not only possible, but plausible, that politicians would lie to get elected and take advantage of the capabilities of XR advertising to do so.

This begs the question: how could politicians use XR advertising techniques to create deceptive ads? What if a politician wanted to claim the economy was going great when it was not? We imagined a situation where strategically placed AR ads would distract the user from evidence of poverty and economic downturn, such as by overlaying a banner ad to hide evidence of poverty. This evidence could be inferred based on a user's location (e.g., when in zip codes that have low median income), as well as image processing to detect evidence of poverty (e.g., shuttered businesses).

We further imagined this ad leveraging the Pervasive Advertising and Extreme Realism features of XR advertising. This would mean that the ad is on at all times and always able to hide evidence of poverty. Moreover, instead of displaying a banner ad to hide the image of poverty, the image could be replaced with a digital recreation of the same scene but without indications of poverty.

6.5 Scenario 5: Pervasive T-Shirts

A sports brand company wants to increase sales. It plans a new marketing campaign aimed at increasing the frequency at which consumers see the brand logo, with the hope that the more often consumers see the brand, the more familiar they are with it and the higher the chances they will purchase their product. The company develops AR ads that place a photorealistic digital image of its brand logo onto other people's T-Shirts. The ad is sophisticated enough to detect competing brands' logos and replaces them with its own logo. Thus, consumers who use AR glasses are subtly exposed to this ad by seeing how around them many people are wearing clothing of this brand. Surely this must mean the brand is of good quality, right? Why else would so many people be wearing it?

6.5.1 Construction Process. To construct this scenario, we first considered what marketing techniques a clothing brand could use to increase its sales. One way of doing this would be to increase the exposure a consumer has to that brand; for a clothing brand, this could involve having people a consumer interacts with have an item of that brand. Thus, an individual would see their friends, family members, and strangers wear a shirt bearing the same brand. We arrived at this conclusion by studying the literature, which suggests that such a strategy is likely to work. The more often a consumer sees an ad, the more likely they are to buy the product [22]. Similarly, word-of-mouth advertising (people known to a consumer recommend a product) is a very effective form of advertising [21, 94]; though this scenario is not technically the same as word-of-mouth advertising, seeing a friend wear a particular brand of clothing could function as a pseudo-endorsement. Thus, a consumer exposed to this form of advertising may be more likely to buy clothing from that brand.

We then asked how this could be accomplished through XR advertising techniques. AR advertising would allow a company to overlay digital images onto the real world, including overlaying brand logos over rival brand logos). Extreme Realism could render these logos photorealistic and indistinguishable from reality; and Pervasive Advertising would ensure this happens all the time when AR glasses are being worn constantly. Combined, these aspects would enable a brand to increase the number of times a consumer sees their brand logo by projecting their logo onto existing items of clothing.

Although the consequences may seem trivial (buying one clothing brand because of mistaken beliefs about its popularity), the manipulative principle is still the same: consumers purchasing products under false pretenses.

6.6 Scenario 6: Deodorant Crush

Wei is a seventeen-year-old teenage boy. By scanning Wei's message chats, activities on social media, and measuring biometric data such as pupil dilation collected through the AR glasses he is wearing, an algorithm infers that Wei harbors a secret crush for fellow classmate Jennifer. Waiting until biometric data reveals that Wei is particularly aroused, an ad appears for a deodorant that is a sure-fire way to seduce girls. The spokesperson in the ad bears a striking resemblance to Jennifer.

6.6.1 Construction Process. One manipulative advertising technique used currently is that of falsely associating certain positive feelings with a product [97]. In this vein, ads sometimes use sexualized imagery to sell their products [16] — by evoking sexually arousing images with their products, companies hope that consumers associate the feelings of sexual arousal with the product, and may thus be more likely to buy the product [16]. For instance, AXE, a company that sells male deodorant (among other products) [122], creates ads that feature men using the body spray to seduce women [80]. Some of the demographics AXE targets are teenage boys [109]. We then started to wonder what would happen if a similar deodorant company tried to use XR ads that leveraged sexual arousal, and how XR might intensify this feeling of sexual arousal.

One potential way we thought this could happen is through the data collection capabilities of XR devices. XR devices such as AR glasses can capture large quantities of a user's physiological data [31]. If, through Pervasive Advertising, these glasses are worn at all times, meaning data can be collected at all times, it would be possible to infer when a user is aroused. As such, sexually suggestive ads could be shown in moments when a user is most aroused and most likely to respond to arousal. If the ad leverages XR's ability to create immersive advertisements, the sexual arousal could be further enhanced.

But to add a layer of complexity, the data collection capabilities of XR devices could not only tell when a user is aroused, but potentially infer who arouses them. Algorithms could correlate times when a user is most aroused with data about who they are viewing or talking to at that time to infer a potential crush or sexual attraction to an individual, and could couple this information with data obtained from sources like social media. Leveraging Hyperpersonalized Advertising, ads could feature avatars and images that are specifically targeted to maximize a user's sexual desires.

As such, we imagined a scenario where a teenager wearing AR glasses was subjected to ads from a deodorant company; ads that would be designed and tailored to maximize sexual arousal in the user. The reason this is manipulative is because this sexual arousal could impact user's evaluation of the product, biasing the purchasing decisions that they make.

6.7 Scenario 7: Hunger Pangs

Hassan uses AR glasses in his day-to-day life. Among other things, Hassan uses these glasses for navigation — he can input a destination, and arrows will appear to indicate what direction to go in. Unbeknownst to Hassan, the AR glasses are equipped with physiological sensors that can detect subtle changes in sweat composition, using this as a heuristic for determining Hassan's hunger levels. When Hassan is feeling especially hungry, the navigation app leads Hassan in particular directions that have him walk right past an unhealthy fast food restaurant. The ruse works, and Hassan finds himself eating at this unhealthy restaurant more and more often.

6.7.1 Construction Process. The vast data collection capabilities of XR devices mean that a user's physiological state could be readily inferred. We asked ourselves what physiological states would companies be interested in measuring. One we identified is hunger; it stands to reason that consumers are more likely to enter restaurants or buy snacks when they are hungry, since when they are not hungry, they may be less interested in food.

But would it be possible for such sensors to measure hunger? One of the symptoms of hunger is sweating, caused by low blood sugar [36]. At the same time, there is a rise in wearable sensors that are capable of detecting sweat [96]. It would be plausible to assume that there could be AR devices with sweat sensors. Perhaps the sweat sensor could be marketed as a useful addon to allow for a great variety of applications (for example, it could be used by fitness apps to track a user's exercise and exertion; or be part of an app to measure how sick a user is feeling), or just be part of a sensor bank integrated into the glasses' temples.

What could companies do with this information? For inspiration, we looked at how advertising functioned in Nintendo's AR location-based game, Pokémon Go. Nintendo struck partnerships with restaurants so that consumers gained special prizes for going to certain restaurants [27]; by placing prizes in certain locations, Nintendo managed to direct people to these establishments. Thus, we imagined situations in which through a similar manner consumers are indirectly nudged into walking by certain restaurants, but based on their hunger levels.

The manipulative portion of this scenario happens when Hassan is brought in front of the fast-food restaurant precisely when he is hungry. On his own, Hassan perhaps would have chosen a different restaurant. Maybe if Hassan is running late to an appointment and needs a quick bite to eat, the restaurant is the only one he has

the time to go to — but through a different route, perhaps other, healthier restaurant choices would have become available.

6.8 Synthesis: Manipulation Techniques and Risks

The seven scenarios we constructed highlight different ways in which advertising in XR can be manipulative. Some scenarios are manipulative in ways that are possible today, but are amplified and exacerbated in an XR environment (e.g., Military Games, Ugly Furniture). Other scenarios are more futuristic and reliant on unique features of XR devices (e.g., Deodorant Crush, Pervasive T-Shirts). Some scenarios work through similar mechanisms, others are vastly different. To make sense of these scenarios, we summarized five key mechanisms through which the presented ads are manipulative.

The first is **misleading experience marketing** (Military Games; Ugly Furniture). As we expanded in Section 5.3, one of the biggest promises of XR advertising is that of experience marketing — showing consumers products through XR technologies before they purchase them. Although the products seen may seem real, the previewed products will not be the actual products, but rather, digital recreations of them. Manipulation occurs when these experiences are doctored to present experiences and previews that are better than reality. While doctoring advertising images is not unique to XR, there is the danger that these manipulations are more effective in XR due the realness of the experience (consumers living through an experience and interacting with an actual object).

The second is the **inducing artificial emotions in consumers** (Military Games; Deodorant Crush). XR technologies can create artificial experiences for people to live through. Even though the experiences may be artificial, the feelings and emotions they generate in users are very real [99]. If the feelings are positive and particularly powerful, they may bias consumer's evaluation of the product. The immersivity of XR and the ability to simulate lived experiences (instead of seeing experiences on a screen) could make these emotions more powerful, and so more effective.

The third is **targeting consumers while they are vulnerable** (Deodorant Crush; Hunger Pangs). The vast data collection capabilities of XR devices mean that consumers may be presented with ads at times when they are emotionally vulnerable or especially susceptible to a certain product. The exploitation of such emotions may override a consumer's ability to rationally evaluate the ad, potentially causing consumers to buy and engage with products they otherwise would not.

The fourth is **emotional manipulation through hyperpersonalization** (Fake Relatives; Deodorant Crush). Leveraging the vast data collection capabilities of XR devices, and with the rise of deepfake technologies (technologies that can make realistic photos and videos of fake events; such as celebrities making statements they haven't made) [106], XR ads can be created that simulate individuals who have significant emotional sway over a consumer (e.g., a trusted figure, or a figure the consumer has affection for). This technique is one that will not be unique to XR devices, since deepfake technologies and vast data collections will presumably be present in other technologies as well (e.g., online news, social media). But it will likely be present in XR advertising, meaning it

deserves consideration as one of the key features of manipulative XR advertising.

The fifth is **distorting reality** (Fake Relatives; Political Alternate Reality; Pervasive T-Shirts). This danger is most relevant to AR glasses and other future AR/MR technologies. As seen in the scenarios, ads in XR graphics have the possibility of hiding reality or changing it, by changing what the consumer sees. This is especially important for determining consumer behavior. Reality (or more accurately, what people *believe* to be reality) affects people's behavior. If a person's understanding of what constitutes reality is compromised, they may act differently, and buy different products, than they would under a different reality.

7 RESEARCH CHALLENGES

In the previous section we highlighted five ways in which XR advertising may be manipulative: misleading experience marketing; inducing artificial emotions in consumers; targeting people when they are vulnerable; emotional manipulation through hyperpersonalization; and distortion of reality. From a technological perspective, these scenarios are plausible; the technology exists to make these scenarios real, and even though some scenarios (e.g., those that require a distortion of reality) require a degree of photorealism and device sophistication beyond current capabilities, technologies are trending in that direction and so it is likely that these scenarios will be realistic in the near future. Past precedent of how businesses have leveraged advertising also suggests that some businesses will attempt to manipulate consumers into buying their products — either through the ways described here, or through new techniques.

However, XR advertising is still in its infancy. XR devices have not yet achieved mainstream usage, in part due to the cost and bulkiness of the devices. Though XR marketing campaigns exist, they have not yet entered mainstream consciousness or form part of major advertising strategies, and spending on XR advertising is dwarfed by the spending of advertising in other mediums [17, 116]. As such, the manipulative scenarios we described are at the moment just that — scenarios. At this point, little is known about whether those scenarios will be realized, or what their effects on consumers will be.

This is where researchers need to step in. To properly mitigate the problem of manipulative XR advertising, we need to better understand not only what manipulative scenarios are and how they impact consumers, but also understand: What are possible intervention strategies? How can we mitigate risks of manipulative XR advertising in these and other scenarios? How might we provide guardrails for XR advertising that ensure advertising is fair and not harmful to consumers?

As a way of bridging this knowledge gap, stipulated by the constructed scenarios, we describe research challenges to investigate and ultimately mitigate the harms of XR advertising. We first lay out what research challenges remain to better understand and address manipulative XR scenarios; then propose several ways to approach these challenges. This is not meant to be taken as the definitive guide to XR manipulative advertising research, but rather, as the start of a conversation around what are the questions that need to be answered. Which ones are worth answering, and what methods and approaches are best suited or required to answering them.
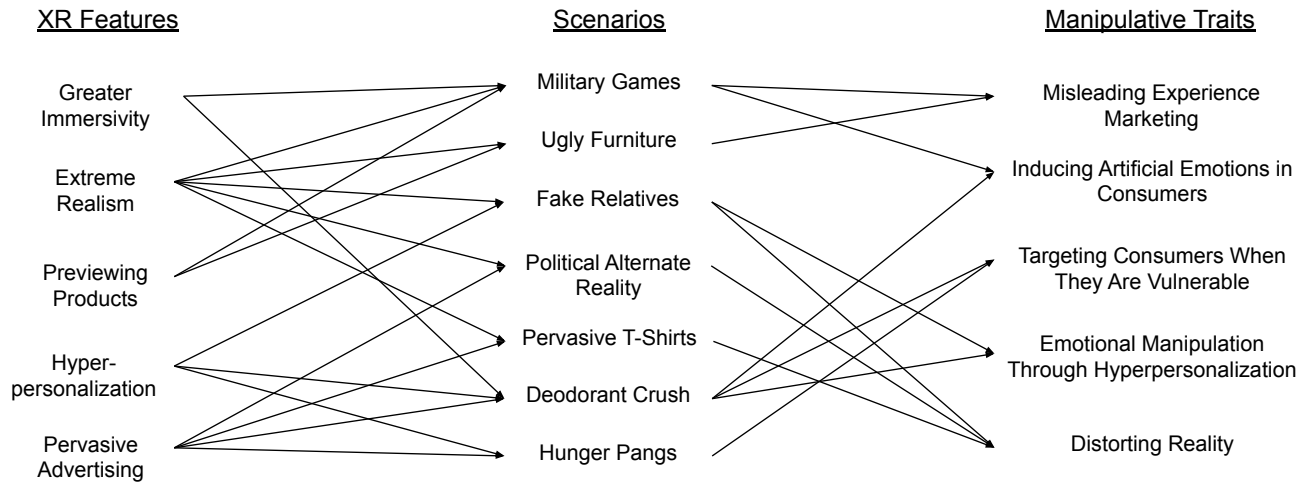
XR Features

Greater Immersivity

Extreme Realism

Previewing Products

Hyper-personalization

Pervasive Advertising

Scenarios

Military Games

Ugly Furniture

Fake Relatives

Political Alternate Reality

Pervasive T-Shirts

Deodorant Crush

Hunger Pangs

Manipulative Traits

Misleading Experience Marketing

Inducing Artificial Emotions in Consumers

Targeting Consumers When They Are Vulnerable

Emotional Manipulation Through Hyperpersonalization

Distorting Reality

Figure 2: Figure linking the identified XR advertising characteristics; the constructed scenarios; and the respective manipulative mechanisms.

By explicitly laying out some approaches to answer the questions, we hope to provoke reflection and conversation by and with researchers, developers, designers, consumers, and policymakers that are impactful, meaningful, and conducive to conducting research in this area and expanding what we know about XR advertising and manipulation.

We highlight four main research challenges, each with specific research questions: (1) analyzing and monitoring the XR advertising landscape, (2) privacy risks of XR, (3) unpacking the immersivity of XR, and (4) developing XR ad literacy. These challenges and research questions are summarized in Table 1.

7.1 Analyzing and Monitoring the XR Advertising Landscape

To properly understand the effects of manipulative scenarios in XR, it is important to lay the groundwork and **understand what are the capabilities and types of XR advertisements that exist, and what types of XR advertising scenarios consumers are actually being exposed to**. The background section of this paper is an example of such work; however, a deeper analysis is warranted.

For example, while XR advertising techniques have been discussed in the literature, we have a limited understanding of what XR advertising techniques are actually used in practice. To move beyond anecdotal examples, it is important to systematically analyze existing types of XR advertisements in order to categorize XR ad experiences that are available and determine the prevalence of different ad types. Are certain XR ad scenarios limited to certain countries, businesses, or sociocultural contexts? Some work exists in this area, such as companies giving insights to marketers about the future of XR advertising [135] and scholars performing content analyses on AR ads [41, 124]. However, most of this work has focused on AR advertising, with less focus on VR or other forms of

mixed reality. Moreover, given the rapid development and change of the availability and type of XR technologies and advertisements, these developed taxonomies must be re-examined, challenged, and updated frequently to learn what new types of advertising scenarios develop.

Furthermore, how and why companies develop XR advertising experiences deserves further investigation. For example, **who are the *companies* that are developing XR ad experiences?** Are most XR ad experiences developed in-house by corporations (e.g., large corporations having their own XR advertising division) or by specific advertising agencies? Have middle-men advertising networks emerged that connect companies and advertisers with XR publishers, similar to how Google AdMob connects companies and advertisers with mobile app developers? Knowing who are the stakeholders involved in XR advertising and understanding their goals and motivations will shed light on what type of manipulation they might engage in, and what interventions are more likely to be effective.

Regarding manipulation in XR advertising specifically, we should ask **what manipulative techniques are present in advertising.** There is ample documentation of manipulative strategies, dark patterns, and nudging techniques that are used in traditional forms of advertising [6]. Do these techniques also appear in XR ads? How frequently? Several papers have canvassed existing ads as well as digital experiences for manipulative techniques [4, 86, 102]; a similar methodology could be applied to examine XR advertising for the manipulative characteristics we described.

7.2 Privacy Risks of XR

Two of the identified harms — targeting consumers when they are vulnerable and emotional manipulation through hyperpersonalization — rely on the ability to collect vast quantities of consumer data

Research Challenge	Research Questions
Analyzing and Monitoring the XR Advertising Landscape	• What XR ad techniques are used in the field? • Categorize available XR ad experiences and relative prevalence. • Are certain XR ad scenarios limited to certain countries, businesses, or sociocultural contexts? • Who are the companies that are developing XR ad experiences? • What manipulative techniques are present in XR advertising?
Privacy Risks of XR	• Understand what data XR advertisers can collect. • Understand what data XR advertisers do collect. • Analyze privacy policies, terms of service, websites, patents, and other relevant documentation companies that advertise in XR. • What impact will this data collection have on consumers? • How could this data be leveraged for manipulation? • Involve consumers and understand what are (un)acceptable data collection practices. • Intervention strategies to mitigate harms from malicious data collection.
Unpacking the Immersivity of XR	• Examine whether XR ads are more immersive than traditional ads, and what factors influence this immersivity. • Explore the interaction between XR ad immersivity and ad effectiveness. • Explore impact of increased immersivity on consumers ability to rationally process an ad.
Developing XR Ad Literacy	• What are ways to increase consumer's XR ad literacy? • What interventions allow consumers to better navigate XR ads? • Are there mechanisms to detect misleading and subtle advertisements?

Table 1: Summary of identified research challenges to further unpack and understand manipulative XR advertising, and potential research questions within each challenge

through XR devices, including physiological data. XR's ability to collect consumer data not only underpins XR advertising manipulation techniques, but also many other ethical risks of XR devices, such as surveillance by law enforcement agencies, potential discrimination by employers, and loss of autonomy [90]. With regards to examining the privacy risks of XR technologies, there is still much to be learned.

Guzman et al. conducted a thorough review of security and privacy research in Mixed Reality [54]. They highlight open research challenges, such as better understanding the scanning capabilities of current MR devices and developing 'best privacy practices' for developing MR applications. We second their calls to action, and highlight some further research challenges specifically geared at the privacy risks within the context of XR advertising.

One of the first challenges is to **better understand what data advertisers *can* collect and infer in XR, and what data do/would they collect?** This would involve examining XR devices to understand what sensors exist in these devices and what data can be collected, and monitoring these devices over time as new sensors are added to consumer-available devices. More specifically to advertising, there is a need to analyze the privacy policies, terms of service, websites, patents, and other relevant documentation of companies that advertise in XR or that develop XR apps and devices

to better understand their data practices and potential privacy risks that might emerge from industrial research and development activities. Another approach would be to directly examine the data traffic of XR devices and XR advertising experiences to understand what data is being collected and streamed to a manufacturer's backends. This has been done successfully in studying IoT devices (e.g., see [56]).

Another challenge beyond knowing what data is collected is to understand **what impact will this data collection have on consumers**. For example, researchers found that eye gaze direction could potentially be used to infer a user's sexuality [101]. Guzman et al. wondered whether the scanning capabilities of current MR devices could be used to detect the physiological signals of bystanders [54]. Are there similar connections between physiological data that an XR device can collect (eye direction, gait, hand position) and a user's sensitive traits (sexuality, personality)? More specifically, does any data correlate to consumer's shopping habits, purchasing preferences or intent?

Alongside knowing what information can be collected about consumers, another challenge to explore is determining **how this information could be leveraged for manipulation**. For example, does tailoring an ad to a user's unique personality traits make an ad more effective, and how effective is this targeted persuasion?

Alternatively, following Guzman et al's call for developing best data practices, it would be valuable to **involve consumers so as to understand what are acceptable and unacceptable practices with regards to consumer data collection for use in advertising.** Consumers may be comfortable with some data being used to target ads, but not others, depending on the sensitivity of the data and what the data is used for [88, 126]. Using vignette studies, focus groups, qualitative interviews, and surveys, consumers' preferences can be learned and used to inform what are adequate data collection practices, as well as inform mitigation strategies. Adams et al. developed a code of ethics for VR developers co-created with VR developers [1] — a similar approach using participatory design more tailored to advertising could yield a useful resource for best advertising practices for both advertisers and XR developers seeking to monetize their apps through advertising.

Furthermore, we need to be asking **what are intervention strategies that mitigate the potential harms from this data collection.** For example, what tools can we create to give consumer's agency and control over this data collection process? Could a system similar to smartphone 'permissions' work? What about informing people that the ad they are seeing is based on data collected by their XR device (e.g., "You are viewing product X because our records detect you are personality Y, based on eye tracking data collected from your Oculus Rift S") — how should such messages be worded, how should they be integrated into XR experiences, do consumers find this messaging informative and useful, and does it help consumers resist the manipulative effects of XR advertising?

7.3 Unpacking the Immersivity of XR

Another feature of XR advertising that underpins many manipulative techniques is the increased immersivity and realism in XR devices. The increased immersivity can make generated images, objects, and experiences seem real, provoke strong positive emotions in users, and even alter a consumer's perception of reality — all of which may manipulate consumers into buying products they do not need.

All these techniques hinge on the assumption that XR advertising is more immersive, and therefore, more effective. Although most literature suggests that this is the case [111, 127], there is by no means a firm consensus [42]. More work is needed to **fully explore the assumption of XR ad immersivity and its impact on persuasion and ad effectiveness**. Immersivity is important to ad manipulation because some scholars have posited that immersivity is *inherently* manipulative, given its impact on consumer's ability to perceive ads. The increased immersivity and interactivity can potentially sabotage consumer's ability to critically evaluate an ad's message, through either inducing positive feelings in the user, which may inhibit the user's resistance strategies to the advertising's arguments [52, 73] (especially true if the ad is interactive in a playful manner [62]); or through the increased cognitive load of being in an immersive and interactive environment, meaning that fewer cognitive resources can be spent critically evaluating the ad's message and enacting resistance strategies to counter the ad's message [52], making the ad more convincing. Given the impact on consumer's ability to rationally and logically process ads, this could constitute a form of manipulation.

Whether XR ads are more immersive or not than traditional ads, and what factors influence this immersivity, should be studied with experiments and user studies. One key question to ask is whether the immersivity of XR advertising (and its subsequent effectiveness) is partially due to the novelty of the technology (as has been suggested by some scholars [55]), and whether users become immune or desensitized to this immersivity. This could be accomplished by conducting longitudinal studies with VR users to understand how their sense of immersion changes over time, using validated scales for measuring immersivity and/or physiological sensors.

More specifically to advertising, another challenge is to investigate **how increased immersivity impacts consumer's interactions with ads in manipulative ways**. Prior work has suggested that immersive ads are more effective than non-immersive ads; and in the context of XR technologies, that immersive XR ads are more effective than non-immersive XR ads[23, 50, 123, 127]. However, there is some nuance to this effectiveness. Feng et al., for example, find that 360°-video ads (a form of XR advertising) were *not* more effective than 2D-video counterparts if the ad had a low or high level of narrative structure [42]. Similarly, Leung et al. find that although VR advertisements were more effective in the short term, in the long term traditional ads were more effective [69]. Thus, it is not a foregone conclusion that XR advertising, by being more immersive than traditional ads, would also be more effective. Teasing out this connection is vital to determining what are the effects of increased immersivity on consumers.

7.4 Developing XR Ad Literacy

Ad literacy is defined as the ability to navigate and process advertisements: "an individual's ability to recognize advertising and to understand its persuasive intent" (exact quotation given by Hudders et al. [57], originally citing Wright et al. [133]). Aspects of ad literacy include the ability to properly identify when something is an ad, and being able to distinguish ad messaging from truth (e.g., what claims are true versus what claims are exaggerations).

In the context of XR advertising manipulation, **ad literacy is necessary for enabling consumers to navigate XR advertising and resist potential manipulative effects.** Ad literacy could help people identify manipulative XR advertising, or at least know how to verify whether product previews are accurate depictions of the product they are selling. Ad literacy could potentially help consumers be aware of the dangers of photorealistic advertising, and develop techniques on how to recognize photorealistic advertising when it happens.

There are many research challenges in this area of ad literacy. First, **what are ways to increase consumer's XR ad literacy?** How should educational interventions or trainings be designed and delivered so that they help consumers increase their ad literacy? Delving more specifically into manipulation harms, can educational trainings help consumers recognize photorealistic advertisements and be more skeptical of experience marketing?

Alongside this challenge of increasing ad literacy is to understand it. **What does advertising literacy means in the context of XR advertising?** Could we measure it? If so, how? Some ad literacy scales exist (e.g., [103]) — however, to our knowledge, no

validated scale exists for XR advertising. There is a need to adapt existing scales to XR advertising. Once it is possible to reliably assess ad literacy, we can question what the impact of ad literacy is on resisting manipulation. Does higher XR ad literacy correlate with higher resistance to manipulative ads?

Moving beyond ad literacy on an individual basis, we can ask what software interventions can help consumers better recognize advertising. In the context of photorealistic ads or subtle advertising techniques such as product placement, does labeling the ad help? And if so, what should ad labeling look like? There can be a lot of nuance to a label, with the positioning of the label and what language is used potentially influencing whether people see the label and how they react to the ad once it has been labeled and brought to their attention [68, 131]. Moreover, how can labels be developed in ways that both inform consumers of subtle ads that are happening but do not severely impair the XR experience the consumer wants to enjoy?

On a more technical side, **are there mechanisms or tools** that can automate the detection of subtle AR digital overlays when they are happening **to aid in labeling and identifying these ads?** Such work could borrow from work done on identifying deepfakes and digitally altered images [2, 79, 134], but would have to be adapted to XR contexts.

8 CONCLUSION

In this paper, we constructed scenarios to explore how XR advertising could be manipulative. We identify five ways XR advertising can be manipulative: misleading experience marketing; inducing artificial emotions in consumers; targeting consumers when they are vulnerable; emotional manipulation; and distorting reality. Based on these mechanisms, we describe a research agenda and challenges for mitigating associated risks. Some of the challenges we highlight are the need for further research to better understand the impact that XR advertising immersivity has on consumers; developing and evaluating privacy frameworks to understand what are acceptable data practices for XR advertising; and developing interventions to increase XR ad literacy among consumers.

It is our hope that our work will help facilitate discourse around the potential manipulative harms of XR advertising, and spur research on this topic. As we argue, XR advertising is likely to become prevalent and mainstream; and given the history of advertising, manipulative advertising will soon follow. It is important to start these conversations and this research *now*, and not be caught flat-footed by manipulative XR advertising when it inevitably appears.

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