Deceptive Patterns in Immersive Environments: How XR Can Expand Markets But Expose Sensitive Information

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Abstract

Extended Reality (XR) offers a unique and immersive experience in which advertisers and developers can present products to consumers. Microtransactions exist in video games to further revenue generated by video games and allow players access to cosmetics, additional content, or game progression. However, such marketing strategies employed by video game developers and companies present a financial burden on players and, potentially, their families. By leveraging user behavior and biometric data collected by XR devices, advertisers and developers can determine user demographic information, cognitive state, and present advertisements tailored to the user's specific needs at the opportune time to make a sale. As developers and companies expand data collection and restrict customization of privacy settings, it is important to highlight these changes as vulnerable populations—specifically children—are directly affected and exposed to privacy risks. In this position paper, we discuss advertising techniques present in existing immersive spaces (i.e., video games), posit opportunities for dark patterns and manipulative design in XR, and discuss suggestions for further research into possible exploitation in the space of XR.

Keywords

Dark patterns, deceptive risks, extended reality, eye-tracking privacy, marketing, advertisements, video games, decision-making

1. Introduction

Microtransactions have become commonplace in gaming, particularly in games with a multiplayer or social component and, according to a 2019 study [1], account for 50% of total revenue of video game publishers [2, 3, 1, 4]. Players can purchase a variety of game objects ranging from cosmetics to customize their avatars, items or characters to give themselves a competitive edge, and unlock access to extra content. These immersive spaces present a unique opportunity for video game developers to advertise their microtransactions to players directly based on their specific needs. However, these microtransactions can have adverse effects for the player base. Fairplay's report on how children and adolescents interact within the Metaverse found that children are predisposed to dislike intrusive ads, yet marketing strategies exist to engage users of online gaming spaces by applying social and emotional pressure to maximize profit while also exploiting adolescent vulnerabilities and developmental needs [5]. As video games continue to expand into the extended reality (XR) space, video games will increase in immersion, embodiment, and allow biometric access to the game itself [6]. These biometrics—including hand, head, and eye tracking—offer a unique insight into players and their cognitive state [6, 7]. Such data would allow video games to determine the optimal time to make a sale and change the content of the advertisement such that it is relevant to the player in that moment: by leveraging machine learning (ML) models, advertisements can adapt in real-time to manipulate users into purchasing content [8, 9].

The Federal Trade Commission (FTC) released a report on the rise of dark patterns and manipulative user interface (UI) design [8]. Their findings indicate how companies are increasingly deploying digital dark patterns to subvert user expectations and purchase products while also revealing personal

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information [8]. Fairplay's report outlines harms to players including social pressure to purchase virtual goods in order to maintain good social standing within a peer-based community [5]. In addition, financial burdens are placed upon families, children and adolescents are exposed to homophobia and racism through avatar customization, and mental and physical health are affected through harassment from peers and engagement maximizing efforts from the platform itself [5]. For platforms with user-generated content such as Roblox, creators observe several disturbing elements exposed to children including deceptive designs, gambling-based gameplay, normalization of anti-social behaviors, sexual abuse and adult roleplay, and scams. The creators themselves posit such behavior is based on Roblox's monetization model [10, 11]. In fact, some Roblox developers deploy deceptive designs, including UI manipulation to encourage impulsive user spending, specifically to exploit children due to their vulnerability and lack of financial understanding [12]. Problematic gaming and gambling behaviors are associated with frequent purchases of microtransactions [13]. While parental controls exist in video games to protect children and limit spending and screen-time, parents may not be aware of such privacy controls of settings or features [14]. In February 2026, a parent posted on LinkedIn of their concern regarding Roblox revoking access to their child's privacy settings once they turned thirteen [15]. This suggests video game developers are removing protections for children once they become adolescents; however, this shift occurs without prior notice and despite parental desire for such controls. Without policy to provide enforceable protection for consumers, and children, how can developers maintain user trust if parental and privacy controls are rolled back? Even with such protections, how can existing methods for advertising in traditional immersive spaces—including gaming—be further exacerbated in XR?

2. Manipulative Ads and Marketing Strategies in Video Games

As of the writing of this paper, XR has yet to be widely adopted. Still, we can look to traditional gaming platforms for the current state of how dark patterns emerge in immersive spaces. Games with microtransactions are especially incentivized to employ aggressive in-game marketing to their players. To this end, manipulative UIs and dark patterns alike are employed by games across all platforms. This is effective across many different styles of game: gacha games, massively multiplayer online role-playing games (MMORPGs), and XR games, among others.

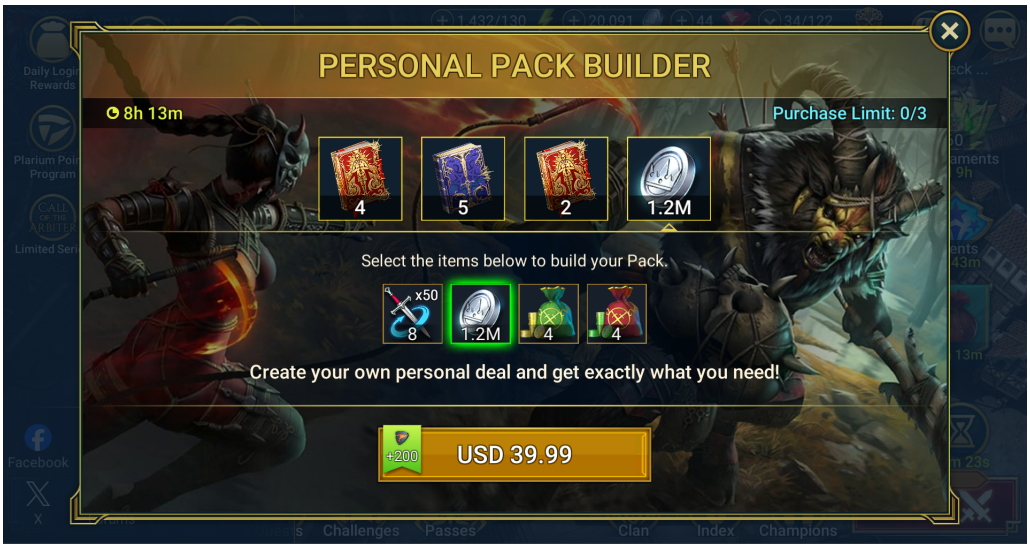

Figure 1: A screenshot of an in-game advertisement in *Raid: Shadow Legends*. The advertisement allows the user to create their own game object package to purchase as a microtransaction. The limited-time nature of these offers adds a sense of urgency to their call to action to make the purchase and boost account progress.

2.1. Gacha Games and Pay-to-Win Strategies

Gacha games are free-to-play online games where players unlock content—such as characters, weapons, items, cosmetics—through a vending (gachapon) machine mechanic. Players use real-world money to purchase in-game currency to perform "pulls" or "spins" for a chance to receive content from loot boxes. The odds of unlocking content are rarely publicized. Most countries do not categorize gacha games as a form of gambling. Nevertheless, gacha games expose their player base to marketing strategies on a regular basis.

The mobile and desktop character collection game *RAID: Shadow Legends* (RAID) engages with dark patterns with core game design elements. The game generates demand for microtransactions (Figure 1) by requiring resources for gameplay loops, loot box pulls, and resource-intensive events, then harvests this demand by regularly displaying offers to players [16]. Characters available for collection—generally through a loot box gacha system—are regularly exposed to players as enemies where they are made aware of their designs and abilities [16]. Additional gambling attempts to acquire these characters through loot boxes known as "shards" can be purchased with real-world money at any time. Aggressive pop-up ads are shown to players upon login and navigation to the player's "bastion" or hub: the main area of preparation for the game [16]. *RAID* and many other games also leverage players' "fear of missing out" (FOMO) by presenting limited time offers and deals: "This is a rare offer - you don't know if you'll see it again!" [16]. This presents a sense of urgency for players to make the purchase while inducing a sense of fear that such a deal will not be offered to them in the future. In addition, *RAID* offers a "pay-to-win" aspect for players: instead of performing a repetitive, tedious task (grinding) intended to frustrate players, loot boxes and resources can be purchased to progress in the game [17].

Collaboration and competition with other players both present various gameplay incentives to boost progress through microtransactions. Players are automatically pitted against one another in both individual and clan-wide tournaments requiring engagement in various gameplay loops [16]. Items can be consumed to boost performance within the tournament; these items can be purchased through microtransactions. This also introduces a social gaming aspect wherein players can see each other's clan contribution points during clan-wide events [16]. Clans can kick players from their community if players do not perform well [16]. Membership in a clan is required to access several areas of the game where important resources can be earned in collaboration with clanmates [16]. Finally, *RAID* also utilizes a global messaging system which informs players when another player receives high-quality items from loot boxes [16]. This urges other players to purchase loot boxes to progress.

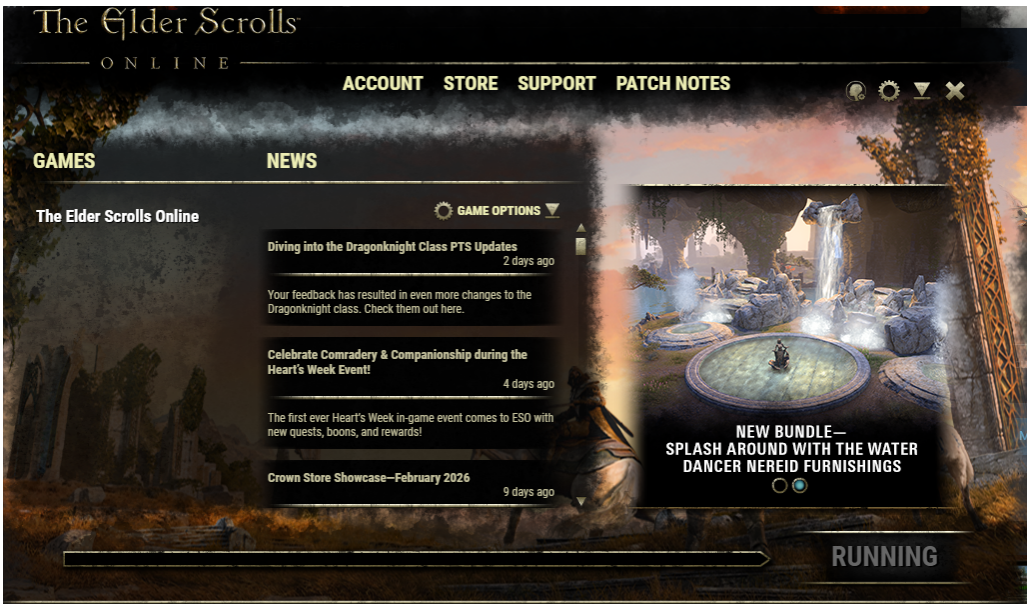

Figure 2: Space in the launcher is utilized to create impressions for advertisements featuring new products.

2.2. Massively Multiplayer Online Role-Playing Games

The massively multiplayer online role-playing game (MMORPG) *The Elder Scrolls Online* (ESO) also exposes players to advertisements for in-game content. Upon launching the game, the update launcher (Figure 2) features new items available for purchase [18]. After selecting a character to play, the player is greeted by a pop-up featuring various limited-time items available for sale; discounts are highlighted for subscribers [18]. New areas, customization options, and consumables that provide temporary buffs are available for purchase with in-game currency purchased with real-world money [18]. New gameplay content and gear locked behind these paywalls entices players into engaging in microtransactions. Additionally, a monthly subscription paid with real-world currency bestows several gameplay benefits on players: increased storage space, resource gain, discounts on in-game purchases, and unlimited space for crafting materials [18]. The unlimited space for crafting materials is particularly useful as without the crafting bag, all materials—potentially hundreds of items—are placed into the player inventory, which has limited space. In fact, some players report the game is unplayable without the crafting bag [19].

In addition, players themselves in the game world act as advertisements. When players encounter each other, they are able to see each other's level, class, armor, and companions [18]. Armor cosmetics and companions can be unlocked through in-game actions—such as quests—or they can be purchased through the in-game store with real-world currency [18]. Some cosmetics are difficult to unlock, only being offered during certain daily activities (dailies) and group activities [18]. The group activities require collaboration between players and can take up to an hour to complete [18]. Even so, the dailies and group activities may not always drop the desired cosmetic style [18]. However, these cosmetics can be accessed through the in-game store: players can receive instant gratification in regards to their appearance if they do not wish to grind through mission requirements [18]. Still, not all cosmetics are available for purchase as the in-game store rotates its available selection [18]. This rotating selection exploits FOMO within the player base to get the cosmetic immediately or to subject themselves to the grind. This is particularly concerning as those who are unable to purchase such items may need to spend days or months grinding for one object, potentially detracting from their game experience and inducing frustration to get the look they want and maintain social capital.

2.3. XR Games

Advertisements in games are not limited to traditional mobile, console, and desktop platforms: these can also be extended to XR. As shown in Figure 3, songs from popular artists set to *Beat Saber* levels serves as content marketing in the context of the game [20]. Content marketing is a marketing strategy in which a company will create and distribute media content to entice customers [21]. Purchasing these new tracks serves a dual purpose of providing new in-game content and increasing product awareness for the music used to create the new levels. As XR is still an emerging technology, the initial investment to experience XR along with the association and bias of XR used solely for gaming may be difficult to overcome for some individuals [22]. In addition, studies show certain populations—including women—are more at risk for simulation sickness [23, 22]. These factors may contribute to the lack of popularity in XR games, experiences, and monetization. However, the interest for XR is present with the development of always-on displays such as the Meta Ray-Ban Display Glasses, an augmented reality (AR) device that provides visual information on the in-lens display [24]. Such lightweight, everyday devices can introduce a broader population to XR and showcase use beyond gaming. As XR continues to develop and, ultimately reduces in cost and gains in popularity, the risk of monetization still remains.

2.4. Backlash of Monetization

There have also been instances where microtransactions have been intentionally removed from video games due to backlash. In 2015, *PAYDAY 2* introduced safes—their version of loot boxes or gacha pulls—to the game. Players would be randomly awarded a safe upon completion of a mission. These safes gave players a random weapon or armor skin which could potentially also boost aspects of gameplay (i.e.,

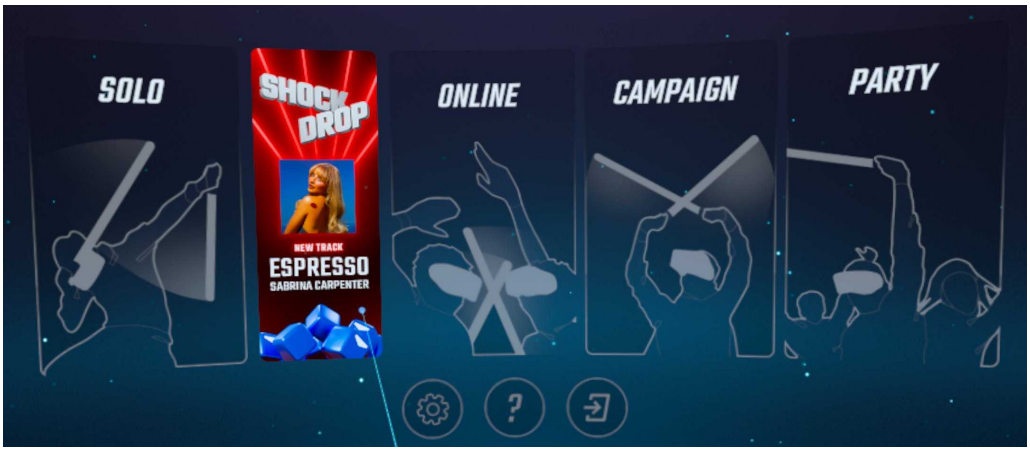

Figure 3: In-game screenshot of the home screen in *Beat Saber*. Downloadable content is displayed in color while the gameplay menu options are shown in grayscale.

increase accuracy, stability, concealment, team boost). Safes could only be opened with drills. These drills could be bought with in-game currency that was purchased with real-world money, received from completing missions, purchased on the Steam Community Market, or traded between players. The addition of this content received widespread backlash from the community [25]. The developers released statements citing the need to introduce microtransactions to maintain the game [25]. The developers reasoned that, due to their decision to reduce the price point of the game, they needed to generate revenue in other ways to ensure updates and content packs were released [25]. After *PAYDAY* and its intellectual property were acquired by a different game developer, all microtransactions were removed from the game [26]. Safes could now be opened without the purchase of a drill and safes could still be received as a reward for completing missions. Interestingly, the gacha elements remained intact despite the removal of paid microtransactions within the game itself. This showcases how the introduction of monetization elements in games can backfire; however, if a game contains microtransactions upon release, it can be readily accepted as part of the game itself by players as demonstrated in RAID and ESO. Nevertheless, *PAYDAY 2* is an example of a player base leveraging engagement against unethical practices to an extent. While players may band together to influence such change, there still exists a need for policy to protect users from dark patterns in gaming. Given the immersive nature of XR and the integration of trackers and sensors on such technologies, dark patterns will continue to emerge.

3. Dark Patterns and Privacy Concerns in XR

As XR has yet to be widely adopted, there exist few examples of manipulative ads and dark patterns in XR. However, this presents an untapped market for businesses. XR presents unique opportunities for deceptive risks and dark patterns. Through the unique nature of immersion in XR, users can experience advertisements within the virtual environment (VE) themselves. These advertisements can be specifically tailored for each user, depending on their demographics, cognitive state, or behavior. This information can be gleaned from interactions with the VE [27] and sensor data, including eye tracking [7] or head and hand motion [28]. This poses a privacy risk as users may not necessarily want their motion data to be used to infer such information, and users may not be aware of the risks of exposing their private data through motion tracking. In addition, this data can be used to analyze behavior and cognitive state to determine the optimal time to display an advertisement and make a sale. Specific groups may be targeted due to their impressionable nature. Children and adolescents can be targeted to take advantage of their desire for peer acceptance. Those with problematic shopping or gaming behaviors and neurodivergent users could be subjected to advertisements that exploit impulsive buying habits. However, research suggests in-game purchases are more closely linked to social aspects rather than problematic gaming behaviors; players are more likely to make purchases when their friends

or community members make purchases or to give as gifts to other players [29, 30, 31]. Players also spend money on games they already own, with the largest amount of money spent on content that enhances gameplay [32].

A possible dark pattern also arises wherein advertisements may show harmful content to users. A user may enter a virtual space and experience harmful advertisements such as explicit content. The explicit content could be displayed directly in front of the user and prevent the user from closing the advertisement by rendering a fake cursor through gaze or controller; advertisements could also be displayed outside of the user's vision and placed directly behind the user so the user is still able to hear the content but is unable to close it due to the advertisement constantly rendered in their blind spot [33]. Gaze manipulation can also be used to guide gaze position, manipulate attention and perception, and potentially manipulate decision-making [34, 35, 36].

In addition to showing harmful content, there is a risk that an advertisement can induce simulation sickness in users. This can cause physical harm to users in the form of vertigo, nausea, and potentially falling. Not only does this pose a potential physical harm, but it also potentially raises the possibility of users refusing to engage with the virtual world. If a harmful advertisement is presented in a specific virtual world, the user may refuse to return to that virtual world and may drive down potential visitors. Developers may not generate enough traffic to maintain the virtual world and lose player traffic to other venues.

From a marketing perspective, eye-tracking data has the potential to efficiently perform market segmentation on users. Segmentation, in a marketing context, is any method of dividing users, customers, or potential customers into groups that differ in a meaningful and actionable way [21]. Eye-tracking data can be used to infer an individual's gender, age, ethnic origin, sexual orientation, neurodivergence, cognitive state, and more [7]. Such extensive data allows advertising spaces in VEs to adapt to and uniquely target users in real-time, as eye tracking reveals more about the user during sessions. Immersive environments could be populated with advertisements based on this data, appealing to particular demographics a user belongs to, allowing businesses a unique opportunity to generate product impressions on consumers more likely to be interested in their product. In addition, machine-learning algorithms can be utilized to analyze user behavior and display ads when users are more likely to make a purchase [8].

Advertisements in immersive environments also provide an opportunity for interactions with content that would be impossible in traditional mediums. Traditionally, static advertising styles such as billboards and posters could serve a dual purpose in immersive environments of generating impressions but XR also allows users to interact with the advertisements, potentially generating a conversion or sale on the spot. In addition, attention can be drawn to both diegetic (i.e., elements perceived as part of the experience) and non-diegetic cues (i.e., elements not perceived as part of the experience) using subtle gaze guidance [37, 35, 38]. This form of gaze guidance can be used to draw attention to objects users would not normally view. In addition, studies show consumers fixate longer on items they wish to purchase, including in virtual reality (VR) [39, 40]. Previous research demonstrates gendered differences in dwell time, fixation count, and pupil diameter in response to viewing different areas of interest in sales and service areas [41, 42]. This information can be leveraged to adapt ads based on user demographics. Machine learning algorithms are in development for determining user behavior and purchasing decisions [8, 43, 44]. Finally, research suggests users are more likely to make risky financial decisions in highly immersive environments than in low-immersion environments [45]. These techniques, inherently unique to XR, allow for more intrusive ads and marketing strategies.

4. Future Work

While research exists comparing dark patterns across web and mobile applications [46], there exists a gap directly comparing the effectiveness of dark patterns between XR and other applications. Studies have shown VR users are more likely to engage in risky financial behaviors in comparison to traditional desktop environments [45]. In addition, biases can be exacerbated in VR. While research has shown

exposure to virtual avatars can reduce racial biases [47], studies have also shown shooter bias still exists within VR [48]. Hundreds of games on the gaming platform Steam are classified as first-person shooter games. If developers employ dark patterns or manipulative design in these games, biases could be exacerbated even further.

As a community, one research direction we should explore is measuring whether dark patterns are more effective in XR than traditional modalities. Previous research has examined and presented several dark pattern designs unique to XR that take advantage of sensors available to XR devices [49]. Different marketing strategies can be explored to measure their effectiveness in XR in comparison to traditional mediums as traditional advertising techniques may not be as effective in XR than across other platforms. Uniquely, the perception and spatial awareness of users can be modified and fine-tuned using biometric data for manipulation [50, 49]. XR could also be examined in how it communicates with other devices over a network. Taking a similar approach to Kowalczyk et. al, users could be observed interacting with XR devices in a freeform space to discover how dark patterns manifest in different ways across devices connected to a local network [51]. This would allow researchers to gain insight on how users interact with XR in their everyday lives and could provide feedback at the end of the session showcasing what data is collected from users and where it goes to further enhance awareness among participants. Finally, interviews with current users and developers of XR devices and applications can identify emerging concerns of the community and known exploits used by developers and creators [10, 11].

By creating a dialogue between users, developers, creators, and publishers, perhaps an equitable solution can be found to limit the use of dark patterns. The outcome of these studies can provide guidelines for future developers, generate material to raise awareness of dark patterns in XR, increase user trust with publishers and game developers, and provide other safeguards for users while allowing for ethical monetization. Given the emerging nature of XR technologies and unknown integration of advertising in practice we also recommend developing and evaluating prototypes of manipulative and deceptive patterns based on current XR design work [52, 36, 49, 53, 54]. Each type of study investigates different dimensions of XR deceptive patterns with complimentary insights towards mitigating risks, concerns, and ethical issues for a fast emerging technology.

5. Conclusion

Research demonstrates the prevalence of dark patterns and manipulative design in video games. Developers leverage social aspects of gaming as well as limit parental controls to drive sales and increase revenue. These predatory tactics can be expanded to immersive XR environments and—with the rich data collected from user behavior and biometrics such as eye tracking and hand motion—fine-tuned to further drive sales. As video game publishers push to revoke parental controls, there is a lack of legislation and enforcement to prevent them from doing so, thus exploiting vulnerable populations, including children. Critical HCI and policy work is required to equip developers and publishers with guidelines or tools to generate ethical advertising techniques that garner user trust while also generating awareness for their products.

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Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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