Misinformation in Virtual Reality

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1 Introduction

The vivid creation of a novel reality is often the goal of most immersive Virtual Reality (VR) experiences. While these perceptual simulations can be used for healing, for example improving mental health (Parsons and Rizzo 2008) or recovering from strokes (Fluet and Deutsch 2013), there is growing concern that the same properties of VR that create realistic and persuasive experiences can be used for manipulation (Slater et al. 2020). As noted in Trauthig and Woolley (see this issue), one of the core threats of VR to trust and safety is the potential for VR to amplify misinformation.

There is already substantial concern about misinformation in our current information ecosystem, from websites to social media to news content, which is composed primarily of text, images, and video (Peng, Lu, and Shen 2023). Misinformation in this media ecosystem has raised fears about polarization, declining trust, and damage to democracy and society (Heller and Bar-Zeev 2021; Hunt and Gentzkow 2017; Koehler 2014). Given the potency of immersive VR for novel experiences that go far beyond text, image, and video, the potential for manipulative persuasion using misinformation is particularly alarming (Woolley 2022). Indeed, with recent technological advances in virtual reality and generative artificial intelligence, there is a growing concern about the need to address these technologies in the context of misinformation given the potential they have to exacerbate the problem. Yet to date, there has been little research on the topic, let alone guidelines for trust and safety stakeholders.

To give a sense of this immersive potency, consider our experience teaching a large class of Stanford University students in the metaverse (Han et al. 2023). A major aspect of the course was for the students to work in groups and build an experience, specifically one that leveraged all the aspects of VR that make it a unique medium. One group chose to build a simulation that starts on the moon, with a panoramic moonscape seen through the eyes of an astronaut, and presented the experience to the teaching staff. We were all physically in different locations but were networked together as avatars. By physically walking in our offices, we controlled our avatars, which similarly walked and approached the virtual lunar lander. By reaching out our hands in the real world, we were able to see our avatar's hands touch the base of it.

Perceptually, we experienced the awe of being on the moon. But then a sound, spatialized to emerge from behind us, caused us to turn our heads around, where we were stunned to see a large warehouse with movie cameras, set lights, and even a catering table with snacks for the movie crew. Walking around in the warehouse and then looking back at the "staged" lunar lander and the US flag through the warehouse windows completely reframed our initial experience of awe. For the teaching staff of the course, it was a jarring experience of how the features of VR could be used to produce such potent misinformation, in this case, that the lunar landing in 1969 was a Hollywood fake. Obviously, none of us have ever walked on the real moon, but the only time we had

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an experience that approximated the experience of moonwalking turned out to be a form of misinformation. Hence, we are introducing the term *mis-experience*, to highlight the experiential, immersive nature of false information presented in VR.

In the present paper, we provide a close examination of how the various features that comprise VR may play specific roles in creating persuasive misinformation. As previous scholars have noted (e.g., Cummings and Bailenson 2016), there is not one standardized implementation of VR; it is instead a configuration of various features and technologies. In this paper, we develop an affordance-based framework to examine how each *affordance*, which refers to features that contribute to a media's functionality, in VR may influence misinformation effects, in particular the creation of false beliefs. This approach becomes particularly useful when one considers the range of headsets now widely available, from Google Cardboard systems, with features that only track head rotation and have a low field of view (FOV), to the Valve Index that maximizes most of the features on our list. We review past research and provide narrative examples to illustrate how each feature can play a role in enhancing misinformation effects. We end with a discussion around current trust and safety implications for different platforms that host VR content and areas for further research as this fast-growing medium develops into the metaverse.

2 Misinformation, disinformation, and misperceptions

While misinformation has existed for centuries, it has recently become salient in the context of current media environments and important societal events, including elections, COVID-19, and geopolitical tensions. Concerns around the spread and prevalence of misinformation have increased substantially due to properties of the internet that allow for the relatively inexpensive creation of false or misleading information and the ease of sharing it across networks (Weeks and Gil de Ziga 2019). Indeed, nearly three in four Americans rank the spread of false information online as a major threat, with only climate change ranking higher (Atske 2022).

In response to these concerns, academic research on misinformation has exploded since 2016. Research examining how misinformation spreads online has found that news that has been fact-checked and determined to be false spreads faster on Twitter compared to real news (Grinberg et al. 2019). Vosoughi found that false news not only spreads more rapidly and deeply than real news through networks on Twitter, but that false news was more novel and elicited more surprise and disgust than true news, which likely contributes to its virality ((Vosoughi, Roy, and Aral 2018).

On the other hand, even though research has found that misinformation spreads quickly, research on how frequently people are actually exposed to misinformation online suggests that is not as frequent as the extensive concerns imply. In a large-scale analysis of the information ecosystem that Americans consume online and on TV, a recent study found that the prevalence of misinformation was quite low, representing less than 1% of most individuals' media diets (Allen et al. 2020). Similarly, research examining exposure to misinformation during presidential elections found that nearly half of Americans were exposed to misinformation websites in 2016 (Guess, Nyhan, and Reifler 2020), but that this number declined to approximately one-quarter of Americans in 2020 (Moore, Dahlke, and Hancock 2022).

For those who are exposed, however, the consequences are negative. First, substantial research finds that people generally struggle with discerning misinformation from credible news on the internet, in part because people do not carefully analyze news sources on social media (Pennycook and Rand 2019). Moreover, even when they do scrutinize, determining the source can still be a difficult task, especially for nonpolitical news (Luo, Hancock, and Markowitz 2020). Second, while there is surprisingly limited research on the downstream effects of misinformation exposure, a few recent studies suggest that exposure can reduce the likelihood to vote in an election (Green et al. 2022) and that it increased the false belief that the 2020 US presidential election was false (Dahlke and Hancock 2022). Third, the exposure and effects studies reveal that misinformation tends to be targeted at those most susceptible to it, such as older adults who may have limited media literacy compared to younger adults (Moore and Hancock 2022), and that it has a disproportionate effect on those individuals (Grinberg et al. 2019; Guess and Lyons 2020).

While most of the current misinformation research is primarily on text-based content, there is increasing, but still limited, research focusing on misinformation in visual or multimodal forms (Peng, Lu, and Shen 2023; Yang, Davis, and Hindman 2023; Sundar, Molina, and Cho 2021). For example, there are increasing concerns with synthetic media, or deepfakes, that use AI to generate a video that appears real and can depict people doing or saying things that they, in fact, did not do or say (Farid 2022).

To advance our understanding of misinformation in VR, we first need to provide some conceptual and definitional background on the concept of misinformation. We draw on prior research that focuses on both the qualities of the information itself, whether it is considered true, and on the perceptions and beliefs that people hold (Nyhan and Reifler 2010). This clarification is important in the context of VR and misinformation, as we are interested in how VR features can influence the presentation of information as true or not, as well as how these features can influence people's beliefs and perceptions. We therefore first define misinformation as "that which contradicts the best expert evidence available at the time (Vraga and Bode 2020, p. 136). In the moon example from our class, the presentation of content depicting the moon landing as a Hollywood fabrication is misinformation according to our definition because it contradicts the expert evidence about the moon landing.

Given our focus on how VR features affect beliefs, we next define misperceptions as the beliefs that people hold about factual matters that are not supported by clear evidence (Nyhan and Reifler 2010). Distinguishing these two distinct but related aspects of misinformation allows us to focus on how perceptual experiences in VR may have an impact on people's false beliefs. It also highlights how VR may influence memories of experiences that can also lead to misperceptions. For example, Loftus' misinformation effect refers to "the impairment in memory for the past that arises after exposure to misleading information" (Loftus 2005, p. 361). Our emphasis on misperceptions reflects instances where an individual receives false information that conflicts with a previous direct experience, hence interfering with the accuracy of the recall of the memory. Given that VR is often used to create experiences, it has the potential to alter memories of real-world experiences, which can lead to misperceptions.

Another aspect unique to VR that has implications for misinformation is how difficult it is to create. Unlike other forms of online communication like social media, to use VR, experiences must be built specifically for the medium, and it is helpful to understand this construction process so that affordances can be understood within the context of the medium. Even with today's push to build the metaverse and the advent of new creation tools, it remains incredibly time-consuming and difficult to build high-quality, compelling content for VR. Unlike a movie or most video games, a VR scene has to be exhaustively reactive, that is, it has to be able to be rendered from any possible distance or angle. To put this in perspective, a film only shows the viewer one angle or distance at a time, and most video games offer players a very limited set of viewpoints. In VR, a person can choose any one of an infinite number of locomotion/gaze combinations as they view a scene. In a pizza parlor, the viewer might decide to crawl on all fours and then turn their head upward to stare at the bottom of a table, and the scene needs to be built in order to support any possible exploration.

Given how difficult it is to develop VR content for misinformation, we may also be able to assume that the creator of VR misinformation intended to foster false beliefs. In this case, in which the intentions of an actor can be inferred as deliberate, VR misinformation could be considered disinformation. Disinformation is a subset of misinformation in which the spread of false information is known to be deliberate and with the intent to cause harm by creating misperceptions (Guess and Lyons 2020). The relative difficulty of creating and sharing misinformation in VR compared to social media suggests that, at least at present, misinformation in VR is likely to have been created by manipulative actors who have the intent to spread false information using VR rather than naive actors who unknowingly spread VR misinformation. Because these constraints are likely to change as VR construction becomes cheaper, less effortful, and easier to share and propagate, we will use the more general term misinformation in the present paper while recognizing that disinformation is possible in many current cases. Finally, with this conceptual background, we define the term mis-experience, which refers to the experience in VR of experiencing misinformation that leads to misperceptions about the real world. In sum, as we use terms related to false information in this paper, *the VR content is misinformation, the user's activity inside VR that presents misinformation is mis-experience, and the false beliefs that mis-experience fosters are misperceptions.*

3 Virtual experience changes real-world behavior and belief

There is a scarcity of research examining VR and misinformation specifically. While a few studies have demonstrated source confusion, in that people will sometimes subsequently remember virtual simulations as if they were real memories (Rubo, Messerli, and Munsch 2021; Segovia and Bailenson 2009), we are unaware of any research that deliberately tests misinformation in VR. However, a number of research programs have examined how virtual experiences change subsequent attitudes and behaviors. Indeed, one of the first theoretical psychological models focusing on VR (Blascovich 2002) was centered around "influence" and how theories of mind, the realism of social actors, and the context of an experience would contribute to a VR simulation changing behaviors ranging from automatic, where users don't realize a change is occurring, to more deliberate actions.

Ahn provides a recent review of VR behavioral change research and focuses on three areas (Ahn 2021). The first is communicating risk, for example, making outcomes surrounding climate change less abstract by having users become a coral whose body disintegrates due to climate bleaching (Ahn et al. 2016). The second is promoting specific behaviors, for example, having people experience future outcomes of their body shape based on eating carrots or chocolate (Fox, Bailenson, and Binney 2009). The third is specific to marketing brands; for example, in VR one can have their bodies integrated into branded experiences focused on products they have never used before in the real world (Ahn and Bailenson 2011).

At the center of this work is that the medium provides an experience, one that skews closer to an actual one than a mediated one, perceptually and psychologically. VR researchers frequently focus on *presence*, which refers to the psychological impact of VR experiences that make them feel real to users (see Bailenson 2018, for an in-depth discussion of presence and experience). Direct experiences translate to higher memory retention and impact beliefs and behaviors differently than indirect experiences (Ahn 2021; Hamilton and Thompson 2007). With direct experiences, individuals more quickly form strong convictions surrounding the experience and more confidently display behaviors consistent with those convictions after the experience (Fazio and Zanna 1981; Wu and Shaffer 1987). We expect that the power of VR to create direct "mis-experiences" is likely to have powerful persuasive effects on how misinformation presented in VR can influence misperceptions, but we note that there is little research that directly tests this hypothesis.

4 Virtual reality use today

In 2022, just under 9 million headsets were sold. Almost all of them were sold by social media companies (80% by Meta, 10% by ByteDance (Ubrani 2023)). Many users download and play *self-contained VR* experiences from marketplaces such as the Steam Store, which is curated by the game development company Valve. In self-contained VR experiences, there is only one live human using the simulation at any given time, and the main element is to accomplish a goal or experience a planned story or narrative. This includes everything from the blockbuster video games released by large studios where one combats zombies, to the tiny small-budget experiences released by one developer that allows users to experience empathy by walking a mile in the avatar of a different identity. Meta also curates access to VR experiences via the Meta Quest application. In February 2023, Sony released their second VR headset, which is available to their 112 million monthly users to access a variety of games when tethered to their Playstation video game console, but at the time of writing this paper, we do not have statistics available on usage.

Social VR platforms allow people to network together as avatars and to build and experience VR scenes together. For example, the VR application VRChat allows people to create a custom 3D world, inhabit any avatar that they can imagine, and then meet and share virtual experiences with other users. The platform is inherently social, with the intention that users meet new people and form relationships and communities. Meta's current VR social networking application is Horizon Worlds, which is estimated to have around 200,000 monthly active users as of the time of writing this article, interacting in over 10,000 virtual environments (Horwitz and Rodriguez 2023).

5 Scene construction in virtual reality is different than social media

To understand misinformation in VR, one must understand the process of building VR content. Many believe that VR hasn't become mainstream due to hardware limitations. However, given that most VR headsets cost about half as much as a smartphone, scholars studying VR often point to the dearth of engaging, effective content as the reason for low adoption rates (Mado and Bailenson 2022). Unlike typing a social media post or recording a video, which anyone can do in seconds, building a successful VR scene is difficult, and can take thousands of hours. Hence the process for misinformation in VR will depend on how the scene construction process evolves. There are two current types of worldbuilding techniques—modeling and capture—and one that is likely forthcoming: generative AI.

Modeling involves building a VR world, one asset at a time. For example, if one were building a specific Washington, DC, pizza parlor, one would use 3D modeling software or photogrammetry to build tables, chairs, food, customers, sounds of cooking and conversation, and perhaps scents depending on one's VR system. Creators use discretion in order to place objects spatially in relation to one another and to program in interactivity among objects (e.g., if pizza color change when one adds crushed red pepper from shaker), animations (e.g., how the customers stand, gaze, and express to one another), and physics (e.g., how far the sound of a voice travels given the acoustics and layout of a digital room).

Capture involves using special cameras to produce spherical video, volumetric capture, stereoscopic video, and other forms of video that can capture a scene "as is" (see Jun and Bailenson 2023, for a recent implementation). For example, a spherical video creates a seamless 360° vista that one can see by turning one's head around, has a high resolution, and is easy to record with a single camera. The challenge is that spherical video only allows for a single viewpoint. For example, if a 360-degree video were shot from the counter of a pizza parlor, the viewer would never be able to look under the tables. Photogrammetry, which infers 3D structure by instantiating lots of different still images of the same object from alternate angles, is a robust technique but does not work well in scenes that have movement, such as a pizza parlor that is crowded with bustling customers. Volumetric capture, which uses passive and active cameras to produce point clouds of scenes, allows for movement within the scene and rendered realistic models, but is expensive and currently requires dedicated rooms.

Generative AI, which can produce language and images from simple prompts, will affect misinformation production drastically in the coming years (Goldstein et al. 2023). Similarly, it will transform how VR scenes are produced, including 3D models, dialogue among embodied agents, and contextual scenes (Lin et al. 2022; Ghorab and Lakhfif 2022; Guo et al. 2022), and could be transformative for allowing VR content production to scale in a manner similar to social media.

6 An affordance approach

VR has been evolving since 1965, when Ivan Sutherland wrote his masterpiece outlining "The Ultimate Display," where the concept of VR was well explicated, but the manner of implementation was not. Indeed, the past few decades have shown an incredible change in what is possible in the medium of VR. For example, in Sutherland's early implementations, headsets were unable to render scenes stereoscopically, or in more than a single color. Fast forwarding the same number of decades forward, headsets should have sight, sound, and smell that are indistinguishable from the real world, and touch that is much more realistic than today. Hence, if we want to understand the impact of VR on persuasion, one way to move forward is to assume that there is no consistent medium called VR, and instead, we should examine a set of immersive technological features that work together to produce an experience of presence, the psychological experience of "being there," when using immersive media (Cummings and Bailenson 2016).

In order to understand how these features can give rise to misperceptions, we draw on the concept of affordances, which refers to the potential actions or uses that an object or technology can enable or allow for a user. It is a relational concept dependent on the properties of the object or technology and the abilities, experiences, intentions, and beliefs of the user. Affordances are not inherent properties of the object or technology, but rather emerge from the interactions between the user and the technology in a given context.

Treem and Leonardi's work on this topic provides a useful framework for understanding how affordances shape social interaction and communication in online environments (Treem and Leonardi 2013). They argue that online communication technologies, such as social media, have a range of affordances that shape how users engage with each other and how they construct their identities and relationships. For example, the affordance of anonymity on online discussion forums may encourage users to share more personal information than they would in face-to-face interactions. Another example is the affordance of hyperlinking in online writing, which allows writers to create connections between different sources of information and ideas in a way that is not possible in print media.

The concept of affordances is important for understanding VR's potential for fostering misperception by allowing us to examine how each feature of VR technology can shape human beliefs and behavior in nondeterministic ways. That is, while each feature we analyze can enhance a sense of immersion or create persuasive content, simply engaging with those features does not necessarily lead to changes in a person's beliefs or behaviors. Instead, an affordance-based approach avoids technological determinism by recognizing both the potential persuasive power of a VR feature and a user's psychological experience of that feature in influencing their beliefs or behaviors. For example, although the teaching team all experienced the moon landing in VR as a faked landing, with VR features that produced a sense of immersion, none of us now believe that the moon landing was faked.

The core point here is that mis-experience in VR does not automatically lead to misperceptions, just as exposure to misinformation in social media or on the internet does not automatically lead to misperceptions. For example, people exposed to misinformation on the internet during the 2020 presidential election were only 4% more likely to believe that the election was fraudulent than those who were not exposed (Dahlke and Hancock 2022). Several behavioral and psychological aspects can play a role in whether VR features that are used to create an immersive misinformation experience will actually lead to belief change. For example, *selective exposure* is a behavioral mechanism in which people select media that are consistent with their desired beliefs, which can lead to misperceptions (Zillmann 1985). If a person selects VR experiences to enhance their beliefs that the moon landing was faked, then the misinformation experienced in VR is likely to foster misperceptions. In contrast, *motivated reasoning* is a psychological dynamic in which people are more likely to believe media content when they have reason to want it to be true (Epley and Gilovich 2016). For example, if a person's preferred candidate lost an election, and then participated in a VR experience that falsely indicated that their candidate won, that VR experience would be more likely to foster a misperception.

Thus, an affordance-based approach that recognizes the interaction between different VR features and characteristics of the user is important. While some features are likely to add persuasive power regardless of the type of misinformation, such as head tracking and avatar behavior realism (Guadagno et al. 2007), other features may not have a strong effect on the potential to foster misperceptions. And the power of these features to foster misperceptions will also depend on the characteristics of the user. With this approach, in which we conceptualize how features in VR can play a role in affording misperceptions for a user, we can gain insights into the potential implications of specific VR features for misinformation without being overly deterministic. Another reason why it is important to consider each of these features separately is that a person who implements VR will need to prioritize them during implementation. A VR headset is a zero-sum host, and features necessarily trade-off with one another. A lot goes into how realistic a scene can look, for example, how many objects can appear in a scene, how detailed those objects are in terms of the number of polygons, the resolution of textures that add realism to objects, and dynamic lighting, to name a few. Designers of VR must constantly attend to these constraints. For example, consider the decision to render scenes stereoscopically, that is, to draw separate renderings of the scene for each eye to provide depth. To do so roughly cuts the quality budget in half, and by rendering a scene monoscopically—sending an identical image to each eye—one can roughly double the amount of processing available for the scene.

Similarly, the choice of which headset one chooses will have consequences. One might seek out a headset for high resolution and a wide field of view in order to maximize the visual awe or scale of a scene. However, headsets that tend to maximize those features will usually have a low framerate, that is, the scene updates less frequently based on the user's movements. Consequently, the visual fidelity will trade off with the naturalness of users' movements. Hence, scenes where users naturally look around the scene often will likely be more effective with headsets that maximize low latency and a high update rate, as opposed to the size and quality of an image (i.e., FOV and resolution). Adding more elaborate tracking to a scene—for example, large spaces to walk in, hand and feet tracking for self-avatars—adds a lot of value in terms of presence but trades off with scale and ease of use (see Mado and Bailenson 2022, for a detailed discussion of why it is difficult to use high-end VR in large-scale VR implementations). The more complicated the hardware system is, the harder scaled use is in terms of users learning the system and for physical spaces to support multiple users concurrently.

In our framework, we focus on two feature types and their affordances in VR. The first category is *immersive features*, which are the technological features the medium provides. The second category, *content features*, relates to how the medium conveys information about the user themselves or other actors in the environment. Table 1 on the next page summarizes the reviewed features and their possible effects on misperceptions.

7 Immersive features

Researchers tend to view VR systems in terms of the set of various immersive features that makes a VR experience unique. In this section we have chosen a subset of the features examined in the meta-analysis by Cummings and Bailenson focusing on ones where there are previous findings and/or plausible affordances to link them to misinformation (Cummings and Bailenson 2016). Instead of taking the approach that VR features universally amplify misinformation, when possible, we attempt to explore the affordance of the feature and discuss boundary conditions, that is, misinformation experiences where a particular feature will *not* be effective.

7.1 Field of view

Field of view is typically associated with more presence and engagement in VR (Hendrix and Barfield 1996; Lin et al. 2002). Field of view is roughly a proxy for how much of the scene a person can see at once. As far as we know there are no studies on the field of view in VR and influence, but the closest proxy would be screen size. The literature on screen size and persuasion shows that, in general, larger images cause more emotional arousal than small images (Detenber and Reeves 1996). More recent research shows that large screens, compared to small screens, are 67% more likely to cause processing that is susceptible to heuristics, that is, persuasive strategies that avoid central processing of messages. In VR, compared to users simply looking at static images, many of the scenarios will be episodic in nature. Consequently, VR simulations might work differently than a typical "screen size" manipulation, in that a large field of

Table 1: Virtual Reality Features and Impact on Misperception

Feature	Description	Impact on Misperception	Affordance Example (Election Fraud)
Field of View (FOV)	How much of the virtual world a learner can see around them at once.	Larger images are more persuasive than smaller ones; users gain a gestalt understanding of a scene.	Users can see two people at once who exchange sidelong glances, and understand they are affiliated, whereas in a small FOV, one would miss the exchange.
Stereoscopy	The process of visual perception in which an in-depth sense of sight creates different perspectives of received information by the horizontal separation of two eyes.	Objects close up are seen as more realistic, though this is not as important for distances approximately more than 6m away.	Only with stereoscopic rendering can users see that the surface of a ballot-stuffer’s pocket has a “lump” in it, which could be hidden ballots.
Spatial Audio	Sounds emerge from the visual location of objects and respond to tracking data such that when one walks to a sound, it gets louder.	Serves to strategically draw attention to areas of the scene, and spatial properties of objects are reinforced.	Only when a user gets close up behind two people near a ballot box do they hear conspiring whispers between them.
Latency and Update Rate	The rate at which the virtual environment responds to users’ movements, and how often sensory information is rendered per second.	Faster feedback leads to the perception that the experience is more realistic.	Walking around an election headquarters feels normal, and users are engaged with natural gestures and movements.
Haptic Feedback	The tactile output of the experience on the user.	Touch can impact behavior outcomes when used to emphasize events or social interactions.	A fellow observer who is trying to convince a user that the election is fraudulent rests his hand on their shoulder while pointing out ballot stuffing.

Table 1: Virtual Reality Features and Impact on Misperception — Cont.

Feature	Description	Impact on Misperception	Affordance Example (Election Fraud)
Olfactory Cues	Releasing relevant scent particles in proportion to one's distance to a virtual object.	Scent increases realism and can also be used to create negative or positive associations in an experience.	A user infers foul play from the body odor of a nervous ballot worker.
Tracking	The user's environment responds to body positioning movements, for example turning one's head or walking in a room (six degrees of freedom).	Agency gives self-efficacy; the user becomes an investigator who makes discoveries.	The user gets to look behind the public-facing ballot box and discover on their own a hidden ballot.
Embodiment	The placement of a user's sense of self in a virtual avatar.	Taking on the body and/or visual perspective of another increases empathy towards the particular identity of that avatar.	A user embodies a ballot worker who is overwhelmed at the ballot box and makes mistakes with vote counting.
Social Actors	The feeling of being there with a "real" person that may or may not behave and look as they would in the physical world.	Perceived avatar agency can create social presence and have a greater persuasive effect on the user.	A creator of a misinformation scene can populate the VR scene with dozens of others who look similar demographically to the user and are vocal about their certainty of fraud.
Persistence and Consistency	The notion that the user is not a required participant in the environment for its existence and persistence in networked, social platforms.	The persistence of a scene should increase the sense that the experience is part of reality, not just a one-off simulation.	A user can visit a ballot stuffing simulation and make a discovery, leave VR, and then return in three hours and see a large-scale forensic investigation underway based on the discovery.

view can possibly detract from the persuasive aspects of some types of misinformation. For example, in the election fraud scene, the wide field of view could allow viewers to be distracted from the exact place of ballot stuffing or make it less salient. In this sense, a narrower field of view may be more effective on small-area, episodic misinformation. On the other hand, for Flat Earth, having a wide field of view likely contributes to the awe experienced in a misinformation scene, as the more of the Earth one can see at once, the more the message is reinforced. Hence, the relationship between the field of view and influence will depend on the nature of the experience.

7.2 Stereoscopy

Stereoscopic rendering refers to rendering a scene twice such that each eye receives a slightly different virtual camera location, similar to how humans see in the real world. Most designers consider stereoscopic vision—that is, seeing depth—to be one affordance that truly sets VR apart from other media. However, it turns out that humans rely on stereoscopic vision primarily for objects nearby, within a range of about six meters (Ono and Comerford 1977). Outside of that range, the feature offers very little psychological value. Consequently, for misinformation that is seen over large distances—for example, a simulation of “Flat Earth,” where one can see large distances with no curvature—the stereoscopic aspect of VR actually shouldn’t increase the persuasiveness of the simulation. On the other hand, consider the misinformation in which a user sees an election worker hiding a small piece of paper in her pocket that will eventually be stuffed into a ballot box. In this instance, seeing the lump in the pocket via depth cues resulting from stereoscopic rendering should make a large contribution to the efficacy of the misinformation, as depth cues led to the discovery of the hiding place, and the cover-up.

7.3 Spatial audio

Spatial audio refers to the use of multiple sound channels to replicate proximity to the listener, such that sounds are localized to the objects that create them. Spatial audio in isolation can contribute to the immersive nature of the scene (Broderick, Duggan, and Redfern 2018; Ritterfeld et al. 2009). Imagine the election rigging example again. Sound in general is an easy-to-understand contributor to immersion, but spatial sounds bring this a step further. Someone whispering into a user’s ear from behind about how you should take some of the ballots out of the ballot box, or the low murmurs from the crowds of voters, can invoke emotional responses radically different from those of single-channel sound. Conversely, spatial audio may not significantly contribute to the persuasive appeal of a flat earth experience depending on the vantage point.

7.4 Update rate and latency

Update rate, how often a scene is rendered each second, and latency, how long a frame takes to render given one’s tracked movement, are very different constructs, but likely will work similarly in the context of misinformation, as they both contribute to the overall impact of a VR experience. Simply, the ability of the environment to render objects and scenes quickly can increase the feeling of presence, and this is most readily seen in a high-latency environment. One study demonstrated that when individuals were presented with feedback delays ranging from 45 to 350 ms, this significantly worsened their sense of agency, sense of body ownership, and simultaneity perception (Waltemate et al. 2016). In a hypothetical misinformation context, when a user’s interactions are not immediately mapped onto the environment (e.g., picking up a ballot and the movement not registering, or speaking to another avatar and receiving delayed nonverbal feedback), the user “feels” the artificial nature of the environment and perceives less presence as a result (Meehan et al. 2003).

Additionally, time-dependent, causal events often contribute beyond realism and presence. Instead, they are often part of the narrative in VR experiences. In the virtual reality experience “Becoming Homeless: A Human Experience,” users interact with their environment while embodying the perspective of a person who has recently lost their housing (Asher et al. 2018). In one portion of the experience, they are faced with the difficult task of trying to keep an eye on both their backpack and an aggressive man trying to harass them. They cannot place both in their field of view at the same time, and when looking at one, the other is at risk of either being stolen or harming them, respectively. This effective storytelling technique only works if both actions are occurring simultaneously, forcing the user to make a difficult decision. This is further enhanced by the simultaneous coughing of the man as he gets closer and the vibration of the backpack as it is tugged from the user’s grasp. If the lag between the user action and the corresponding scene update is high, the emotional context of the scene changes drastically—from an “aha moment” where one realizes the futility of trying to rest on the bus to a lower-stress ride where one needs to attend to their bag.

7.5 Haptic feedback

The tactile output of the experience on the user in a VR environment is typically rendered by simple vibrations in a user’s hand controllers. For example, in the moon landing simulation, one gets a slight vibration in their hand when they reach out and touch the lander. In this sense, haptics contribute to the overall realism of an experience (Kreimeier et al. 2019). But touching objects is different from touching people, and there is a line of research on interpersonal virtual touch, the experience of networking multiple haptic devices in order to allow two people to send and receive touch (J. Bailenson and Yee 2008). For the moon landing simulation built for the Stanford class, the students used a popular VR platform that has a “built-in” handshake affordance. When two avatars reach their arms out and touch hands together, each one of their hand controllers vibrates simultaneously to provide a haptic representation of the mutual grasp. When the group of students who built the fake lunar landing presented their work to the class, they met the teaching staff by the lander, and they each greeted us with a virtual handshake. This haptic interaction likely contributed to the impact of their presentation, as a number of studies have shown virtual interpersonal touch influences persuasive outcomes, such as purchase decisions (Zhao, Ham, and Vlist 2018), choosing to help pick up a pile of dropped coins (Haans et al. 2008), and likability ratings of the other person (J. Bailenson and Yee 2007).

7.6 Olfactory cues

Scent is an incredibly compelling sense when rendered in VR. One of the most researched use cases of scent is part of a VR simulation for exposure therapy for soldiers with PTSD (see Herz 2021, for a recent review). Specific smells such as diesel fuels can act as a trigger for traumatic events, and therapists can use applications such as BraveMind (Mozgai et al. 2021) to facilitate systematic desensitization and reappraisal strategies in order to help undo the associations between particular scents and trauma. One study demonstrated that scent was roughly equal to seeing images, and more compelling than sound, at triggering aversive memories (Toffolo, Smeets, and Hout 2012). Over the past few years, olfactory devices have become portable, and now are light enough to attach to the bottom of a head-mounted display. There are likely two techniques misinformation actors will use involving scent. The first is using scent to increase the realism of a VR simulation, which has been shown to be an effective strategy, especially for exposure to unpleasant scents (Baus and Bouchard 2017). The second is using arbitrary unpleasant scents to pair with experiences that a bad actor seeks to cause aversion to. Both strategies can work simultaneously; for example, a ballot worker can be paired with a scent of body odor for realism, in that since the worker looks and sounds nervous while stuffing the ballot box, he should also smell nervous. Moreover, this feature would also work to cause a general negative association between users and the ballot worker.

7.7 Tracking

Head Tracking is arguably the most essential feature of VR (Lanier 2018). VR functions through a cycle of tracking one's head position, redrawing the scene to show what one should be seeing and hearing at that position, and displaying the content on screens and speakers embedded in a head-mounted display, all at about 90 frames per second. Without head tracking, VR is reduced to a stereoscopic movie, and a large number of research studies show that this active navigation through scenes is what makes the medium uniquely effective (Markowitz et al. 2018). Body tracking is similar to head tracking in that it allows the user to translate body actions and locomotion to the environment. This level of tracking, or at least the feeling of being able to freely move in one's environment, has been shown to significantly increase both presence and the feeling of embodiment, another critical affordance we will discuss (Lee, Kim, and Hwang 2019).

Recent research points to the ability to use head tracking to specifically create theories and then test them to see whether they are true or false. According to Queiroz and colleagues (Queiroz et al. 2022), during VR use "The brain is constantly analyzing body and environmental information to create predictive models about events and the actions' impact on these events". These predictions can be confirmed or not, since the greater the congruence between the action and the predicted consequence, the greater the sense of agency becomes" (p.9, Queiroz et al. 2022; David, Newen, and Vogeley 2008). The agency users receive by being able to use the same naturalistic movements humans have been using for hundreds of thousands of years to perceive and understand a simulation might vary depending on the spatial layout of a scene, but likely will increase the impact of misinformation robustly. When one watches a movie, they are basically observing a linear scene. On the other hand, imagine being in VR and spending hours on a detailed scene hunt where one is looking for evidence of fraud, and then finally finding a stack of uncounted ballots hidden in the back room. Research on VR and agency has demonstrated that this discovery process impacts learning and other psychological outcomes (McGivney, Tribe, and Feng 2022; Rajala, Martin, and Kumpulainen 2016).

8 Content features

In this Section, we discuss features that relate to the content that is experienced during a VR experience. These features are not necessarily unique to VR headsets, but in general, tend to be commonly present when people use the medium. We discuss self-embodiment, the persistence of the world, and social actors.

8.1 Self-embodiment

Perhaps the most well-researched affordance of VR comes in the form of embodiment, which refers to the feeling of one's sense of self residing in their chosen avatar (i.e., a user feels a sense of empathy for the body being inhabited). VR has even been described as a tool that allows one to walk in another's shoes via an avatar who may be different from oneself in terms of age, body shape, gender, race, or even species. The ability to transfer visceral emotions from the experience to the user can translate into changes in behavior, attitudes, and emotional responses during the VR experience, as well as after the user has left the virtual environment (Ahn et al. 2014; Ahn, Le, and Bailenson 2013; Banakou, Groten, and Slater 2013; Maister et al. 2015; Herrera et al. 2018; Ratan et al. 2020). Most of this current research has focused on the positive implications of this effect, but there is reason to believe this work could be used nefariously.

Consider the important work of Hasler, who implements a number of embodiment strategies to help improve relationships between Israelis and Palestinians (Hasler et al. 2021). In one study they created a VR simulation of a confrontation between Israeli soldiers and a Palestinian couple (the woman was visibly pregnant), at a military checkpoint in which the soldiers eventually point their rifles at the couple when the Palestinian man reaches into his pocket. The researchers took great care to ensure that the scene "reflects the realities of the ongoing Israeli-Palestinian conflict and the friction and tensions that culminate in military checkpoints" (p. 2-3, Hasson et al. 2019). In one line of research, Israeli participants could experience the simulation from the perpetual point of view of either the Palestinian couple or the Israeli soldiers (Hasson et al. 2019). The results were robust—Israeli soldiers who embodied the point of view of the Palestinian demonstrated consistent empathetic attitudinal changes compared to control conditions, including delayed tests five months after the VR experiences, showing the Israeli participants made fewer "shoot" decisions when confronted with ambiguous vignettes. The authors of this study were careful to use scenes designed to cause empathy and to reflect the nuance of the conflict, but in the scope of misinformation, one can easily imagine slight edits to the scene to facilitate more nefarious uses of such a powerful tool. The election hacking example can be influenced in a similar way, where a user could be embodied as an election worker who goes by the book and performs perfectly, or perhaps one that is overwhelmed at the ballot box and makes a few honest mistakes, or, alternatively, a fraudulent worker who implements fraud intentionally and consistently over time.

8.2 Persistence and consistency

One of the aspects of virtual worlds that makes them compelling is persistence across time and consistency across people. Independent of the realism of VR, the "worldliness" of the virtual world impacts how people behave. Consider the first widespread metaverse, Second Life, where hundreds of thousands of people visited virtual worlds together rendered on 2D computer screens via avatars (see Blascovich and Bailenson 2011, for historical details). One of the things that made the world so compelling, and so computationally expensive, is that there was a persistent and consistent world, visitable to everyone at any time. Consider a world in which there are interactive events—the virtual temperature changes based on a virtual sun rising, which changes the behaviors of a resident virtual community of iguanas.

The physics of every single event needs to be consistent for everyone: if 100 people join the scene from 100 different locations, they should each see a world lit by sunlight differently based on their position, and the behaviors of iguanas whose behavior changes due to that light, from the proper location. The world needs to be rendered appropriately such that any visitor sees the proper perceptual information based on a consistent system. Moreover, the world needs to maintain its persistence, even if there is nobody visiting the virtual world. In other words, if there is only one visitor to the world that day, and the person visits in the morning, and then comes back in the afternoon, the light (and iguanas) needs to have shifted to the proper position.

This notion that the world is larger than any one user is why the stakes are often high in these worlds (Boellstorff 2015). Interestingly, in today's immersive VR metaverses, platforms such as VRChat allow users to make private instances of public virtual worlds (see Williamson et al. 2021, for a discussion of behavior change in private versus public VR). In other words, if there is a VR restaurant in VRChat, one can visit a public location or clone that 3D model to allow only certain people to come into their own private instance. This enables smaller communities of individuals to develop, similar to the message boards that have been incubators for misinformation narratives on the nonimmersive internet. This may result in fully embodied instances of the proverbial echo chamber as a persistent virtual environment—meaning, virtual environments where the users amplify and reinforce their preexisting beliefs through repetition and a lack of dissent, which is a key contributing mechanism to misinformation creation and spread on the nonimmersive internet (Tornberg 2018).

8.3 Social actors

In VR, scenes often contain people. Indeed, when Jaron Lanier first coined the term VR four decades ago, he included the term "virtual" in the phrase to signify the social aspect of VR. In this section, we will outline three types of mechanisms by which other people in VR can influence users: nonverbal cues, conformity, and transformed social interaction.

Nonverbally, VR brings the "social" back to the network. When people are together in a typical chat room or social media network, one can see text and images of others, typically when those others are intentionally posting. When users are together in VR, they see avatars of one another, and the spatial cues of communication work in a manner similar to the real world. When person A turns their head toward person B, person C sees the sidelong glance in real time. This nonverbal behavior is critical to the VR experience and is one of the reasons platforms such as VRChat are so popular. In the context of VR, these cues contribute to persuasion. For example, Guadagno. (Guadagno et al. 2007), demonstrates that simple changes to avatars in a scene can result in differences in persuasive outcomes. For example, avatars with high behavioral realism who maintained eye contact were more likely to elicit agreement to a proposed policy than avatars with lower realism. Similarly, avatars that maintain close interpersonal distance from users elicit stronger reactions than ones who are farther away (Blascovich 2002). In VR, simply by being able to exhibit proper interactive communication, they become effective at persuasion (Skalski and Tamborini 2007).

In VR, virtual humans can be controlled by the computer; in this, they are referred to as embodied agents instead of avatars. The realism of the virtual human is largely independent of whether a human or a computer controls it, as the quality of computer graphics for models, prerecorded animations, and even speech production is constantly improving. Indeed, even with embodied agents from 20 years ago, adding the proper behavioral algorithms for nonverbal animation could allow some people to fail the Turing Test—to not be able to determine if a virtual human was controlled by a computer or a human in short interactions (Bailenson et al. 2004). In the misinformation context, this allows creators to populate scenes and create the illusion of consensus, but as opposed to bots on social media, these embodied agents will be nonverbally responsive to users as well as verbally responsive. Early work by Blascovich demonstrated that embodied agents encourage conformity (Blascovich 2002). In a virtual casino, people changed their betting behavior when embodied agents were added to the scene—when the agents bet high or low, the users conformed with corresponding bet sizes. In general, research shows that multiple agents are more persuasive than single agents (Kantharaju et al. 2018). In VR, it is easy to populate a scene with dozens of embodied agents, so misinformation scenes will likely use this strategy. Moreover, the embodied agents within a scene can be chosen strategically to maximize demographic similarity to users, as research has shown people were more likely to support a policy initiative when embodied agents of the same gender spoke about the policy, compared to agents of the opposite gender (Guadagno et al. 2007).

The third class of influence from virtual humans will result from transformed social interaction—people who enhance their avatars using social algorithms that give them nonverbal superpowers (Bailenson and Beall 2006). For example, a persuader can alter their appearance to leverage the self-referencing effect, that is, delivered information associated with the self at the time of the encoding is preferred over other information not associated with the self (Kuiper, Rogers, and Kirker 1977). Research on faces has shown that politicians whose faces have been slightly altered to share cosmetic similarities to the targeted voter leads to influence; voters prefer the self-morphed candidate over other candidates, despite not consciously noticing their own face in the image (Bailenson et al. 2008). This self-similarity can also be extended to nonverbal behavior. Social VR functions because tracking data about head and hand movement is constantly sent over the network in order to render movements in real time. Because each person has access to the other's tracking data, they can assimilate that data into their own real-time movements. Bailenson and Yee showed that virtual humans who mimicked a participant's head movements at a four-second delay were more persuasive than those who used typical movements, even though the mimicry was not consciously recognized (J. N. Bailenson and Yee 2005). This behavioral mimicry advantage has also been extended to hand movements (J. Bailenson and Yee 2007). Hence, when attempting misinformation, actors can use these nonverbal algorithms to amplify the impact of their speech with persuasive body language.

9 Conclusions

Virtual Reality is poised to do tremendous good in the world if it can realize its promise (Lanier 2018; Barbot and Kaufman 2020). It can bring together isolated individuals across vast distances and give them a feeling of connectedness. It can create communities that share creative experiences and worlds that are limited only by one's imagination. It holds promise as a tool for education, collaboration, and psychological exploration (Hussein and Ntterdal 2015; Pidel and Ackermann 2020; Chen et al. 2009). Given the efficacy of the medium across so many domains, it is hard to argue that mis-experiences of false information in VR won't also be impactful. This paper is not meant to be alarmist but is rather intended to bring more stakeholders into the conversation to discuss the foreseen issues with the medium.

Through the current analysis, we believe the unique threat of misinformation spread in VR to be real and relevant. We are potentially standing on the precipice of widespread adoption of a new technological communication medium and have the ability to impact its implementation before we suffer from the same pitfalls that befell traditional social media almost a decade ago.

While writing this paper, there was discussion around the negative externalities that might result from giving malicious actors a "playbook" for misinformation in VR. Ultimately, the desire to provide light for an otherwise dormant area of research prevailed, but this does not absolve us from acknowledging the concerns. Example narratives have been kept as apolitical and generalized as possible (while maintaining cultural relevancy) as a mitigation measure. Furthermore, the continuation of this line of research is one that needs to be pursued with care, as the decision to test the effectiveness of misinformation in VR is one that could easily cross the boundaries of established ethical practices (Madary and Metzinger 2016; Behr et al. 2005).

9.1 Current mitigation

Valve, one of the largest marketplaces for VR content, has a minimalist approach to self-contained content moderation; its official policy is that they will allow anyone to upload content to the Steam Store except for things that they decide are "illegal, or straight-up trolling" (*Steam : Steam News : Who Gets To Be On The Steam Store?* 2018). At the time of writing this paper, there were over 4,500 VR applications available for download on the Steam Store, many of them self-contained.

With regard to Social VR, Meta is an especially salient example given their market share of VR headsets. Their strategy on misinformation on non-VR platforms such as Facebook and Instagram is laid out clearly for the spread of text and video, as is outlined in their Community Standards Policy (as well as age restrictions). They specify "manipulated media" and video deepfakes but make no mention of 3D modeling or VR media, which is notable given their shift towards the medium (*Meta | Misinformation Transparency Center* 2023). One can reasonably assume that self-contained content shared within the Quest app will be subject to a curation process, but how it will be detected and applied is still ambiguous.

The standard applied to social VR in Horizon Worlds is more robust. Meta has a Code of Conduct for Virtual Experiences that they enforce by temporarily or permanently suspending accounts. This code of conduct explicitly calls out "engaging in fraud, scams, or other deceptive activities," but not misinformation specifically (*Meta | Code of Conduct for Virtual Experiences* 2023). Tactically, this code of conduct is typically enforced through human moderation. This is either in the form of Community Guides who are real humans, paid by Meta to don headsets, maintain order, and remove malicious users, or in the form of members of the community reporting unruly behavior directly to the platform or removing players by vote.

As another example of social VR moderation, VRChat was a company that began as a VR platform and consequently did not attempt to retrofit social media legacy standards. From their inception, they focused on giving people in a scene the option to eject bad actors from the world by community vote. However, this is a cumbersome process that requires both the identification of malicious intent and consensus from multiple parties in the environment. As pointed out recently by Freeman and Guo, the conclusion from current scholars is that these techniques are not succeeding from an identification and observation perspective (Freeman et al. 2022). As a symptom of this, current social VR platforms are rife with underage children (which usually violates platform policies) and verbal and physical harassment, which is compounded by the inability to scale these human-based moderation efforts (Nix 2023).

When a virtual avatar spreads misinformation in a virtual world, a core question becomes whether Meta, or any such platform, can even tell that it is occurring without human intervention. Real-time misinformation spread in VR is enhanced by an arsenal consisting of nonverbal cues, spatial audio, haptic touch, social conformity, and other affordances that all enable a more persuasive user-to-user message, as opposed to simple text, video, or images alone. More work needs to be done to investigate how the virality of misinformation is affected by this, but the ephemeral (at the individual level) and multimodal nature of the medium presents identification and observation challenges that current automated trust and safety mitigation techniques may struggle with.

One can imagine that if Meta institutes an automated audio analysis tool that tracks certain verbal keywords, a manipulative actor may instead convey their message without using language, for example, by changing the avatar of a political candidate or communicating via nonverbal cues. Should Meta prevent the use of certain harmful avatars, manipulative actors may turn to in-environment communication using handheld virtual writing tools, for example, crayon-writing in the air where words are formed but are not represented symbolically by the platform. Training machine learning algorithms to automatically flag misinformation (as text-based social media platforms do) in a 3D environment is still an underdeveloped area of research due to a lack of effective classifiers for 3D environments. This is due in no small part to a lack of relevant structured training data on misinformation for multimodality mediums (Islam et al. 2020).

9.2 Future work

As other misinformation threat inquiries have concluded, a key step is higher media literacy (Hameleers 2022; Jones-Jang, Mortensen, and Liu 2019). This applies to both the companies providing access to VR content and the users themselves. An understanding of the underlying persuasive mechanisms at work and the gaps in moderation should be approached similarly to how other forms of social media have begun to tackle the matter. Namely, there should be attempts to limit the amplification of known misleading content and an effort to inform and contextualize a user base whenever possible.

VR content providers and creators should be fully aware and respectful of these concerns and should commit resources to the larger trust and safety community. This is especially true when it comes to watchdog organizations, and we can use the Partnership on AI (PAI) as a relevant example. PAI's Responsible Practices for Synthetic Media is a framework for the responsible development, creation, and sharing of synthetic media (Pai 2023). There have been burgeoning attempts regarding the creation of such a consortium for VR, but nothing of the same scale. Further, the trust and safety teams at these companies need to scale in both size, scope, and capability for any believable progress to be made. This includes specialization for spatial mediums and explicitly tailored policies for VR (Derivry and Heller 2023). A human-centered moderation approach may not be adequate when looking at the sheer number of virtual environments that require moderation.

On a more optimistic note, the nature of content in virtual reality will sometimes help platforms detect specific types of content. If one wants to detect a specific array of objects in a YouTube video, for example, a room with a ballot box with at least two people, where Person A is looking at the ballot box, and Person B is looking at Person A, this would be an incredibly challenging problem for computer vision algorithms. However, because 3D models are represented symbolically, the size and shape of objects, the distance among objects, and the orientation of objects (i.e., gaze direction of people) are all potentially available as high-level labels within the files themselves or able to be inferred from the environment (see Blascovich and Bailenson 2011, Chapter 3, for an in-depth discussion). Hence, in VR it may be easier to detect certain types of misinformation scenes compared to current media. This works well for discrete, initialized assets, but still may fall short when it comes to nonsymbolic assets in the environment (e.g., someone taking a virtual spray can and writing a message on a wall).

The ability to reconcile contested information for a simulated environment is also a key area of interest, which parallels the “labeling of misleading content” that social media platforms like Twitter have adopted (*Twitter Help Center* **|** *How we address misinformation on Twitter* 2023). For VR, there is a relevant, but small, area of work on how courtrooms collaboratively verify the accuracy of modeled VR scenes, as scholars for decades have been proposing and testing how one would use VR in legal settings (see Bailenson and Beall 2006, for an early framework). As a hypothetical example, when a courtroom approves a simulation introduced by a single party, that party should be required to submit a list of “assets” or virtual objects included in a simulation and to mark graphically within the simulation those that are stipulated, those that constitute dramatic interpretation, and those that are known to be controversial. Assets that are the subject of debate and discussion by the parties should have a special appearance. They might blink or have a different level of opacity or indicate their controversial status when gazed upon directly. This stipulation process is likely to work in formal settings such as courthouses but will be more difficult in the context of social media. Nevertheless, the precedent is worth noting.

Perhaps the most important outcome of this paper is a call for further research by academics, technology companies, and governments regarding misinformation in VR. There is ample space for follow-on research that can validate these prevailing assumptions and bring more data to bear on this problem set. A high-priority starting point will be for psychologists to evaluate how misinformation presented in VR changes subsequent attitudes and behavior. To the best of our knowledge, there is almost no empirical research in this area, and it is an obvious place to begin. Moreover, understanding how aware the user is of the falseness of the experience should be a research focus. In the same way it is difficult to “unsee” images, it will be difficult to “unexperience” a well-crafted piece of VR misinformation. Can awareness effectively inoculate users against misinformation in VR, or are the affordances impacting them powerful enough to shape someone’s future beliefs regardless?

From a systems level, it will be critical to understand the velocity of misinformation in VR systems and compare that rate to other forms of social media. And of course, there is the chance that empirical research might uncover encouraging results, in that the affordances of VR might actually be used to train individuals to be better at discerning false information from true information. We present these findings as concerns with a significant need for validation to shape further discussion and mitigation efforts.

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