



Bad Breakdowns, Useful Seams, and Face Slapping: Analysis of VR Fails on YouTube

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Figure 1: Figure showcasing key moments in three VR fails clips. In comic strip (a), the VR player loses balance while playing a rollercoaster game in a shopping mall (ID157). A spectator tries to hold the player up. In comic (b), a user is strapped into a wired vest that is held by a metal bar from the ceiling (ID104). They are playing a VR shooter game and scream finding themselves overwhelmed by their virtual opponents. The attendee notices their distress and tries to take the headset off. However, the player responds with more screaming and backs away, afraid and surprised by the unexpected touch. In comic (c), a user is playing a VR game at home and throws their controller across the room to reach a virtual object of interest (ID65).

ABSTRACT

Virtual reality (VR) is increasingly used in complex social and physical settings outside of the lab. However, not much is known about how these settings influence use, nor how to design for them. We analyse 233 YouTube videos of *VR Fails* to: (1) understand when

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breakdowns occur, and (2) reveal how the seams between VR use and the social and physical setting emerge. The videos show a variety of fails, including users flailing, colliding with surroundings, and hitting spectators. They also suggest causes of the fails, including fear, sensorimotor mismatches, and spectator participation. We use the videos as inspiration to generate design ideas. For example, we discuss more flexible boundaries between the real and virtual world, ways of involving spectators, and interaction designs to help overcome fear. Based on the findings, we further discuss the ‘moment of breakdown’ as an opportunity for designing engaging and enhanced VR experiences.

CCS CONCEPTS

- Human-centered computing → Virtual reality.

KEYWORDS

Virtual Reality, VR Fails, VR Breakdowns

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1 INTRODUCTION

As Virtual Reality's popularity grows, we need to better understand and design for its use outside of VR laboratories. In contrast to research labs which can be easily controlled with specific furniture or layout configurations [e.g., 21], domestic spaces are messy, busy, and dynamic. How VR plays out in those spaces and the seams and breakdowns within those interactions remain poorly understood.

With VR's increasing adoption, we are also seeing the rise of community content showcasing its use. YouTube is rife with popular VR gamers completing difficult levels in *BeatSaber*¹, playing haunted-house style games, or showcasing gameplay fails. Prior research has examined YouTube content for insights into technology adoption and interaction design [1, 22]. From this, we suggest YouTube VR videos may provide one lens through which we can better understand how people engage with VR beyond the lab.

We examine *VR fails* on YouTube, as one of the popular emerging themes of videos. These videos capture people in VR colliding with furniture, falling over, hitting spectators, and experiencing fear, joy, nausea, surprise, and more. The videos also capture spectator reactions and participation.

We analyse the VR fails corpus from two perspectives. On the one hand, we think about VR fails as *breakdowns* [3] - moments of stark disruption in the experience. We seek to understand where and why these breakdowns occur, to reveal design opportunities for addressing and solving them. On the other hand, we consider VR fails as *Seamful Design* [5] - exploring how the technical, experiential, and social aspects of VR are stitched together, and how resulting 'fails' may become a positive feature of this shared experience.

We begin with a thematic analysis of 233 VR fails clips, revealing themes across *types* of fails – such as excessive reaction, colliding, hitting, and covering, *causes* of fails – such as fear, sensorimotor mismatch, and spectator participation, and *spectator reactions* – such as laughter, concern, and support behaviours. We discuss each theme in depth, present examples, and highlight how they co-occur. Based on our analysis, and motivated by the examination of VR fails as both breakdowns and an exposé of seamful design, we describe new design opportunities that VR fails inspire. For example, we speculate about how head-mounted pico-projectors may enable shared play and reduce collisions, and how 'natural' gestures may enable novel peak-through dynamics for scary experiences.

VR fails provides a lens through which we can better understand the implications and opportunities of VR use beyond the lab. We highlight what this media shows and how we may incorporate these insights into our interaction design process in HCI.

¹BeatSaber, BeatGames, May 2019

2 RELATED WORK

As VR emerges commercially, research explores how to further develop the experience. Recent research, for example, has looked at novel controller opportunities to enhance haptic feedback [e.g., 24, 41], new techniques to improve locomotion through virtual spaces [26, 35], and new opportunities for shared virtual experiences [13, 34]. Simultaneously, research seeks to better understand the existing experience of VR. We draw from several strands of prior work on presence and the moment of exit, spectator engagement, and VR in the real world and YouTube as a data source.

Presence and Breakdowns in VR

Prior work has highlighted the central challenges associated with VR, such as the effects of simulator sickness [e.g., 36], ocular fatigue [e.g., 17], social anxiety and awareness [e.g., 21], and collisions [15]. Slater et al. [32] sought to understand the breakdowns in experience that occur as a result of these challenges. They counted moments of breakdown as an inverse measure of presence². This clearly positions breakdowns as something to be minimised and avoided, so as to maximise presence. Conversely, despite the many challenges VR breakdowns may pose, studies have shown that they do not necessarily diminish the player's experience, but may instead enrich it [33]. The popularity of the VR fails phenomena on YouTube may support this finding, highlighting the entertainment generated by the breakdowns.

Knibbe et al. [21] explored the variety of factors that impact the transition between virtual and real environments that may result from a breakdown, with a focus on the final 'moment of exit'. They explored four example applications and found that participants experienced spatial and temporal disorientation, control confusion, and heightened social awareness upon exit. Their work suggested the existence of a social contract of VR play, where players discussed the need to feel safe during play and were especially socially-aware at the moment of exit. Kappen et al. [20] echoed the sentiment around social contracts in play, highlighting how the interaction between players and spectators can increase engagement. This motivates a desire for VR to support awareness of 'others' and their relative 'proximity' during play [28]. While research is exploring ways of including passers-by in the VR single-player experience, [e.g., 39], we expect VR fails to reveal more nuance around the social contract of interactions between players and spectators.

Spectator Engagement with Play

Adding to existing work on *social contracts* of play, research has also sought to reveal the different ways in which spectators can engage with play in general [30, 38]. Tekin and Reeves [38] outlined different kinds of spectating in Kinect Play: (1) 'scaffolding' play to seek to display continuous engagement with the player, such as by providing timely instructions, or encouragements, (2) critiquing play technique and gaming movements by the player, (3) recognising and complimenting 'good play', and (4) reflecting on past play (as a former player).

But spectator engagement not only impacts the player's experience, it also directly impacts gameplay. For example, Reeves et

²where presence and immersion are a typical goal in VR; providing a technical foundation and experience such that the player believes they are *there* in the virtual world

al. identified a performative aspect to co-located gaming, where players perform extra gestures that do not directly impact the interface, but instead are for the audience [30]. They present four design approaches to designing public interfaces: (1) ‘secretive’, where manipulations and effects are mostly hidden, (2) ‘expressive’, where the performer’s actions are revealed to spectators, allowing them to appreciate the performer’s interaction, (3) ‘magical’, where spectators see the effects but not the manipulations that caused them, and (4) ‘suspenseful’, where spectators only understand the manipulations behind the visible effects when they become the performer themselves. According to this, VR fails sit across different scales of manipulation. The videos are *expressive* when players perform extra movements to be visible. VR fails are *entertaining* when they result in players failing or losing balance, and they are *magical*, as is the case when players fall over despite not making clear movements.

This performative aspect of co-located gaming is mirrored by the *staging effect*, which occurs when technology use in public spaces creates a performance stage for the user [12]. Dalton et al. [9] echoed Reeves’ findings that in the presence of onlookers (e.g., at a shopping centre) some users interact with technology for the sole purpose of being noticed by others. However, the public stage can also result in a negative experience, where users may avoid interactions altogether to prevent social embarrassment [8].

While this body of work undoubtedly deepens our knowledge of virtual reality, it is still early days for VR research outside of the lab [29], and we have only limited understanding of how VR experiences come to be enacted between players, spectators, and their environment.

VR in the Real World

Recent work has investigated head-mounted display (HMD) use in public settings and the validity of in-the-wild VR studies.

In an in-the-wild deployment of HMDs in a public setting, Mai and Khamis [25] investigated the parallels between interacting with public HMDs and more traditional public displays. They found that recognition of the HMD as an available public display was a challenge. This is partly due to the visual clutter of real spaces, but also the black-box, enclosed, nature of the headset (even while coupled to glowing controllers). Some participants were unclear on the connection between the separate display screen and the HMD, while others searched the demo space for an official authority to allow them to interact with the HMD. Mai and Khamis put forward suggestions for future solutions for accompanying displays to communicate HMD usage and functionality, and invite passers-by to interact without the need for an authority present.

As seen within the context of public settings, HMD use is not only influenced by known VR factors, such as immersion, but also by real-world factors such as perceived boundaries around permission of use. George et al. [11] explored non-experts’ mental models and future expectations towards mobile virtual reality (MVR) through a field study using drawing tasks, a storytelling exercise, and the technology acceptance model (TAM). Their work revealed participants’ struggle to balance wanting to be immersed in the experience and their concern over possible dangers in the real world, such as falling over cables, etc. Furthermore, participants stated their preference

for VR use in the home, rather than in a public setting, due to fear of being observed by strangers and bystanders. However, the public setting was more desirable if participants are accompanied by friends and family. These findings highlight the need to consider factors beyond technical capability when considering designing public HMD experiences.

Mottelson and Hornbæk sought to validate the potential of conducting VR studies in the wild [29], comparing in-lab to out-of-lab VR experiments over three canonical tasks. Their results show that the effects found in the laboratory were comparable to those found in the wild, suggesting that conducting VR studies outside the laboratory is feasible and ecologically valid. Steed et al. [37] pursued a similar angle, running an out-of-lab experiment for mobile app-based VR devices, such as Google Cardboard and Samsung Gear VR, to study presence and embodiment. While their experimental results supported their hypotheses and validated their methodology, they reflect on the additional challenges and work involved in conducting this style of study, such as the required level of polish, ease of use, completeness of experience, etc. As VR headsets become increasingly common-place, these in-the-wild studies will become increasingly practicable.

Understanding the User on YouTube

Recently, YouTube has also been used for insights into the real-world use of emerging devices [2, 18] and specific user contexts with technology [1, 4, 22]. Prior work has highlighted the value of publicly available, user generated content in informing input and interaction design in HCI [1, 2]. For example, Anthony et al. [1] conducted a content analysis of 187 YouTube videos to explore touchscreen use by people with motor impairments. More recently, Komkaite et al. [22] analysed 122 YouTube videos to gain insight into users’ interaction with common non-medical insertable technologies. We argue that such a methodology, applied to the growing corpus of online user-generated VR videos, may also provide real-world insights for VR research, and contribute to the ongoing discussion of VR in-the-wild.

3 EXPLORING VR FAILS

VR fails videos capture momentary transitions between the virtual and real worlds, and the associated reactions of spectators. These momentary transitions occur as players collide with objects in the real world, interact with non-VR spectators, and experience strong emotions, such as fear. Previously, these momentary transitions have been treated akin to breakdowns [32]. In breakdowns, technology becomes visible to us in a new way, failing to function as we anticipate [3]. Seen as VR breakdowns, fails may indicate usability problems; representing mismatches at an interaction level, which cause the user to express surprise or uncertainty of how to engage with the technology. Thus, fails may reveal errors in the VR experience that should be addressed.

However, even a brief exploration of VR fails highlights that these moments are not solely problematic and that they may provide an insight into the motivation and enjoyment of VR use. As such, we also explore the VR fails corpus as an insight into Seamful Design, whereby breakdowns are seen as a ‘resource’ rather than a ‘system failure’ [5]. From this view, we aim to understand how the complex

interactions between personal VR, shared spectator experiences and physical settings play out as enjoyable events within a VR experience. By understanding these moments, VR designers and technologists may come to add them to their repertoire as design opportunities and elements for engagement.

From these two perspectives, we conduct a video content analysis of the most popular VR fails clips on YouTube. We do not attempt to create the ‘fails’ classification, nor reconsider whether videos within the corpus are ‘fails’ per se. Instead, we accept the fails as a community-driven label and instead seek to understand what we may learn from these videos.

3.1 Methodology

Our study includes two phases: (1) video searching - finding user-generated VR fails videos on YouTube, and (2) performing video content analysis (VCA) [27] on the final set of videos.

3.1.1 Phase 1: Video searching. We used YouTube’s search to identify relevant videos. We initially defined our search term as ‘VR fails’, the accepted community-driven term. We explored synonyms of ‘fails’ such as ‘break’, ‘failure’, ‘crash’, ‘malfunction’ and ‘stop’. However, these returned results that are not within our scope, such as scenes from various VR games or troubleshooting videos, and as such were not included. Furthermore, we tried to expand our search by including augmented reality (‘AR’), another technology close to VR, and searched for ‘hilarious’ to capture funny moments caused by fails. However, we yielded no additional, nor relevant results. Thus, our final search term remained at ‘VR fails’.

Initially, all the videos were screened by one of the researchers. We recorded the basic information about the videos, including the title of the video, the webpage link, frequency of viewing (the number of times a video had been watched) and length of the video. We sorted the search results in descending order by the number of views. The majority of the videos in question are compilations. We treated each clip within a compilation as its own video for analysis. If a clip with identical content appeared multiple times across different compilations, we only included it once.

At the time of searching³, the most popular video had 3.067 million views. We looked at all returned results above 27,000 views, as the high number of views demonstrates sufficient community acceptance of the video. Additionally, as the number of views decreased, we observed higher frequencies of duplicate videos in the compilations. We excluded clips of streamed gameplay (such as on *Twitch*), where the VR player is not in view, and one ‘prank’ clip in which someone watched pornography in VR on a subway.

We also excluded videos that are less than 2 seconds in duration, as it is difficult to understand the fail within that short time frame. In total, we found 382 video clips, across 32 compilations, that depicted users experiencing VR and failing. After removing duplicates across the videos, our final data set is 233 videos. This number is similar to the upper range of other YouTube analyses [1, 2, 4, 18, 22]. The clips are 15.83 seconds long on average (std. dev. 10.2s).

3.1.2 Phase 2: Video content analysis. Video content analysis is a well-known methodological procedure for studying qualitative data and is frequently used in studies of mass media [27]. First, we

developed a coding scheme that focused on user interaction with VR and the specifics behind the fails. This was an iterative process, in which all authors viewed the same subset of 16 video clips and refined the coding scheme through discussion. Next, we analysed a further 20 video clips per our coding manual and ensured inter-rater reliability (Fleiss Kappa [10] of .816 for *Types of Fails* and .610 for *Cause of Fails*, indicating high-agreement across four coders [23]). Finally, we coded all video clips in our data set along the coding dimensions (1), as inspired by Anthony et al. [1] and Komkaite et al. [22], with each clip coded by at least two authors. Disagreements were discussed and resolved.

Video characteristics

Type of VR application
Physical context: e.g., home, store
User’s interaction with VR: head-track, hand-track or body-track

Fail characteristics

Point of failure (timestamp)
Type of fail
Cause of fail

Spectator involvement

Spectator visible/audible: yes or no
Secondary display for spectators: yes or no
Spectator interaction before fail
Spectator reaction in response to fail

Table 1: The final 10 dimensions used to code the VR fails videos (inspired by Antony et al.[1])

4 WHAT DO WE SEE IN VR FAILS VIDEOS?

This section provides an overview of how we think about fails and the types of fails we see in our data set. We also highlight the interaction styles that we observed between the user-in-VR and their spectators.

From the videos, we interpret fails as a clash at the intersection between the virtual and real worlds. This may include physical clashes between the player and real-world objects, or social clashes between the players’ actions and spectator expectations. Importantly, fails are determined through the spectator’s perspective, and may not always be experienced as a fail by the player. We identify the moment of failure as either (1) the point of greatest reaction by the audience, or (2) the moment of intersection between the player and their physical surrounds.

We analysed 233 clips of VR fails. The majority of the clips (61%) were filmed in a private setting, featuring sofas, dining tables, bookshelves, and daily clutter. The other 39% were in public spaces such as in conference booths, in the central walkway of a shopping centre, anchored to a sales cabinet in an electronics store, or in a workplace surrounded by colleagues. The vast majority of videos include one or more spectators (including those capturing the video). These spectators are typically stood or sat around actively watching the player and sharing in the experience. The camera is typically focused primarily on the player, but sometimes also includes a VR view (through an additional display - 53%) for the spectators.

³We conducted our YouTube search on 15th May 2020

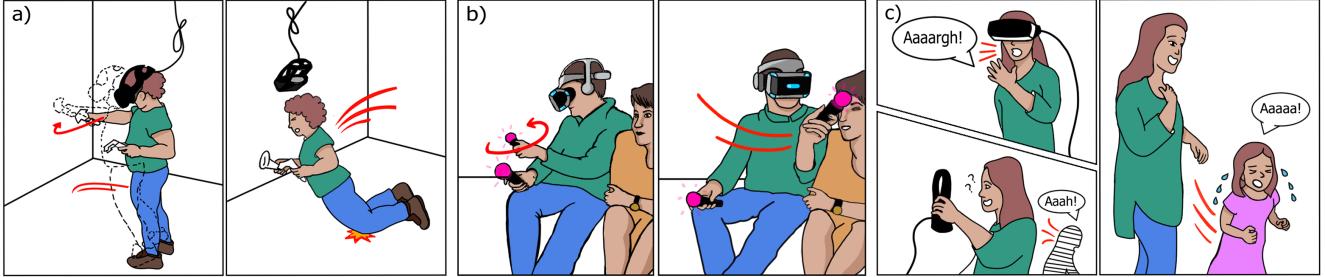


Figure 2: Illustrations of key fails clips. Comic strip *a*) illustrates the video (ID38) in which a young player is slowly rotating their controller to manipulate a virtual object in front of them. Eventually, the player leans far enough to fall forward and, as they fall, the headset partially arrests their fall, but releases just in time for their face to collide with a wall. Comic *b*) shows a fail (ID20) in which the player moves a controller around themselves, eventually hitting the person next to them. The spectator was not paying attention to the controllers. In comic *c*) we capture the fail (ID55) in which the player screams, seemingly scared by something from the VR game. They take off their headset and notice that the child behind them was scared by their yelling and has started crying.

The most common headsets were head-tracked only (53%), where the engagement is primarily visual and not embodied, such as with a Google Cardboard or Samsung Gear VR. The second most common type of headsets were full-featured (35%), such as the HTC Vive, followed by hand-tracked (12%), such as the Playstation VR.

One of the fails clips had an educational purpose (a car mechanics training setting), whereas all others focused on game mechanics. The most common types of games were experiential, making the most of VR's immersive nature, such as walk-the-plank and roller-coaster experiences (23%), followed by horror games (18%). We also see other types of games such as action (12%), sport (11%), and others (like racing and puzzle games, 4%). In many of the cases (30%), it is unclear which application is being used due to the camera angle of filming or lack of additional display.

4.1 Types of Fails

Through our analysis, we identified six types of fail: Colliding (9% of clips), Hitting (10%), Falling Over (18%), Excessive Reaction (53%), Covering (7%), and Other (3%). Some clips result in players 'exiting' the virtual reality experience (i.e., removing the headset), while others demonstrate players recovering or continuing with their experience. In the following, we present the six types of fail, together with highlights of the content that we see across these types and their relation to exiting. We provide example clip IDs as we go, the links for which can be found in the supplementary material.

4.1.1 Colliding. Twenty videos show people *Colliding* in VR. These videos include people walking into walls (ID179) or furniture (ID177). In one clip, we see the player quickly walk into an upright mattress (ID11), as they dash to interact with a virtual game element. This mattress was positioned as a protective barrier in the space (a room in a home), perhaps suggesting that running towards that position was a common occurrence. In another example, a player stands on the end of a virtual and physical plank (i.e., present in reality and in their game), before taking a large step off the plank and straight into a glass door (ID144) (Figure 3b). Notably here, the player is being

encouraged on by a spectator, telling them "...you should just jump off. Just jump.", who surely should have preempted the collision with the door. This is indicative of many clips, where the spectator appears more knowledgeable of the experience.

Only a small portion (3/20) of collisions result in players exiting the virtual experience (e.g., ID62, where damage to the headset necessitates exiting). In most cases, players seemingly recover and continue (e.g., ID177), or, at the very least, the video does not show exiting (i.e., ID148).

4.1.2 Hitting. Twenty-three videos show VR players actively *hitting* things in their environments. (This is different to passively *colliding* their hands with objects in the environment). Players hit walls (e.g., ID21), furniture (ID13), and spectators (ID20). In clip ID218, we see a man in a school hall walk forward approximately 5 meters and hit a wall with his controller - breaking his controller in half. This clip is notable as few commercial VR applications require that range of locomotion, yet players often interpret virtual spaces as fully explorable (i.e., walkable). Further, in this example, the game itself is music-based (possibly *BeatSaber*), and the crowd are participating by singing along. This is a rare example of indirect participation in the data set, where the spectators are deriving enjoyment from a feature of the game, rather than from the player's experience.

In clips ID220 and ID20 (Figure 2b), the VR player inadvertently hits (punches) a nearby spectator. In both of these cases, the spectator is watching a display of the VR players' view. Even with this shared view, the spectators do not preempt the movements the VR player is likely to perform. In ID220, this has quite serious consequences, as the spectator is knocked out by the VR player. Unaware, despite the commotion from the other spectators, the immersed user continues playing. This unawareness of spectators in the shared physical environment is consistent with Mai et al.'s [25] findings, where all participants forgot about their real-world surroundings, including spectators, after some period of immersion.

In 6/23 cases, the player exits VR after hitting something.

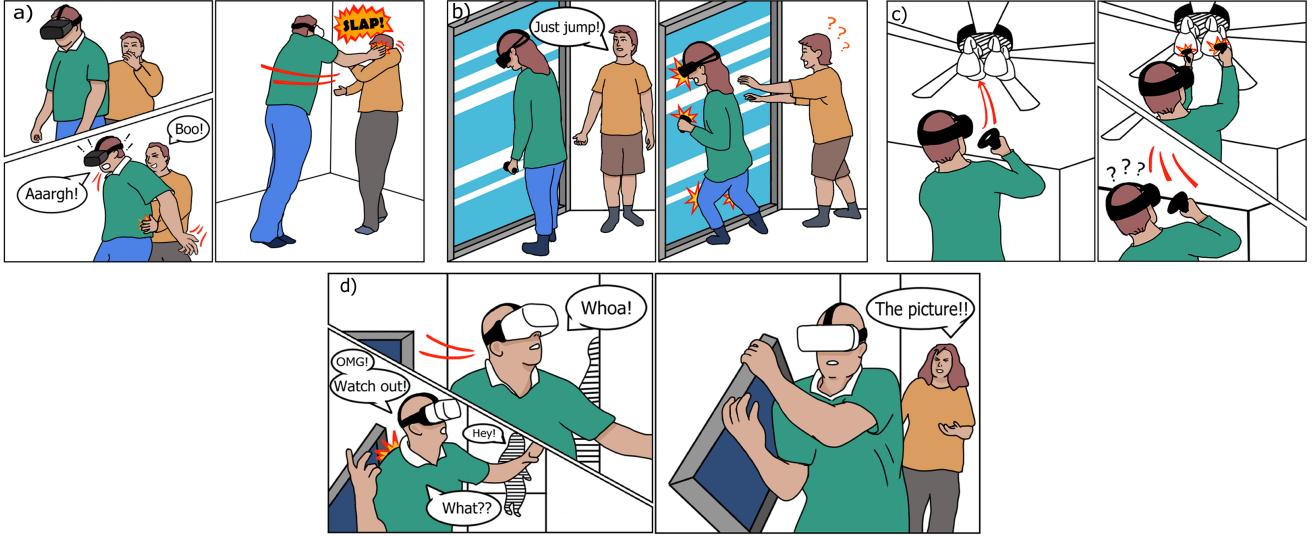


Figure 3: Illustrations of key VR fails. Comic *a*) shows the clip (ID73) in which a spectator suddenly touches the player's waist in an attempt to scare them. In response, the player turns around immediately and slaps the spectator. In comic strip *b*) we capture the fail (ID144) in which a player is standing on a plank in what appears to be the middle of their living room. The player is looking down and a spectator instructs them to *just jump*. The player takes a step and makes the jump but hits the glass door in front of them. In comic *c*) we illustrate the fail (ID230) in which a user is playing a VR game holding their arms up. As they reach further in the virtual game, they hit the ceiling fan light. Comic strip *d*) illustrates the fail (ID12) in which the player is surprised and scared by a virtual element in the game and steps backwards, colliding with a painting which causes it to fall off the wall. A spectator notices the falling object and scolds the player for damaging it, adding that it is an expensive painting.

4.1.3 Falling Over. In forty-three of the VR fails clips players fall over. This primarily occurs during locomotion (e.g., 58) or because the game does not fully support an intended action (e.g., 40). In 13 of these cases (30%), this results in the player exiting VR.

In clip ID22, ID222, and ID229, the player is performing the required action (playing snooker, climbing, and inspecting an engine, respectively) as they would in the real world. While the applications encourage that action, they do not fully support their execution. For example, in real-world snooker a player will often lean on the table; a climber will use the wall to counterbalance; and a mechanic will lean on the edge of a vehicle for support. In these clips, we see the players attempt to execute this standard co-action in the virtual space, resulting in them losing their balance. We describe this as a *False Signifier* (which we will refer back to when discussing *Causes of Fails*: 4.2.5).

Clips ID38 and ID29, show the player falling over during locomotion. In ID38, the VR headset is anchored to the ceiling. As the player falls, the headset partially arrests their fall, but releases just in time for their face to collide with a wall (figure 2a).

4.1.4 Excessive Reaction. The most numerous type of fail we see is 'excessive reaction' (123 clips). These clips involved players experiencing heightened reactions to VR, including physical reactions (38 clips) such as flailing (throwing their arms and legs around, e.g., ID77) and falling into an observer for physical support (ID94); vocal reactions (31 clips) such as screaming (through fear, ID142, or joy,

ID75), and combinations of these (54 clips)(e.g., ID46). We also saw 11 instances of players fully engaging with the experience (e.g., fast sprinting on an omni-directional treadmill - ID113, or boxing very enthusiastically - ID89), in a manner that is simultaneously very entertaining for spectators. We suggest these excessive reactions are frequently fails because they fall outside of expected social norms of behaviour and are unexpected by the spectators (including participants' pets, for whom the behaviour is especially bizarre - e.g., ID54). This is described by Simon [31] as *gestural excess*, a form of movement often seen in body-based gaming that would cause ridicule and shame outside of the envelope of gaming, but create its kinaesthetic pleasure to the player in-game. Notable here, these gestural excesses are not usually experienced as fails or breakdowns by the players, but occur as fails only for the spectators.

In 15% of clips, this results in the player exiting VR. This is most frequently a result of fear. We will return to a discussion of this below, in *Causes of Fails*: 4.2.1.

4.1.5 Covering. Our dataset includes 17 examples of people *Covering*. In these clips, players adopt protective poses, whether tucking into a ball (ID103) or covering their face (in ID51, the player covers her head with a blanket and in ID211, the player uses a blanket to constantly hide behind), in response to the in-game content. Again, as a result of fear, three clips result in players exiting VR.

4.1.6 Other. Our VR fails dataset contains six outlier clips, which do not fit easily into our other categories or are not sufficiently numerous to warrant their own category. These clips include two instances of players accidentally throwing their controller at a wall (ID65 (Figure 1c) and ID153), three clips of spectator fails (ID130 - where a spectator tries to hide in the corner so to not get hit by the player, see Figure 5), and one clip where the VR headset falls off (ID72 - resulting in exiting).

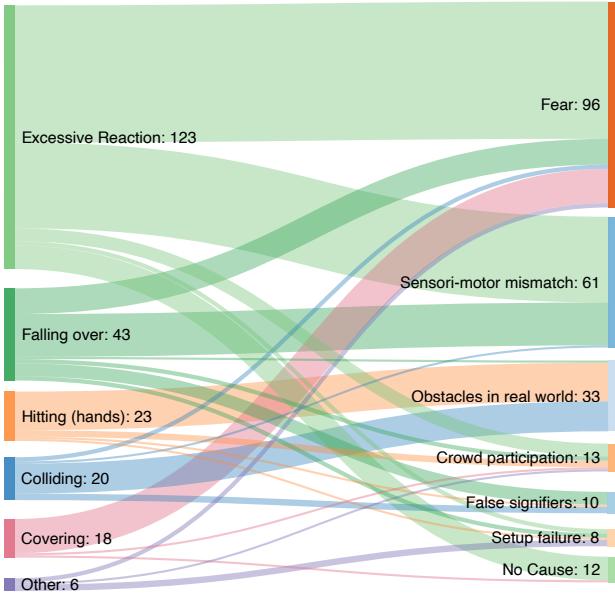


Figure 4: Relationships between Types of VR fails (left) and Causes of VR fails (right).

4.2 Causes of Fails

From a design perspective, we are interested in understanding both *how* VR players fail and *why* players fail. Across our six types of fails, we found seven corresponding causes of fails: Fear (40%), Sensori-motor mismatch (26%), Obstacles in the Real World (14%), Crowd Participation (6%), False Signifiers (4%), Setup Failure (3%), and No Cause (6%) (Figure 4).

4.2.1 Fear. Many VR example applications take advantage of the players' immersion to induce fear, whether jump scares (ID59), collision fear (i.e., objects coming at you, as in ID209), or motion-based fear (as experienced on a rollercoaster, e.g., ID120, ID232). As a result of this, in 94 of the clips fear caused the fail.

Clip ID55, for example, shows someone screaming as a result of a jump scare in virtual reality. Their loud and alarming reaction causes two spectating children to start crying (Figure 2c). In clip ID99, we see a player in an underwater shark cage, experiencing fear as the shark suddenly approaches. In many introductory VR experiences (i.e., experiences that are not intended to be complete games, rather short experiences to demonstrate the capability of

VR), such as shark cages, haunted houses, and un-real rollercoasters, fear is targeted as a quick win within an immersive experience.

Fear causes a complete range of VR fails; including Excessive Reactions (ID69, ID74, ID138), Covering (ID25), Falling Over (ID199), and even Colliding (ID9, where the player attempts to run away from their fear, straight into a wall).

4.2.2 Sensori-motor Mismatch. Sixty-one clips result in fails caused by sensori-motor mismatch, where sensory (primarily visual and proprioceptive) cues are temporally decoupled from movement. This predominantly results in *Falling Over* and *Excessive Reactions*. Across these clips, we suggest there are two dominant forms of mismatch; (a) latency in the headset, and (b) visual-only feedback. These two forms of mismatch are challenging to precisely identify, and require our interpretation as VR experience designers.

A set of clips demonstrate players beginning to lean, stumbling to recover, and then falling over (ID44 and ID210). We would expect the players to take a step as they begin to lean, and so counteract their shifting weight. However, we instead see the players attempting to take this step too late. We suggest this is likely a culmination of latency in both the headset and our sensorimotor (especially proprioceptive) loop. Another set of clips demonstrate players participating in fast-motion experiences, such as rollercoasters (ID157, ID188, ID224), where the visual-only feedback leads to balance issues (through a lack of vestibular cues, as opposed to proprioceptive cues).

4.2.3 Obstacles in the Real World. Obstacles in the Real World are the primary causes of *Colliding* and *Hitting* fails. Important here, these real world objects do not have a virtual counterpart. We see players make contact with televisions, tables, walls, mattresses, toys, and stairs, for example. In clip ID230, the player hits a lamp above their head (Figure 3c). This is notable as VR devices require the user to specify their play area prior to starting a game, however, no game requires the player to specify the ceiling boundary.

4.2.4 Crowd Participation. In 13 clips we see fails as a result of crowd participation. On the one hand, these fails stem from spectators interfering with the player. For example, in clip ID73, we see a spectator tickle the VR player, causing the player to turn around and hit them (Figure 3a). In clip ID45, a spectator attempts to interrupt a player, causing them to scream.

On the other hand, we see spectators being the cause of the fail. For example, in clip ID189, the spectator attempts to retreat and hide from the player in the corner of the room, to prevent getting hit accidentally. As the player nears, their concern grows.

4.2.5 False Signifiers. False Signifiers cause 4% of the fails. These are opportunities and actions within the game, that cannot fully support the associated real-world action. We have previously discussed climbing, snooker, and engine bay examples of this (4.1.3). ID22 shows another such example, where a child attempts to skydive from a plane. They stand gazing out of the door in VR, before throwing themselves out of the door, as they would from a real plane. They quickly exit the camera's view, as they collide with the solid floor.

4.2.6 Setup Failure. In eight clips, we see people fail as a result of setup failure. Primarily, this stems from players accidentally

throwing the controllers (ID65, ID173, ID153), because they are not sufficiently strapped to their hands. Across all clips, we also see the emergence of a range of additional physical simulators to support the VR experience (such as treadmills - ID113, spinning chairs - ID124, and rodeo-style horses - ID116). We also see players breaking or falling out of these simulators (ID116 and ID3).

4.2.7 No Cause. There is a subset of 14 videos that contain no obvious cause of fail. The majority of these clips relate to the *Excessive Reaction* type, specifically those where the players' actions are odd from a social-spectator perspective. The only possible cause here, for a subset, could be 'enthusiastic participation'.

4.3 Spectator Interaction

Our corpus showcases a wide range of how spectators engage with players. We define spectators as nearby onlookers who actively follow the in-game experience, but are not wearing the VR headset. We typically see spectators crowded in a group of two or more, such as at home parties or in shopping malls, gathered close and focused solely on the player. In some clips we see multiple people sat around on sofas watching, in others a crowd stands nearby watching over the player's shoulder. We also see clips with only a single spectator filming. In some videos, the observers simply walk past the shared environment and only become spectators at the moment of failure, which is often indicated by a scream from the player, or the loud noise of a collision. In response to these fails, we see an overwhelming amount of laughter and mockery from spectators. These reactions are consistent with Harper and Mantis' work [14] on the social organisation of Kinect play, which emphasise accounts of "fostering [of] laughter" and "ridicule and mockery". Even when the fails result in unfortunate accidents in the home (i.e., to furniture or other persons), the spectators and players are still able to jointly laugh and find shared enjoyment in the absurdity of the VR experience. In more serious accidents, spectators are also seen running to the player to check if "[they] are okay," expressing a grave amount of concern as they help the player recover from the fails.

In 53% of videos, the VR view is made available to spectators through an additional display, such as the living room TV, a monitor or projections on the wall. This enables the spectators to share in the virtual experience and facilitates impromptu participation (ID23, ID190, ID208). We see a range of interaction between the player and spectators before the moment of failure. These interactions include (a) providing gameplay instructions to the player (ID6, ID16), (b) providing contextual cues about the real environment (ID26), (c) general chatter between the player and the spectator(s) (ID11, ID59), and (d) physical support (such as holding the players to prevent them falling over - ID24, ID156).

In observing spectator reactions to the moment of failure, we see three prominent reactions: laughing and screaming, active help and support, and expressing concern. The spectator reactions are not mutually exclusive to each other.

4.3.1 Laughing and screaming. The most common form of spectator reaction we see is laughing or screaming (59%). We see laughing and screaming occur most with *Excessive Reaction* fails, followed by

Falling over. These reactions range anywhere from slightly chuckling (ID141) to full hysterics (ID7, ID40, ID95). In clip ID53, a spectator closeby waves his hand as if to say 'hello' to the approaching VR player. Unaware of the spectator's whereabouts, the player slaps the spectator in the face. The oddness of the player's behaviour, and perhaps the contrasting response to the 'hello', results in fits of laughter from the group of spectators, including the spectator who has just been slapped.

We also see spectators screaming and experiencing fear themselves by watching the VR player. In clip ID136, the player's scream in response to losing her balance on a rollercoaster game caused an infant to cry in the background.

4.3.2 Expressing empathy and concern. Spectators also expressed empathy and concern in 12% of the videos. This is most frequently seen in the *Falling over* category. We often see *Active help and support* co-occurring with empathy and concern. In clip ID41, the VR player loses balance on his chair and falls backwards, hitting the staircase behind him before falling to the ground. The filming spectator remarks in shock "Oh...no!", while another spectator rushes to help the player up, and we can see others in the background covering their mouth with a concerned expression. Interestingly, there are some instances where the spectator expresses concern towards the headset or furniture, and *not* the VR player. In clip ID12, the spectator remarks and expresses frustration that the player collides with a painting that is "*really worth some money*" (Figure 3d). Meanwhile, in clip ID215, the spectator runs towards the headset that was dropped on the floor. In these videos, the spectators' concerns revolve around damages to objects in the real world rather than the player.

4.3.3 Active help and support. In many videos where we see an expression of sympathy and concern from spectators, this concern often leads to an offer of help and support to the player during or after a fail (29%). We suggest that this occurs when spectators perceive that the fail has caused damage (to the player or the environment). We see this most prevalent with *Excessive Reaction* fails, followed by *Falling over*. In many of the excessive reaction fails where the player physically flails (ID94, ID157 (Figure 1a), and ID166), the spectator provides support by holding the VR player to provide balance (ID18, ID90, ID163), or attempts to *catch* the player before they fall over (ID81, ID93). When the VR player falls over, spectators are often seen rushing towards the player and checking if they have hurt themselves. We see this in clip ID29 when the spectator drops the camera to run to the player who has fallen over to offer help. In some instances, the spectator facilitates the exit on behalf of the player, as seen in clip ID104. Here, a spectator nearby attempts to approach the player to take the headset off (despite not being asked to) upon hearing screams from the player and interpreting that as a call for help (Figure 1b).

4.4 Discussion

The VR fails clips reveal interesting insights into the use of virtual reality for HCI. First, VR as a technology is designed to be immersive and support full-body, lifelike (or 'natural') interaction. As a result of this, the clips reveal players treating the environment as a fully-supported real-world space. For example, we see players seeking



Figure 5: Illustrations of key VR fails clips. In comic *a*) we show a video (ID130) in which a VR player nears a spectator. As the player gets closer and closer, the spectator backs into a corner and holds his arms close to their body to avoid being hit. Comic strip *b*) shows a clip (ID131) that captures an example of co-play between a player and a spectator. Here, the user plays a VR skiing game and the spectator is holding their hands, taking control of the player's movements. During this, the player is scared by a cliff that appears in the virtual environment and jumps up and screams, leaning on the spectator for support and making them laugh.

to walk long distances (ID62, ID218), use un-tracked body-parts (such as kicking whilst boxing, ID89), and lean on virtual-only objects (ID222). These actions all fall outside of the design of the game, but yet could be considered ‘expected’ behaviours. These fails could be interpreted as failures in game design and, from a breakdowns perspective, perhaps game designers need to go further to differentiate between supported and virtual-only objects and stimuli. From an alternate perspective, however, perhaps these fails are part of developing an understanding and expertise in VR, and in turn facilitate some of the joy and entertainment that we witness.

Second, previous work has hinted at the existence of a social contract associated with VR-play [21]. Placing yourself in VR requires a certain level of trust in the people and spaces around you, as you are sensorily decoupled from the space in which you play. This social contract plays out in numerous different ways across the VR fails clips. On the one hand, we see clips of spectators attempting to move out of the way of the player, to not impede their play (ID130). This is a clear instance of prioritising the player. On the other hand, we see the player physically striking spectators (ID171), being reprimanded for risking damaging their environment (ID12), and being interrupted for being too loud (ID45). These are all instances of play needing to fit within the lived environment, potentially at the expense of the play experience. While in a lab setting, VR participants are ‘protected’ and ‘prioritised’ by the researchers-as-spectators, this relationship perhaps has greater equity outside of the lab.

Next, the clips reveal different ways in which fails are experienced. Some fails, such as collisions and hitting, are experienced and/or enjoyed by both the player and the spectators. Other clips, however, such as excessive reactions (whether physical or emotional), are experienced as fails only by the spectators. To the player, these reactions may form a natural part of the interaction or experience. Following Reeves et al. [30], we also see clear instances of players performing for spectators, purposefully overacting their experience for the joy of those around them. We believe that novelty bias is one driver for this type of fail, notably where players participate in scripted VR experiences (e.g., roller coasters, shark cages, etc.). However, for the completeness of our analysis, it is

important to understand these fails as a contributor to VR Fails, and the design implications in Section 5 are not directly derived from the novelty fails (i.e., flailing, screaming, etc.). Further, if we view these interactions as breakdowns, we could solve them by revealing more of the player’s environment and experience to the spectators. This would serve to create a better-shared understanding between the immersed users and the spectators. However, these unexpected reactions play a role in creating part of the excitement and enjoyment for the spectator, at the seams of the player and spectator experience, and could be further emphasised.

Most VR experiences require the player to specify a boundary grid prior to starting a game. This acts as a virtual wall, revealing itself when you are a short distance from it and preventing you from colliding with the real environment. However, our analysis of VR fails revealed that play spaces are rarely as neat, static, or well-specified as headset manufacturers and researchers design for. For example, people and pets wander in and out, and play occurs in the middle of non-uniform cluttered environments. This introduces many opportunities for collisions and hitting, as the fails clips show. Further, many games require fast movements for interaction (such as swinging lightsabers in *BeatSaber*), that interact poorly with this visual boundary grid metaphor, leaving the player little time to respond and alter their actions. VR experiences reveal many opportunities that the play space cannot fully support, e.g., allowing players to swing a bat when near a boundary and revealing non-player-characters for interaction who are outside the play space. So, while it may be reasonable to require a clear play space for VR, game designers need a more dynamic approach to space configurations, taking on some of the area awareness burdens that are currently placed on players.

Across the fails clips we see spectators observing and interacting in different ways. They offer encouragement and advice, observe quietly, sing along to the background music, and provide physical support. A subset of this interaction directly echoes the sentiment of work by Cheng and colleagues, such as the physical haptics provided by spectators in HapticTurk [6]. In one instance, we see a spectator puppeting the player to perform the necessary skiing

actions (ID88). Further, in the out-of-home clips, we see instances of other approaches to additional haptic input, such as tickling players' legs with a feather duster (ID115). In this particular clip, the player is mounted into a spinning cage-like seat, so it is difficult to imagine that the feather duster contributes much to the overall experience.

Many of the spectator interactions, however, do not include physical participation. Instead, the spectators act as an additional expert 'eye', offering advice and instructions to the players. It is rare, however, to see instructions being interpreted correctly, and this is a frequent cause of fails. For example, we see one player throwing their VR controller in response to hearing the spectator saying "*throw the racket*", or another player attempting to perform the spectator's instruction of "*just jump*" and end up colliding with the wall (ID144 - Figure 3b). To encourage and enhance participation, designers could provide a set of language specific to the game, to create a purposeful inclusion dynamic for spectators to provide information from the real world to players. This is currently performed well in the multi-player, co-located VR game *Keep Talking and Nobody Explodes*⁴.

5 DESIGN IMPLICATIONS

Having examined the diverse range of fail experiences, we depart from our findings to uncover new design opportunities for VR experiences. We group these design opportunities into categories: (1) Preventing Collisions, (2) New Interactions, and (3) Spectator Engagement.

5.1 Preventing Collisions

If we consider VR fails as *breakdowns*, then we should explore opportunities to address or prevent them, especially if the implications are more serious, such as with collisions (e.g., ID144) and hitting (ID220).

Changing the Play Space. The fails, especially those caused by Obstacles in the Real World, highlight a need to explore more nuanced approaches to play areas and virtual boundaries (or 'guardians'). On the one hand, this could be as simple as allowing users to specify more complex play area shapes, for example by enabling players to specify boundaries around fixed obstacles within the space (such as with the co-worker sat at their desk within the play area - ID172), and around the ceiling and overhead obstacles (e.g., in ID230). This would serve to reduce collision and hitting fails. Additionally, by reimagining the boundary grid, we may both reduce the chance of fails and present new gameplay opportunities.

Currently, in many commercial headsets (such as the Oculus Quest), as the player passes through the boundary grid, the front-facing cameras turn on, revealing the real world. We suggest expanding this technique as a gameplay opportunity: a **mixed-reality boundary play space** (Figure 6).

Departing from clip ID220: *The boxing game loads, revealing a gloved-up opponent. The player starts jumping from side to side, and throwing punches. As the player approaches the boundary, a virtual grid marks the edge of the virtual play space. Passing through this boundary, the player can 'see-through' the headset to the real world.*

⁴Keep Talking and Nobody Explodes, Steel Crate Games, 2015.

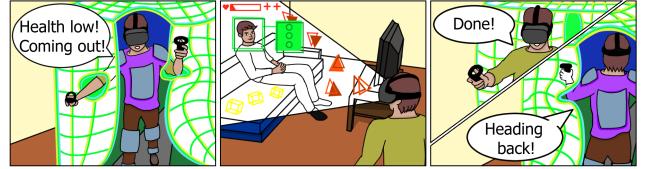


Figure 6: Illustration showing the mixed-reality boundary play space, where the space outside the boundary grid can be used for novel interactions. In this instance, without removing the headset, the player steps out of the virtual game world to regenerate health and interact with the spectator, before stepping back in to the game.

This 'mixed-reality' space, however, is not necessarily beyond the game - the boxing opponent could follow the player through into this space. This space could also support novel game 'abilities', such as enabling communication with other players, map views, health regeneration, etc. Depending on the experience, this area could also enable the player to 'step out' of the virtual space to interact with spectators. Looking back, the player can still see into the virtual world, and simply steps back in to re-enter the ring and continue play.

Changing the Game. A number of clips show players colliding with walls (e.g., ID144), televisions (ID13), and picture frames (ID12). Current VR experiences place the burden of spatial positioning on the player; the player needs to keep track of play boundaries, repositioning themselves as they approach walls, etc. While we previously considered changing the boundary behaviour, there also exist opportunities to change the mechanics of these games to account for player positioning and context (Figure 7).



Figure 7: Illustration of changing game elements in order to prevent the player from stepping beyond the boundary grid of their play area. Here, the game switches the player's sword for a shield, to prevent them swinging their arm beyond their play area.

In clip ID11, the player stands in the middle of their play space, sword in hand. During play, the user walks forward, nearing the boundary of their space. To prevent large swinging actions and potential collisions, the game changes their sword to a shield, constraining the motion the player is likely to perform. At all times, pre-empting larger movements the player might make, the game highlights objects and enemies that are available for interaction vs. approaching but not yet available.

5.2 New Interactions

Alongside considering VR fails as breakdowns to be avoided, we can also consider them a constructive lens through which to reveal new interaction opportunities. Across the corpus, we see players performing actions that arise instinctively, for example curling into a ball (ID103), kicking (ID77), covering their face (ID211) and so on. We can incorporate these actions into controls themselves, for example enabling ‘peek-through’ or ‘scaredy-cat’ mode (Figure 8). These controls can further be context-dependent. In a horror VR game, the screen can go dark once the user covers their face in order to make the fear stimuli disappear. For an action game where users might cover their face because of incoming objects, the game could provide them with a shield once it detects covering.

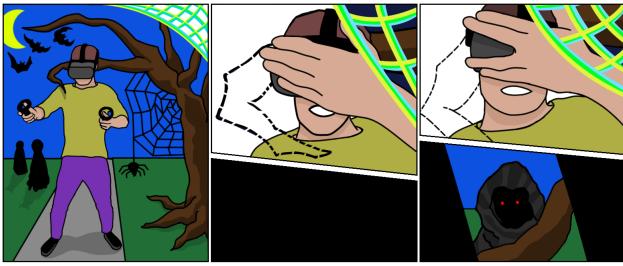


Figure 8: VR could offer new headset interaction opportunities. For example, this illustrations shows a peek-through mode, in which the player covers the headset to disable the display, and parting their fingers reveals thin slithers of view.

The player walks through a haunted house, full of dark shadows and eerie music. Scared, the player hides their head behind their hands. The screen goes dark. The player slowly parts their fingers, enabling peek-through mode - revealing only small slithers of the virtual view.

5.3 Spectator Engagement

Increasing Spectator Awareness. VR fails clips reveal a range of techniques for sharing visual insights into the virtual world with the spectator. For example, we see a variety of co-located screens, whether desktop displays (e.g., ID223, ID224), televisions (ID9) or wall-scale projections (ID81). While this supports a level of understanding of the experience, it does not appear to support spatial understanding of the play area. As a result of this, it can be hard for the spectator to predict the space requirements or likely actions of the player. In ID20, for instance, we see the spectator getting hit by the player though they are simultaneously watching the game view on television.

Current work on shared VR experiences [e.g., 16, 19, 40] use projectors to share a spatially co-located view. These explorations examine only modestly dynamic settings, where revealing objects and environment details enable the spectator to understand the space. As the applications become more dynamic and the view angle changes more frequently, these projections will become increasingly hard to interpret and render. In these scenarios, these projectors could be re-purposed to **project simple visual movement predictions** (Figure 9).

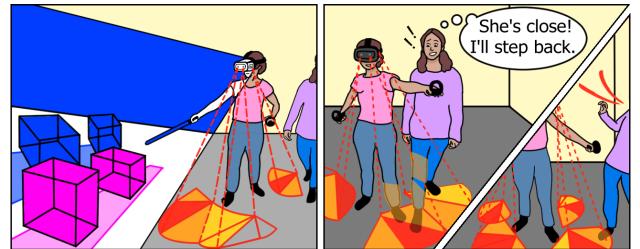


Figure 9: Illustration demonstrating a head-mounted projector, to notify onlookers about the likelihood of the player’s movements. This abstract display supports spectator participation by enabling them to move furniture and people to prevent collisions.

The player loads their favourite song in Beatsaber - a game requiring the player to slash flying cubes with a lightsaber in time with the music. Their head-mounted pico-projector projects red polygons onto the ground in front, showing spectators where the player is likely to swing their arms next. Seeing their legs light up red, one of the spectators quickly moves out of the area.

Increasing Spectator Participation. Our analysis reveals that the most prevalent spectator reaction in fail videos are laughter (e.g., ID172) and screaming (ID136). More recently, games such as that Acron: Attack of the Squirrels!⁵ and Ruckus Ridge VR Party⁶ enable collocated spectator engagement through asymmetrical gaming, whereby spectators can join the gaming experience on non-HMD devices such as mobile phones and PC. Given the prevalence of spectating VR, we expect many more such participatory experiences to emerge.

One such opportunity could be to enable spectators to simply impact the game using non-digital modalities, such as through **spectator power-ups**.

The player is in the midst of a fighting game and is becoming quickly overwhelmed. The game recognises specific forms of vocal encouragement from the spectators, and gives the player more ‘health’ points. As encouragement, the spectators could make specific hand gestures towards the immersed user that are then displayed in the game. Additionally, they could interact with objects found in the mixed-reality space which they can see through the player’s view of the game on a separate screen.

6 DISCUSSION

VR is increasingly used in complex social and physical settings. We investigated how such environments influence VR use by analysing 233 YouTube videos of fails. We have identified typical failures and the reasons they occur. Further, we have identified design opportunities from the fails. Next, we discuss the main findings as well as concerns about validity when working with video as data.

⁵Acron: Attack of the Squirrels!, Resolution Games, 2019

⁶Ruckus Ridge VR Party, ForeignVR, 2016

6.1 VR Outside the Lab

Although we have focused on breakdowns and seams, it is worth reflecting on the videos as a source of data on VR outside the lab. The videos showcased a variety of positive, engaged experiences. Immersion appears to work for users, even in very social settings and cluttered spaces, very different from most VR laboratories. The videos also highlighted the important role of spectators, showing how varied social contracts about spectating play out in VR in front of an audience. In that way, our analysis is more detailed than typical crowdsourced VR studies [e.g., 29, 37] and more large-scale than typical studies of spectator experiences [e.g., 30].

The number and popularity of VR fails videos may be due to the novelty of immersive technology. This will likely change as the technology matures and more people play VR games. Currently, however, videos of VR fails seems to capture both first-time and returning users, alone and together. Fails themselves (beyond just VR fails) are a popular video type with a rich history, emerging from television shows such as *Jackass* and *Takeshi's Castle*, and then broadening to unscripted self-captured moments with the emergence of personal video capture devices and smartphones. This genre, of course, does not cover all VR experiences outside of the lab. Nevertheless, the clips in general rarely seem acted or scripted; some fails, then, should be considered an opportunity for VR designers and developers to hold on to, promote, and design for.

6.2 Avoiding Breakdowns

We see a range of fails within the VR fails clips. Some of these fails are dangerous, causing harm to spectators (ID220) and players (ID38) alike. As designers, it is our responsibility to prevent people from hurting themselves or others, or unwittingly breaking things within their environment. We should look to design opportunities that prevent some of these dangers. Motivated by the fails that we see, we have presented some initial ideas, such as reimagining the VR boundary grid, as techniques for preventing further collision and hitting type fails.

The specific types of breakdowns that we identified are useful to researchers and designers because they separate some key mechanisms, for instance, between the categories of sensorimotor mismatch and false signifiers. This extends earlier categories of broad breakdowns [32].

6.3 Designing from Fails

Many of the fails that we analyse result in a shared joyful experience: we see players and spectators laughing together; people deciding to capture these moments on video and sharing them with a wider audience; and these shared video clips receiving millions of views. Consequently, we should not look to replace or fix the aspects of VR design that lead to these fails (i.e., jump scares, vertigo-experiences, fast motion embodied play, spectator engagement and involvement), as they appear to be a central tenet of VR play and its intersection with the real world. Instead, we should design to further promote these features of VR, and some research is actively doing so [e.g., 6, 7]. Following this approach, we further present design ideas, such as providing contextual motion predictions to spectators in order to prevent them becoming unwitting obstacles.

Video gaming itself is often a shared experience, where player and spectator engagement drive and promote enjoyment. VR fails reveal similar traits in VR gaming, albeit with different interaction dynamics. VR, by design, is a private experience within a world hidden in a headset. In turn, it reveals little of the visual cues to the spectator. While some clips feature additional displays for spectators, we see onlookers finding other ways to participate and enjoy the shared gaming experience (e.g., singing along to the soundtrack, physically interacting with the player, or simply enjoying their reactions). The secret elements of the VR players' experience (their visual cues, and spatial understanding and affordances), reveal new kinds of participation and enjoyment that should be harnessed and exploited further. Anecdotally, we have observed this type of enjoyment occur in some popular *BeatSaber* songs, which have been perfectly choreographed to make the player perform the famous associated dance for any spectator (for example, *Gangnam Style* by Psy). This is an example of Reeves et al.'s *expressive* spectator experience [30], where the player becomes a performer for the audience.

6.4 Limitations

We analyse VR fails to begin to understand how VR is played in-the-wild, and its interplays with spectators and the lived environment. We believe VR fails provides a good starting point for this kind of analysis. That said, however, the corpus is not representative of broader real-world use as it is specifically collated by the community to showcase clashes at the intersection of VR and the real world. As such, it excludes the mundane, everyday, private play that may yet constitute a large part of VR use. Future research should approach this from various perspectives and incorporate many views in order to accurately capture the breadth of experiences of consumers with virtual reality. For example, Twitch or other gameplay streaming platforms may provide another insightful source of data.

Further, analysing the clips is difficult. The home-video nature of the clips can introduce uncertainty to the coding. For example, some clips end very quickly after a fail (making it hard to determine if it resulted in exiting or how the spectators supported the player), some provide no insight into specifics of the VR experience (i.e., what game they are playing), and some have no single moment of failure. Thus, a part of our coding relied on our own expertise as VR designers and researchers.

The primary use case of virtual reality is currently gaming; most clips concerned gaming. While other application areas are emerging, these are not prevalent across the VR fails corpus. Future work should explore the breakdowns and useful seams in other application areas.

7 CONCLUSION

Empirically describing the use of VR remains an important research challenge. In particular, the social and physical factors that shape VR remain underexplored. We have used clips of breakdowns in VR as a source of data to understand those factors and how they may inform design. Through our findings, we propose a range of design ideas that aim towards involving spectators and the physical environment, in order to enhance the VR experience.

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