# Lingering Effects Associated with Virtual Reality: An Analysis Based on Consumer Discussions Over Time

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## ABSTRACT

Since the release of the Oculus Rift CV1 in 2016, millions of VR headsets became available to consumers across the globe. Since then, many users have logged their experiences through online discussion forums. We found that many reported experiencing various "lingering effects" generally after spending at least a full hour in VR. Two major categories were identified and divided into sub-categories: perceptual effects and behavioral effects.Users agreed that these effects completely disappeared after several weeks and felt no long-term side effects. The topics of interest we identified here could be foundations for future research in laboratory settings.

**Keywords:** virtual reality, user experience, side effects, Reddit.

**Index Terms:** Human-centered computing—Virtual reality—; Human-centered computing—social content sharing—

## 1 INTRODUCTION

A major consequence of the recent widespread availability of VR is that more people are using VR, and are using it for longer periods of time. As such, it is more important than ever that we understand how prolonged exposure to VR affects the people who use it. There are many challenges associated with longitudinal research, especially when this research must be conducted in laboratory settings, as opposed to in the field [1,3,4]. While controlled, experimental longitudinal studies are essential for answering some questions, we argue that other methods can also be used to gain insights about how users' responses to VR evolves as they gain experience with the technology over time. Currently, some longitudinal research concerning Reddit posts has been done, though only relating to Reddit data as a whole, not focusing on any one particular subreddit [2]. We found that through Reddit, users have generated large quantities of data about their experiences with VR in these online forums devoted to VR games. Through a qualitative analysis of these online discussions, we attempt to understand what lingering side effects the general population of users report experiencing after using VR games and applications, and on how these lingering side effects evolve over time as users spend more time in VR. We identified two major categories (with additional sub-themes) of lingering side effects: effects on perception in the real world, and effects on behavior in the real world.We then coded this data according to four temporal concepts: 1) how long must be spent in VR to trigger an effect, 2) how long until the onset of the effect upon exiting VR, 3) the duration of a specific effect, and 4) the total duration that side effects can occur. We found that users almost unanimously agreed that these lingering effects only occurred after spending at least one hour in VR, and that all lingering effects would disappear within several weeks of beginning to use VR.

## 2 METHODS

To gather consumer discussions about lingering effects in VR, we turned to the popular discussion forum Reddit, specifically the sub forum /r/Vive subreddit. All conversations made within two years following April 5th, 2016, (the day the HTC Vive was released) were included in our search. Conversations on Reddit are composed of an initial post followed by a nested threads of comments. During the two year period that we sampled, 121,550 posts and 2,183,924 comments were made on /r/Vive. We performed our search using the Reddit API, through the portal hosted at *www.Redditsearch.io*. We included both posts and comments that met our search criteria, which enabled us to identify both root discussions of interest, as well as relevant tangential discussions that emerged in the comments.

We identified common phrases and words that were often present in conversations we found during our exploratory search. These phrases included: 'feels weird after', 'side effect after', 'disassociation', and 'disoriented after'.These search terms were then used to identify even more conversations that involved a variety of discussion surrounding numerous lingering side effects. In total, 1,710 comments were retrieved using these search terms. Though this number is small in comparison to the total number of comments made during the overall two year period, discussions concerning lingering effects were generally rare overall thereby not constituting a major topic of discussion in this subreddit.

## 3 RESULTS OF THE QUALITATIVE ANALYSIS

### 3.1 Perceptual aftereffects

In many discussions, users' stated the perception of their own bodies and the world around them were altered. Many users reported disrupted feelings of body ownership. This phenomenon manifested itself either across users' entire body, or specifically in their hands. Users reflected that they "felt their hands were not part of my body anymore" or that their hands were in the wrong position. Users also expressed surprise at how their hands physically interacted with the world around them saying, "When I interact with real objects, I'm surprised that my hands don't go straight through them." This may be attributed to a common convention in current VR games: on grasping an object in VR, the grasped object replaces the controller model representing the hand. As such, when manipulating objects in VR users saw the object where their hand was located without any representation of their hands.

With regard to their entire bodies, some users reported moments when they "would bump into stuff because [they] forget [they] had a body." Others experienced moments when they felt like they "lost tracking in real life" and had to "freeze for a second until [they] reacquired [themselves]." Self-avatars are rare in VR games. As such, most reports about disrupted body ownership were concerned with feeling detached from their body. However, one user reported an experience with an early VR game that simulated a self-avatar using the Razer Hydra and inverse kinematics. He reported that "after getting out of the game it would usually take me to up to half an hour for my mind to accept that my RL arms were actually my arms, and not some 'foreign' part (pinching my arms helped my brain to accept that they were part of my body)." This suggests that additional forms of body ownership disruption may be experienced as consumer VR applications begin to simulate self-avatars.

Many users also reported experiences where the real world seemed "off" after spending time in VR. This "off-ness" was typically linked to difficulty judging the distance to real objects, or

feelings that the world had somehow become more two-dimensional. These experiences varied in terms of intensity, ranging a user who reported "[their] depth perception was a tiny bit off," to users who said that "I feel like my brain can't tell distance anymore in real life." Participants also reported how specific visual elements of VR appeared to persist in the real world after exiting VR. One user said "everything looked as if I was looking through the Vive lens." Other users reported seeing something like the screen door effect, where the real world appeared to be composed of pixels. This effect could persist for a long duration in some users, even to the extent that users would "see 'grid eyes' when they wake up [the next day]" after long sessions in VR.

Users also reported two other unusual aftereffects pertaining to vision in the real world: a heightened sense of dimensionality for 2D text or images, and a strong awareness of the individual pixels present in displays. In the first effect, users spoke of "visual glitches" that occurred outside of VR, where "text would randomly appear 3D." This included "floating text when browsing the web" and seeing "stuff on regular 2D TV appearing a bit like 3D-glasses." Users also reported a heightened awareness of the pixels present in displays (e.g. "I see the pixels on high density mobile displays, which required a bit of work to see clearly before").

The final perceptual after effect was a haptic effect of an ongoing sensation that the HTC Vive's cord is running down their back, even after removing the HMD. Users often referred to this effect as the "phantom cord," where users reported that "after using [their] Vive, [they] could still feel the cord down the back of [their] neck even when the HMD was off." This effect could also manifest itself behaviorally, where if users "ran over some wires with a chair at work" they would "make sure my HMD wasn't about to fall."

### 3.2 Behavioral aftereffects

Users commonly reported a sense of unreality associated with the real world after exiting VR: "Especially right after I take off the headset, I have a hard time figuring out whether I am in reality or not." In order to verify the reality of their experiences after removing the headset, users would deliberately touch objects to confirm their real nature, e.g. "I would often touch things (my desk, my phone, etc.) just too reaffirm they are indeed real". Users also reported they would "walk a bit slower in their house to make sure the chaperone system didn't pop up." Users also expressed hesitation when attempting to support themselves using physical objects (e.g. "I never shift my weight onto anything unless my hand is on it for about a second for my brain to make sure its real"). This behavior emerges from the risk of "just falling through it" associated with attempting to support oneself on objects in VR. This hesitation was then carried over into the real world after exiting VR.

While the previous two effects dealt with direct interactions with the real world, the final effects described involved instinctively attempting to use VR interaction metaphors in real life. These included both locomotion metaphors and interaction metaphors. Users regularly reported attempting "to teleport to things I need to pick up" or "pressing the trigger buttons to pick up objects in front of me in real life,". One user reported that "after a few hours in VR, I got some coffee, and then just let the cup drop from my hand. My brain just forgot to hold on."

### 3.3 Reports on the duration of lingering effects

Users were nearly unanimous in that the aftereffects described were only triggered after VR play sessions lasting for a minimum of one full consecutive hour of engagement. Effects were reported to manifest anywhere between "right after I take off my headset" to a few hours later. After which users reported the effects lasting anywhere from only "a few seconds" to "12 hours" to persisting even into the following day. As such, it is difficult to draw conclusions about the "typical" duration of these aftereffects. It may be that

different aftereffects are associated with different lengths, or the the time spent in VR prior to the aftereffects appearance is related to the duration the effect lasts, but this would require more studies.

Users were unanimous in their agreement that these lingering aftereffects eventually did stop occurring. The most common length of time reported for the complete disappearance of effects was after "a couple of weeks" of regular VR use.

## 4 CONCLUSION

Our analysis suggests that VR user is associated with lingering aftereffects, but that these effects seem to completely disappear within a relatively short period of time (at the most, several weeks). The most commonly reported side effects were perceptual side effects, including altered perceptions of body ownership and proprioception, altered depth perception, an assortment of unusual visual phenomenon, and a lingering haptic sensation from the cord connected to the HTC Vive. Behavioral side effects were also reported, including feeling a need to verify the reality of the real world through touch, hesitancy when walking or leaning against objects in the real world, and attempts to use VR locomotion and interaction metaphors in real life. Users agreed that these effects only seemed to occur after spending at least one continuous hour in a VR application. The duration of an effect could vary considerably, from mere moments to lasting into the next day. Users also agreed that they eventually stopped experiencing any side effects, usually within several weeks.

### 4.1 Limitations

It is important to put this work in context: it examines what side effects are associated with VR, and how long they can last, *through the lens of self-reported user experience*. While this gives us access to more material than can typically be gathered in controlled laboratory experiments, it also introduces at least two limitations. First, our data relies on subjective self-reports drawn from uncontrolled settings. This limits the extent to which specific details can be quantified (e.g. the amount of depth compression typically experienced, the average duration of lingering effects), and users are unable to report on effects of which they themselves are unaware. Second, there was an element of self-selection involved in this data set. We observed that users unanimously agreed that lingering effects disappeared after several weeks of VR usage; however, given their potentially unpleasant nature, it is possible that these effects persisted in some users, who then stopped using VR and thus did not engage in this forum. It is important that these limitations be considered when applying these results, and for future research to test and quantify our observations in controlled experiments.

## 5 ACKNOWLEDGMENTS

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