

Investigating Future Negative Consequences of Virtual Reality

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An Introduction into Virtual Pathologies

Virtual refers to an object or environment that does not exist physically but is made to appear so through software. Reality refers to the “state of being real” or of existing. Thus, it would seem that the name virtual reality (VR) is a contradiction in terms, a technology that is designed to make what is not real appear as though it is. The ability to resolve this contradiction is what makes for a successful product, but also what could make it dangerous. It is relatively easy to look at the current state of VR verisimilitude and wonder how that environment could ever be mistaken for everyday reality. However, at the pace of technology’s progress these virtual worlds could come to seriously compete with our reality and exacerbate social problems such as addiction.

With considerate foresight, it is possible to preempt some negative impacts of technology adoption. For this reason, technological momentum is a useful hermeneutic for the development and consequent social role of this technology. If guidelines for the healthy and productive use of VR are created early on in its development, then society will be better off than if nothing is done until VR becomes a large and important part of the daily lives of many. However, little research exists at present that could lead to direct answers. The first step, therefore, is to assess the potential risks using the limited research that is currently available. The research aims to answer how can current use of technology inform society about the potential negative impact of widespread adoption of virtual reality technology on society at large?

Academic and Non Academic Sources

This paper primarily utilizes document analysis from academic papers and research to compare the effects between the capabilities of current technology and the burgeoning world of

virtual reality. The first category of documents is research about conventional video games and pathological technology use. The purpose of these articles is to utilize the high-quality research done by professional researchers about negative consequences and reactions to technology that exist for more conventional media consumption but not for VR. These papers mostly touch on the subject of video gaming disorders such as addiction. Video games have been singled out of the plethora of other personal technology regularly utilized by the average person today for their similarity to VR, as both involve a virtual world and the simulation of some real-life behavior.

The second category of evidence is academic research comparing conventional technology usage to VR. The academic research in particular focuses on the difference in emotional arousal that a two-dimensional image or video or game elicits compared to a similar but totally immersive experience in VR. Other works cited in this paper concern the degree of “immersive-ness” commonly referred to in literature as presence comparing VR to conventional media. The point of the papers is to allow for comparison between VR and more common forms of technology use and to allow for some extrapolation about the course that VR will take going forward. Finally, pieces of casual writing will be considered to informally assess expert opinion on the subject; these will mostly come in the form of news or magazine articles such as an opinion piece from Vice Media (Tisdale, 2016).

Virtual Reality Background

Virtual reality refers to the simulation of a virtual environment meant to evoke the real world or the totalizing immersion of the real world. This is usually achieved by having the user wear a headset and have sounds played by earbuds or headphones. While the concept of virtual reality is not new, recent technological advances, such as low persistence displays, have made VR accessible for consumers. The introduction of the first widely consumed piece of VR

hardware, the Oculus Rift, was only launched commercially in 2016 (Oculus, 2015). Since then other consumer grade headsets have been introduced from companies such as Sony and Microsoft, but the technology is still very much in its early days and is developing rapidly. Mainly known for gaming, the technology has attracted interest from corporations for use in training as well as in the medical community. While there are a number of therapeutic uses of VR such as therapy for PTSD (Deng et al., 2019), video game addiction (Park et al., 2016) and anxiety (Carl et al., 2019), potential negative consequences must be considered as well. The usefulness of VR comes from its ability to simulate lifelike experiences in a controlled setting; however, this is also what opens the door to potential abuse such as unhealth escapism in virtual worlds.

Technology use has proliferated in recent years, especially in the last decade, and pathological technology use is a well-documented phenomenon that can manifest itself in many different ways. This paper suggests that VR could be addictive in the same way that videogames can be addictive. Internet gaming disorder is well recognized enough that it is in the diagnostic standard manual (American Psychiatric Association, 2013). Video games have many similarities in that they create a virtual environment which people can perform activities that they might not be able to in their real lives. Since conventional video games can be addictive (Van Rooij et al., 2011), what does that mean for if it is considered a more engaging and arousing form of gaming such as VR?

Technological Momentum of Virtual Reality

The primary framework used to analyze the topic of VR adoption and usage is technological momentum. Technological momentum is a theory produced and popularized by historian of science Thomas P. Hughes (Hughes, 1969). Simply put, the theory states that the

relationship between technology and society is reciprocal. The relationships in other theories such as technological determinism, where technology determines the behavior of society, or the social construction of technology (SCOT), where society determines the form of technology. The ability to reconcile these two seemingly contradictory positions is one reason that this theory applies well to the topic of VR and society. Investigating from the perspective of either of the more static frameworks would result in a fundamentally limited analysis. The second reason for technological momentum's suitability is the reciprocal nature that can change over time. The interplay between the two opposing forces over time is the most important nuance of the framework. For example, Hughes states that generally when technologies are immature and only just being adopted on a large scale society has great influence over the form and role that the technology takes on; however, when the technology is firmly established and widely influential the balance tips the other way and society is shaped by the technology. The dynamism makes the observations more flexible and applicable to the future instead of a purely descriptive static state representation. A flexible framework is useful as VR is not firmly entrenched in our society yet, but this paper is primarily concerned with its impact on society in the future.

Few scholars have performed extensive analysis of the efficacy of technological momentum. There are some examples of the framework serving as the context for analyzing models such as customer relationship management (Wang & Burton Swanson, 2008). Hughes wrote about the framework in his seminal paper on the subject about hydrogenation in prewar Germany (Hughes, 1969). This gap of a meta-analysis of technological determinism in the literature is surprising given that technological momentum is one of the canonical theories of STS promulgated by one of its leading members.

Analyzed Documents and Studies

Addiction to virtual worlds affects only a small population, but has negative consequences. Aspects that make virtual worlds both compelling and the aspects that make them ripe for compulsive abuse depend heavily on the level of immersion and presence in the world. Studies comparing virtual reality to the types of conventionally immersive games examined in the first part of the results section show that they demonstrate higher levels of immersion and presence which would cause them to be more compelling, potentially dangerously so. VR is also more intense in another category important to predicting compulsive use: emotional response. VR elicited more intense emotional reactions associated with pleasure seeking behavior than from people in two dimensional environments. All of this points towards VR aggravating already existing pathological technology usage.

Conventional Virtual Worlds

While there is a relatively wide array of consumer grade VR products on the market today, most people have little contact with it. Many people use and associate the technology with video games and leisure. If then many potential users think of VR as a nonessential or trivial luxury, many researchers apply VR as purely therapeutic or a clinical procedure. Due to the lack of research this paper must look elsewhere for how people interact with virtual worlds. The first type of virtual worlds is video games and virtual environments that have game like components. (N.B. the term “video games” means a game played on a computer or console) Video gaming, more than other forms of interaction with personal technology such as mobile phones, provides a reasonable proxy for how one might interact with VR. Furthermore, they represent a link between contemporary usage of technology and a future of widespread VR adoption since video games can be experienced either with two dimensional screens and a mouse and keyboard or in a sophisticated VR headset. Comparisons can then be made between the two ways of performing

video games with the same virtual environment so as not to introduce a confounding variable such as being in two different virtual worlds.

Video game addiction is one uncommon outcome of heavy video game usage. The estimate for the percentage of active gamers addicted to online video games ranges but is consistently in the low single digits (Van Rooij et al., 2011). A Dutch study found that the addicted population was around three percent of all online gaming while an at-risk population of around 1.5% percent that very heavily uses video games without being addicted (Van Rooij et al., 2011). While the vast majority of people who play online video games do not become addicted, the sheer popularity of video gaming and the size of the global player base in absolute terms the number of people could be very large. Younger people and men tend to be at a higher risk of gaming addiction (Mihara & Higuchi, 2017). Personality traits associated with video game addiction include narcissism and neuroticism (Sublette & Mullan, 2012).

The degree of immersion into a virtual world has strong impacts on the addictiveness of the game. The game type that most commonly causes compulsive or addicted behavior are the so called massively multiplayer online game (MMOG), also known as a Massively Multiplayer Online Role-Playing Game (MMORPG) (Sublette & Mullan, 2012). This type of game is the most immersive of the virtual worlds created by video games. Players walk around in an open-ended world with an avatar that they could customize to represent themselves. This is the type of game that will become much more entertaining with virtual reality to enhance the feelings of presence and to reduce intrusions from the outside world. In this type of game, the user is encouraged to identify with their avatar in the game as if they were doing the actions themselves. When transferred to VR, this close association between the real-life user and his or her online persona may blur the line between actual and virtual reality.

While the intensity of the impact of a video gaming addiction are hotly debated by experts as explained earlier, those experts generally accepted that gaming disorders have negative consequences for those who are addicted. Addicted persons suffer from declines in face-to-face sociability explained by increases in online sociability (Schmitt & Livingston, 2015). Academic performance tends to suffer and among those with gaming addictions as shown by lower college GPAs compared to their peers (Schmitt & Livingston, 2015). The same study by Schmidt and Livingston found that positive college engagement such as club membership was down as well as negative behaviors such as alcohol violations and disciplinary infractions, demonstrating that it seems all types of socialization were down pointing to a high degree of preoccupation with online gaming.

Conventional vs. Virtual Reality

The discussion so far is not specific to virtual reality necessarily and none of the studies considered virtual reality gaming. The next aim of the paper is to compare virtual reality to conventional media consumption, including video games and other two-dimensional forms. The addictive potential and emotive response of virtual reality depends on the related concepts of presence and immersion. Immersion is generally used in an academic context to refer to the degree of sensorimotor connection between the user and his or her avatar in a virtual world (Slater, 2018). If the user feels a high degree of connection with their virtual host and they feel that the movements they make in real life correspond well to the virtual world, then their self-reported sense of presence will be higher (Slater, 2018). Immersion can be more qualitatively described as feeling as though you can manipulate all aspects of your body in VR. The second concept of presence is the sense that the user is actually present in the simulated environment; a user experiencing a high degree of presence in a virtual environment might say that they felt as if

they were “really there.” Especially in non-academic settings, these terms are used interchangeably.

The level of engagement of an experience depends on the sense of presence that a virtual world is able to create, so if VR produces a higher feeling of presence then it will be more likely to cause addictive behaviors. One study found that playing virtual reality games created a higher sense of presence, and it also crucially tracked the degree of intuitiveness in the playing of a game in a non-immersive environment versus VR and found the barrier of entry to VR gaming is no higher than that of traditional games (Pallavicini et al., 2019). As responsiveness and familiarity with VR systems increases, they could become even more usable to the average person than the classic keyboard and mouse of the currently dominant style of video gaming. In another study by computer science professors Roettl and Terlutter comparing two dimensional, three dimensional and VR experiences, found that the VR environment was considered more lifelike by the participants than even the three-dimensional exposure condition (Roettl & Terlutter, 2018). In an opinion piece technologist Alex Tisdale, the author posited that this could be due not only to the greater sensory stimulation, but also because virtual reality removes some of the distractions that interrupt the intense feelings of presence that a game or virtual world can produce (Tisdale, 2016). While immersion breaking, as the phenomenon is commonly known, acts as a mediating influence on conventional video games its absence from VR gaming could increase the risk for addictive or compulsive behavior.

The second important aspect for any sort of addictive behavior is the sense of reward and positive emotional feedback from an activity. Video games, as discussed earlier, are known to promote pathological reward seeking in a small component of the population. If VR produces more intense and pleasurable emotional reactions, it will have a higher potential for abuse.

Generally, studies have found that a VR environment elicits a greater degree of emotional response compared to a similar non immersive virtual environment. Most studies have focused on positive emotions stating that users consistently reported more intense and more positive emotions during experiences in VR as compared to experiences in 2D; these players reported no similar increase in happiness after playing the same game on the desktop (Pallavicini et al., 2019). Elsey et al., a group of psychology researchers in the Netherlands, found that men experience significantly greater arousal when viewing pornography in a VR setting while women did not experience significantly more arousal (Elsey et al., 2019). So called point-of-view scenes, in which the viewer sees from the standpoint of a participant in the sexual act especially raised the level of arousal in men, reinforcing the hypothesis that immersion is something that is important in the attraction that is felt towards VR. When participants see themselves as present within the virtual environment, they experience a greater amount of emotional reaction. Elsey and the other authors stated that “maximizing realness in virtual scenes may therefore be a means of heightening emotional engagement” (Elsey et al., 2019). Finally, a study compared exploration of a real art museum to a VR exploration of the same museum. Contrasted with these previous studies, the virtual experience mirrored the real life experience with similar amounts of emotional arousal indicating that VR is a good simulator of real life experiences (Marín-Morales et al., 2019).

Synthesis of Research and Framework

The STS framework through this paper, used to examine the results of the research presented earlier, is technological momentum. Technological momentum generally divides the life of a technology into two phases. one in which the technology is new and still emerging into society and the other in which the technology is firmly entrenched in society and is highly or at

least generally mature. This first stage will be referred to as the formative phase, and the second will be referred to as the exertive phase. VR is in the formative phase with relatively low familiarity amongst the general population outside of name recognition, and strictly technological innovation in the space is still relatively fast paced. Society is still in the process of determining what the uses of VR will be. There are almost no areas of industry, medicine, or commerce in which the use of VR is a vital and irreplaceable component vital to the functioning of daily life. However, VR is beginning to make inroads into those areas with much interest in training and therapeutic uses. Individuals are in the beginning of thinking about how they would fit VR into their lives and how they want virtual worlds to look like.

Technological momentum dictates that VR will, like other technologies, eventually move into the exertive phase and become an influential part of life of a great number of people (Hughes, 1969). Video games are further along in this process and demonstrate that VR could eventually have similar effects on people. The increasing prominence of virtual worlds, of which VR will likely be strongly represented, shows that it will possibly be the source of some anti-social or addictive behavior due to the strong emotional reactions and potential for escapism. Once this technology is highly developed it will be much more potent than it is today and will prove stronger to resist for those who are already tempted by the less immersive virtual worlds that are already widespread. This is the eponymous momentum that a technology can gather. When virtual reality becomes a commonplace tool for training workers or for treating anxiety, people will become more exposed to the technology and could be induced to use it recreationally. Thankfully, the research indicates that currently virtual worlds only negatively impact a small number of users, many of whom have complicating personality traits that make the assessment of the impact of the technology use more difficult (Grüsser et al., 2007).

However, as momentum gathers behind the technology due to its increased level of arousal, presence, and immersion combined with widespread use and availability, the situation could change dramatically for the worse.

For these reasons, it is important that a framework be developed now to proactively shape the course of VR development and adoption before it has negative outcomes. As VR becomes both more realistic and more important to people, there must be both formal and informal guidelines. As one author has argued there may be a need for some degree of criminal law to enter the world of virtual reality to prevent abuse (Hansen, 2019). As the verisimilitude of these virtual experiences increases so does the potential for real life trauma sustained due to assault, violence, or exploitation in virtual worlds. There has already been concern about the virtual exploitation of minors expressed by various governments in virtual environments such as the game Second Life (*Reader Roundtable*, n.d.). Second Life is not itself a VR game but is an open ended and immersive virtual world; there is also a more recently released virtual reality version of the game. In the same game fraud is hugely present in the simulated economy of the game causing some users to experience real world financial loss (Gardiner, 2007). All of these problems will only increase with the further development of VR and should be addressed before the technology can fully enter the exertive phase of its existence.

There were many limitations to this research some of which are mentioned in the course of this paper. The first is the lack of academic research directly into the negative psych-physical consequences in VR. A second related limitation is that the lack of direct research forced a reliance on extrapolation of similar but not identical virtual worlds like video games. The relatively short time scale of the research project (less than nine months) means that the topic could not be explored exhaustively and action could not be taken beyond a metanalysis of

existing studies. The poor understanding in the scientific community of the mechanisms behind addiction in virtual environments prevented the development of stronger causal links between VR and addiction.

Recommendations for future work are mainly to remedy the previously mentioned limitations of this project. Scientists should direct their attention to longer term studies of the effects of VR on brain chemistry and social interaction and abuse. Longitudinal studies have only just become possible and would help the understanding of this topic immensely. Studies should also concern the mechanism of addiction behind all sorts of virtual pathologies ranging from compulsive internet use to video game addiction.

Conclusion

VR will likely exacerbate the already existing problems associated with virtual worlds. The comparison of VR with conventional virtual environments demonstrates that poor productivity, low sociability, and addiction are the likely outcomes of increasing the market penetration of VR. When compared to these conventional methods of experiencing virtual environments, immersive VR using headsets of the kind currently introduced to the market consistently create greater emotional reactions. This research has implications across society. Governments should see pathological technology use and VR abuse in particular as a public health problem worthy of attention and potentially regulation. Individuals should be aware of the risks associated with the overuse of this technology. Overall, the goal of this paper is to start a productive conversation so that the problems may be resolved before the entrenchment of VR in public life.

Works Cited

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.).
- Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., Asmundson, G. J. G., Carlbring, P., & Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. *Journal of Anxiety Disorders*, 61, 27–36.
<https://doi.org/10.1016/j.janxdis.2018.08.003>
- Deng, W., Hu, D., Xu, S., Liu, X., Zhao, J., Chen, Q., Liu, J., Zhang, Z., Jiang, W., Ma, L., Hong, X., Cheng, S., Liu, B., & Li, X. (2019). The efficacy of virtual reality exposure therapy for PTSD symptoms: A systematic review and meta-analysis. *Journal of Affective Disorders*, 257, 698–709. <https://doi.org/10.1016/j.jad.2019.07.086>
- Elsay, J. W. B., van Andel, K., Kater, R. B., Reints, I. M., & Spiering, M. (2019). The impact of virtual reality versus 2D pornography on sexual arousal and presence. *Computers in Human Behavior*, 97, 35–43. <https://doi.org/10.1016/j.chb.2019.02.031>
- Gardiner, B. (2007, August 15). Bank Failure in Second Life Leads to Calls for Regulation. *Wired*. <https://www.wired.com/2007/08/bank-failure-in-second-life-leads-to-calls-for-regulation/>
- Grüsser, S. M., Thalemann, R., & Griffiths, M. D. (2007). Excessive Computer Game Playing: Evidence for Addiction and Aggression? *CyberPsychology & Behavior*, 10(2), 290–292.
<https://doi.org/10.1089/cpb.2006.9956>

- Hansen, J. (2019). Virtual Indecent Assault: Time for the Criminal Law to Enter the Realm of Virtual Reality. *Victoria University of Wellington Law Review*, 50(1), 57.
<https://doi.org/10.26686/vuwlr.v50i1.5553>
- Hughes, T. P. (1969). TECHNOLOGICAL MOMENTUM IN HISTORY: HYDROGENATION IN GERMANY 1898–1933. *Past and Present*, 44(1), 106–132.
<https://doi.org/10.1093/past/44.1.106>
- Marín-Morales, J., Higuera-Trujillo, J. L., Greco, A., Guixeres, J., Llinares, C., Gentili, C., Scilingo, E. P., Alcañiz, M., & Valenza, G. (2019). Real vs. immersive-virtual emotional experience: Analysis of psycho-physiological patterns in a free exploration of an art museum. *PLOS ONE*, 14(10), e0223881. <https://doi.org/10.1371/journal.pone.0223881>
- Mihara, S., & Higuchi, S. (2017). Cross-sectional and longitudinal epidemiological studies of Internet gaming disorder: A systematic review of the literature. *Psychiatry and Clinical Neurosciences*, 71(7), 425–444. <https://doi.org/10.1111/pcn.12532>
- Oculus. (2015, May). *First Look at the Rift, Shipping Q1 2016*. Oculus VR.
<https://www.oculus.com/blog/first-look-at-the-rift-shipping-q1-2016>
- Pallavicini, F., Pepe, A., & Minissi, M. E. (2019). Gaming in Virtual Reality: What Changes in Terms of Usability, Emotional Response and Sense of Presence Compared to Non-Immersive Video Games? *Simulation & Gaming*, 50(2), 136–159.
<https://doi.org/10.1177/1046878119831420>
- Park, S. Y., Kim, S. M., Roh, S., Soh, M.-A., Lee, S. H., Kim, H., Lee, Y. S., & Han, D. H. (2016). The effects of a virtual reality treatment program for online gaming addiction. *Computer Methods and Programs in Biomedicine*, 129, 99–108.
<https://doi.org/10.1016/j.cmpb.2016.01.015>

- Reader Roundtable: “Virtual Rape” Claim Brings Belgian Police to Second Life | Virtually Blind | Virtual Law | Benjamin Duranske.* (n.d.). Retrieved February 20, 2020, from <http://virtuallyblind.com/2007/04/24/open-roundtable-allegations-of-virtual-rape-bring-belgian-police-to-second-life/>
- Roetl, J., & Terlutter, R. (2018). The same video game in 2D, 3D or virtual reality – How does technology impact game evaluation and brand placements? *PLOS ONE*, 13(7), e0200724. <https://doi.org/10.1371/journal.pone.0200724>
- Schmitt, Z. L., & Livingston, M. G. (2015). Video Game Addiction and College Performance Among Males: Results from a 1 Year Longitudinal Study. *Cyberpsychology, Behavior, and Social Networking*, 18(1), 25–29. <https://doi.org/10.1089/cyber.2014.0403>
- Slater, M. (2018). Immersion and the illusion of presence in virtual reality. *British Journal of Psychology*, 109(3), 431–433. <https://doi.org/10.1111/bjop.12305>
- Sublette, V. A., & Mullan, B. (2012). Consequences of Play: A Systematic Review of the Effects of Online Gaming. *International Journal of Mental Health and Addiction*, 10(1), 3–23. <https://doi.org/10.1007/s11469-010-9304-3>
- Tisdale, A. (2016, June 8). Gaming in Virtual Reality Could Be the Very Real Death of You. *Vice*. https://www.vice.com/en_us/article/4w5g7d/gaming-in-virtual-reality-could-be-the-very-real-death-of-you-911
- Van Rooij, A. J., Schoenmakers, T. M., Vermulst, A. A., Van Den Eijnden, R. J. J. M., & Van De Mheen, D. (2011). Online video game addiction: Identification of addicted adolescent gamers: Online video game addiction. *Addiction*, 106(1), 205–212. <https://doi.org/10.1111/j.1360-0443.2010.03104.x>

Wang, P., & Burton Swanson, E. (2008). Customer relationship management as advertised: Exploiting and sustaining technological momentum. *Information Technology & People*, 21(4), 323–349. <https://doi.org/10.1108/09593840810919662>