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Beyond the hype: longitudinal trends in virtual reality perceptions beyond the COVID-19 pandemic

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Abstract

Introduction.—The metaverse is shaped significantly by spatial computing technologies, such as virtual reality (VR). However, the promise of a VR-facilitated metaverse remains unfulfilled, and public perceptions of these technologies are fluid. Therefore, this study investigates perceptions and intentions to use VR over three years, both during and after the COVID-19 pandemic.

Method.—We conducted three waves of cross-sectional surveys from 2020 to 2022 (N = 928), via Amazon Mechanical Turk.

Analysis.—Data were analysed using OLS regression and mediation-moderation analysis using Hayes' PROCESS Model 85.

Results.—Respondents' perceptions of VR as both easy to use and useful predict their intentions to use the technology, with usefulness being the stronger predictor. When examining changes over time, in 2021, VR ownership was not a predictor of perceived usefulness, and it was associated with a decrease in intentions to use VR, potentially reflecting the dynamics of the hype cycle. The direct and indirect effects of COVID-19 on VR acceptance persisted throughout all three years of the study but appear to be diminishing with time.

Conclusion.—This study contributes to the theoretical and practical discourse on the metaverse's development, advocating for a nuanced understanding of VR's role as a critical component of this digital frontier.

Introduction

The metaverse concept represents a three-dimensional evolution of the internet that leverages extended reality technologies to help create an immersive, persistent, shared, and decentralized virtual world (Hwang & Chien, 2022). Virtual reality (VR), facilitated by head-mounted displays (HMDs), allows users to enter the 'metaverse' by immersing

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themselves in digital worlds. The potential applications of VR and the metaverse are vast and varied, as are its proponents. However, concerns and challenges persist regarding the future of this rapidly changing technology. For example, despite strides, VR adoption remains relatively low (Petrov, 2021). There are also questions about the long-term use of VR devices after adoption. For example, a report found that 69% of VR adopters use it less than once a month (AR Insider, 2020). These findings raise questions about long-term VR engagement and its viability as a gateway to the metaverse. Some scholars suggest that VR may represent a temporary trend, which demonstrates mixed results in certain applications such as advertising (Duguay, Dietzel, & Myles, 2022). Consequently, if the metaverse is to gain widespread traction, it is important to examine not only the factors contributing to VR adoption but also people's intention to use VR over time.

Concerns about VR extended beyond adoption and usage rates. Both academics and end users have expressed potential issues such as privacy and data protection within the metaverse framework (Egliston & Carter, 2022). The trajectory of VR as an integral element of the metaverse ecosystem remains an unfolding narrative. Significant industry shifts, such as Facebook's rebranding to "Meta," highlight a strategic pivot towards the metaverse, largely driven by VR technology (Meta, 2021). While this rebranding was not solely due to Meta's focus on the metaverse, its significance should not be underestimated, as Meta has been one of the most prominent investors in VR technology since it purchased Oculus in 2014 for approximately 2 billion dollars (Meta, 2014). This evolving narrative demands an in-depth exploration of public perceptions of VR, as a foundational technology of the metaverse, which are changing over time. These perceptions are not static and may significantly shape the technology's integration (or lack thereof) into everyday life moving forward.

A growing body of scholarship has examined VR acceptance and adoption across several contexts relevant to the metaverse. For example, researchers have studied the factors influencing users' willingness to adopt VR in tourism and educational contexts (Jang, Ko, Shin, & Han, 2021; Kim, Lee, & Preis, 2020). In this promising body of scholarship, the technology acceptance model (TAM) has emerged as a valuable framework for understanding VR adoption across different contexts (Ball, Huang, & Francis, 2021; Jang et al., 2021; Lee, Kim, & Choi, 2019). This body of work highlights the nuanced and evolving relationship between technology and user, particularly in the context of the metaverse. Scholars have even created a VR-specific version of TAM that adds several key variables, such as curiosity (Manis & Choi, 2019). While these studies are insightful, a common limitation of VR research in general, and VR adoption studies in particular, is the lack of longitudinal data (Ball et al., 2021), which restricts the ability to examine trends over time. This gap presents both research challenges and opportunities for further research.

Longitudinal studies are essential because attitudes toward technology may change due to historical events. For example, attitudes towards virtual worlds have been shown to vary based on time, (Luse, Mennecke, & Triplett, 2013) and device ownership status (Korucu & Bicer, 2018). Additionally, the pandemic has catalysed shifts in the digital landscape, notably impacting the perception and use of technologies like VR. Recent studies have indicated that the functionalities and affordances of technologies, such as virtual dating

apps, have changed or evolved in response to the 2019 coronavirus disease (COVID-19) (Duguay et al., 2022). These shifts are critical to understanding the trajectory of VR and its integration into the metaverse post-pandemic. Moreover, studies have found that the perceived impacts of COVID-19 were related to VR perceptions at the beginning of the pandemic (Ball et al., 2021). Thus, examining VR perceptions both during and after the COVID-19 pandemic is essential to assess if these pandemic-related effects are enduring.

Theoretical background

The technology acceptance model (TAM)

TAM has proven useful for broadly examining emerging technology adoption and VR adoption more specifically. In essence, TAM examines how potential users' perceptions that new technology is both useful and easy to use ultimately influence their intention to use (ITU) a new technology (Davis, Bagozzi, & Warshaw, 1989). Specifically, the perceived usefulness (PU) of a technology is related to a user's belief that a new technology could improve their life in a meaningful way. Furthermore, a technology's perceived ease of use (PEOU) is related to a user's belief that using a new technology will not require too much effort. Perceived ease of use can also enhance the perceived usefulness of technology, as technologies that are easier to use are often perceived as more beneficial. Both perceptions (usefulness and ease of use) subsequently impact potential users' willingness to adopt (intent to use), which is theoretically linked to technology adoption (purchase behaviour).

TAM has been used successfully for over a decade to examine VR acceptance and adoption (Fagan, Kilmon, & Pandey, 2012). This body of scholarship continues to grow as new scales are developed, and different contexts and populations are examined (Bunz, Seibert, & Hendrickse, 2021; Jang et al., 2021). As a result, scholars have built upon the TAM framework by examining key external variables that also impact VR acceptance and adoption (Castiblanco Jimenez, Cepeda García, Violante, Marcolin, & Vezzetti, 2020; Sagnier, Loup-Escande, Lourdeaux, Thouvenin, & Valléry, 2020). A notable advancement in this area is the creation of a VR-specific version of TAM, known as the 'virtual reality hardware acceptance model' (VR-HAM) (Manis & Choi, 2019). VR-HAM includes a series of external variables that form a complex model predicting VR use and purchase intentions. For instance, VR-HAM considers user variables such as curiosity and its impact on perceived ease of use. However, while the TAM literature shows promise, the results are still mixed. For example, in one study, while the perceived usefulness of VR predicted participants' intention to use VR, the perceived ease of use did not (Sagnier et al., 2020). This study also explored external factors that reduce intentions to use VR, such as cybersickness (Sagnier et al., 2020). Therefore, further research is still required to explore the factors that encourage and discourage VR perceptions and to continue testing the efficacy of TAM in a VR context.

Another crucial external user variable that has emerged in the literature is material access to the hardware or technology (Van Deursen & Van Dijk, 2019). Specifically, the digital divide literature suggests that having access to VR can influence perceptions of that technology as users gain first-hand experience, whether positive or negative (Huang, Ball, Cotten, & O'Neal, 2020). Furthermore, VR ownership does not necessarily guarantee intention to

use VR, as reports have indicated that 69% of VR owners report using the hardware less than once a month (AR Insider, 2020). In other words, if people purchase VR, but their experience is negative, then they may have less intentions to use VR in the future. Thus, our study will explore how material access, or ownership of VR hardware, affects people's perceptions of VR and, ultimately, their intention to use it.

VR ownership during the COVID-19 pandemic

While user-level external variables are potentially important influencers of VR acceptance and adoption, contextual factors also play an important role. Specifically, the onset of the COVID-19 pandemic, as an external variable, presents a unique context to study VR technology adoption (Ball et al., 2021). In March 2020, most of the world instituted mandatory stay-at-home orders (i.e., lockdown procedures) to curb the spread of COVID-19 (Goodman & Schulkin, 2020). During this time, people's lives became increasingly disrupted as they are confined to their homes for extended periods. As a result, some industries experienced a 'boom' as the demand for home-based technology and entertainment suddenly and dramatically increased. For instance, the video game industry saw a significant increase, with a 12% rise in global sales (Clement, 2021), indicating a similar potential for growth in VR usage.

The appeal of VR, including its applications in gaming and virtual travel, naturally increased as people sought new forms of entertainment and escapism during lockdowns (Ball et al., 2021). While concrete figures are challenging to obtain, some popular press articles estimate that spending on extended reality technologies increased by 50% in 2020, fuelled at least in part by the pandemic (Vardomatski, 2021). Interestingly, online surveys indicated a disparity in VR usage: while 26% of teens in the US owned a VR device, nearly half of these users seldom utilized them (Lin, 2022). This raises questions about the long-term engagement with VR technologies post-adoption.

Three years post-COVID-19, the pandemic's impact persists, though signs indicate a shift towards a more stable and predictable situation, potentially moving from a pandemic to an endemic (Grennan, 2019). By early 2023, 68.5% of the global population had been vaccinated against COVID-19 (Our World in Data, 2022), leading to a relaxation of strict containment measures. Consequently, industries that flourished during the pandemic, like video games, began to experience a downturn (Monaco-Vavrik, 2022). This fluctuating landscape underscores the need to continue examining technology adoption in a post-pandemic world.

Prior VR adoption research found that COVID-19-related factors, such as financial and health worries, are related to VR acceptance and adoption. For example, the perceived impact of COVID-19 improved the perceived usefulness of VR as the pandemic provided a potential use case for the technology (Huang, Ball, & Francis, 2023). Moreover, the pandemic influenced how people used VR, with some turning to it for work and others for coping with mental health challenges (Ball et al., 2021). In this study, we aim to extend this research by exploring the long-term impacts of COVID-19 on VR technology acceptance and adoption.

Hypotheses and research questions

To explore the influence of the pandemic on VR adoption and further our understanding of how VR is perceived over time, we have developed a conceptual model based on the Technology Acceptance Model (TAM) and its extensions. This model serves as the foundation for our hypotheses and research questions, which investigate both direct and indirect effects of VR ownership and the perceived impacts of COVID-19 on VR use (see Figure 1).

We propose the following six hypotheses based on our conceptual model:

H1: VR Ownership has a direct effect on (a) Perceived Ease of Using VR, (b) Perceived Usefulness of VR, and (c) Intention to Use VR.

H2: Perceived impacts of COVID-19 have a direct effect on (a) Perceived Ease of Using VR, (b) Perceived Usefulness of VR, and (c) Intention to Use VR.

H3: Perceived Ease of Using VR will have a positive direct effect on Perceived Usefulness of VR.

H4: (a) Perceived Ease of Using VR and (b) Perceived Usefulness of VR will have a positive direct effect on Intention to Use VR.

H5: VR Ownership has an indirect effect on Intention to Use VR via both Perceived Ease of Using VR and Perceived Usefulness of VR.

H6: Perceived impacts of COVID-19 have an indirect effect on Intention to Use VR via both Perceived Ease of Using VR and Perceived Usefulness of VR.

In addition to our hypotheses, we pose the following research questions to delve deeper into the temporal dynamics of VR adoption influenced by external variables:

RQ1: Does VR ownership impact users' PEOU, PU, and ITU related to VR technology differently in the past three years?

RQ2: Do the perceived impacts of COVID-19 impact users' PEOU, PU, and ITU related to VR technology differently in the past three years?

Methods

Participants and procedures

The current study includes a three-wave cross-sectional survey that began in 2020. All three waves of data collection were conducted through Amazon Mechanical Turk (MTurk), an online crowdsourcing platform widely used for research purposes (Goodman et al., 2013). MTurk participants, known as 'Turkers', receive monetary compensation for completing Human Intelligence Tasks (HITs) on the MTurk platform (Paolacci & Chandler, 2014). Compensation varies based on task complexity, with Turkers earning from 1 cent to several dollars per HIT (Ross, Irani, Silberman, Zaldivar, & Tomlinson, 2010). The data

quality from MTurk is generally considered equal to or better than data collected from undergraduate research pools (Miller, Crowe, Weiss, Maples-Keller, & Lynam, 2017).

The researchers posted three HITs on MTurk during the Fall of 2020, the Summer of 2021, and the Fall of 2022, detailing the survey purposes and associated monetary compensation. Each wave of HITs was open to participants within the United States until approximately 315 responses were received, typically over 72 hours (3 consecutive days). The target of 315 responses per wave aimed for 300 complete datasets with an additional 5% to account for potential missing or incomplete data. The sample size for each wave is in line with other studies that have examined VR adoption (Bunz et al., 2021; Jang et al., 2021; Lee et al., 2019). Respondents were not required to own a VR headset to participate in the study. A total of 928 participants were recruited for this study. Twenty-six participants with incomplete surveys or missing data were excluded, reducing the usable sample to 902. All participants received one US dollar upon submitting their survey codes to MTurk. All study procedures were approved by the Institutional Review Board at a US university, adhering to ethical standards. Respondent identifiers were removed post-incentive distribution, and results are reported in aggregate.

Survey instruments

This three-wave study uses a custom-created cross-sectional survey to investigate the impacts of COVID-19 on people's attitudes toward virtual reality. The questionnaires across all three years were composed of questions related to (1) technology acceptance and adoption (TAM), (2) COVID-19 impacts, and (3) demographics.

We utilized TAM items related to VR adoption developed by Manis and Choi (2019). These items, slightly modified from Davis's (1989) traditional TAM measures, form three scales: perceived ease of using VR (PEOU, Cronbach's $\alpha = 0.853$), perceived usefulness of VR (PU, Cronbach's $\alpha = 0.876$), and intention to use VR (ITU, Cronbach's $\alpha = 0.857$). Each scale comprises four equally weighted items, with overall scale scores ranging from 1 (lowest) to 7 (highest). Sample items include 'I believe using VR hardware would help me be more productive (PU)' and 'I believe using VR hardware would be easy for me (PEOU)'.

The COVID-19 measures employed in this study were adopted verbatim from a recent study that examined the perceived impacts of COVID-19 on psychological outcomes (Tull et al., 2020). We asked participants to report how much the pandemic impacts them in the following domains: financial worry, social support, health anxiety, and loneliness. The response categories ranged from 1(no impact at all) to 5 (impacted my life a great deal), and the items were averaged to attain an overall scale score ranging from 1 (respondent marked each of the four items as 1) to 5 (respondent marked each of the four items as 5).

We also included several VR-related and demographic control variables, including device ownership (i.e., material access) and types of devices participants owned. Lastly, we asked participants about their demographic information, including sex, age, income, education level, and race. The order of the sections presented in the questionnaire was as follows: technology acceptance variables, VR-related variables, the perceived impacts of COVID-19, and control variables.

Analytic tools

We employed descriptive analyses, ordinary least squares regressions (OLS), and mediation-moderation analyses. Descriptive analyses provided basic variable information, while OLS tested the four hypotheses. Mediation-moderation analyses, conducted using Hayes's (2018) PROCESS macro in SPSS v29, explored the two research questions regarding VR technology adoption.

Results

Descriptive analysis

The descriptive analysis included (1) demographic characteristics of participants and their VR ownership and (2) means and standardized deviations of the variables of interest. For demographic information, 61.6% of participants identified themselves as males, 69.2% were white, and more than half of the respondents were 25-34 years old. Regarding the respondents' household income, more than one-third of the participants were between $40,000 and $59,999. For the education levels, almost 80% of participants possessed a 4-year degree or higher, while less than 10% did not have some level of higher education. This participant profile is consistent with the demographic trends typically seen in the U.S. MTurk population, as noted in other studies exploring MTurk user demographics (Moss, Rosenzweig, Robinson, & Litman, 2020).

Regarding VR hardware ownership, close to 75% of respondents reported owning some form of VR hardware. This rate of VR hardware ownership in our study appears higher than the figures reported in previous VR adoption studies, such as 50% in Manis & Choi (2019) and 69.6% in Huang, Ball, and Francis (2023). However, it's noteworthy that most respondents indicated ownership of more accessible, lower-cost VR hardware, like Google Cardboard (19.7%) and Samsung Gear VR (51.2%). In contrast, only a smaller fraction, about 15%, reported possessing higher-end VR head-mounted displays (HMDs) such as the HTC Vive or the Valve Index. In other words, while VR adoption appears high in our sample (74.1%), it is essential to note that there is a great deal of variability in the type and quality of VR devices owned, and most (77%) devices our respondents reported owning are low-cost headsets with limited immersive characteristics and features such as Google Cardboard. Table 1 provides a detailed breakdown of these demographic characteristics and the specifics of VR hardware ownership among the participants.

The variables of interest include VR hardware ownership, the perceived impacts of COVID-19, and TAM variables. Almost 75% of respondents reported owning VR hardware, although most own entry-level devices such as Samsung Gear VR and Google Cardboard. For the perceived impacts of COVID-19, the means were calculated based on the responses of the 902 participants. Participants reported moderate overall perceived impact of COVID-19 (Cronbach's $\alpha = 0.853$). Participants also reported a moderate amount of COVID-19 impacts across all four categories. Financial worry and lack of social support are the top two perceived impacts, followed by loneliness and health anxiety. Regarding TAM-related variables, participants reported an average of 5.47 and 5.61 points out of a 7-point Likert-like scale (7 as the highest) when asked about the PEOU and PU of VR

hardware. Furthermore, participants also reported a strong intention to use (5.43) on average. Table 2 presents the descriptive analysis of the perceived impacts of COVID-19 and the TAM variables.

OLS regression results

A series of OLS regressions were conducted to test our hypotheses, with results detailed in Table 3. In Model 1, the focus was on the direct effects of VR ownership and the perceived impacts of COVID-19 on participants' perceived ease of using VR (PEOU), addressing Hypotheses H1 and H2. The main predictors were VR ownership and the perceived impacts of COVID-19, with demographic variables such as sex, age, race, educational level, and household income as control variables. Model 2 explored the relationship between PEOU and perceived usefulness (PU), in line with Hypothesis H4. Here, PU was the dependent variable, with PEOU included as a critical predictor along with the variables from Model 1.

Model 3 examined the direct effects of VR ownership and COVID-19 on Intention to Use VR (ITU), relevant to Hypotheses H1 and H2. This model integrated the main variables - VR ownership and COVID-19 impacts - and demographic variables as predictors. Model 4 expanded the analysis to include PEOU and PU as predictors of ITU, crucial for exploring the potential mediating relationships posited in Hypotheses H3, H5, and H6. It compared the differences between Models 3 and 4 to assess mediation. There is no multicollinearity (VIF < 4) in all four models, and the values of skewness (between −2 to +2) and kurtosis (between−7 to +7) were considered acceptable (Hair et al., 2010).

The OLS regression results from Models 1-4 provided insightful findings. In Models 1, 2, and 3, the analyses revealed that VR ownership significantly predicted perceived usefulness (PU, β =.12, p < .001) and intention to use VR (ITU, β =.16, p < .001) but did not significantly predict perceived ease of use (PEOU). This *partial support for H1* suggests a complex relationship between VR ownership and its perceived attributes. On the other hand, the perceived impacts of COVID-19 significantly influenced PEOU (β =.26, p < .001), PU (β =.15, p < .001), and ITU (β =.33, p < .001), offering *full support for H2* and highlighting the significant role of the pandemic in shaping attitudes towards VR. The findings also showed a positive influence of PEOU on PU (β =.65, p < 0.001), *fully supporting H3*. This underscores the importance of ease of use in enhancing the perceived usefulness of VR.

In Models 3 and 4, mediation relationships were further explored. Both PEOU (β =.28, p < 0.001) and PU (β =.59, p < 0.01) emerged as significant predictors of ITU in Model 4, *fully supporting H4*, with PU being the more influential factor. Notably, the effect of VR ownership on ITU was mediated by PEOU and PU, as evidenced by a more than 56% decrease in its effect (from .16 in Model 3 to .07 in Model 4), *supporting H5*. Similarly, the impact of COVID-19 on ITU also showed a significant decrease (almost 79% from .33 in Model 3 to .07 in Model 4), indicating an indirect effect via PEOU and PU and *supporting H6*.

Demographic variables played a notable role as well. Household income (β =.07, p < 0.05) was a predictor of PEOU, and education level (β =.08, p < 0.001) influenced PU. These

findings emphasize the importance of demographic factors in the adoption and perception of VR technology.

Mediation-moderation results

To answer our research questions, we conducted two mediation-moderation analyses using PROCESS model 85 with 5,000 bootstrap samples and a 95% confidence interval. In the first PROCESS analysis, we explored VR ownership as the independent variable and ITU as the dependent variable. The year of data collection was a moderator, and PEOU and PU served as mediators. Demographic variables and COVID-19 were included as covariates.

Our analysis revealed significant interaction effects of VR ownership on PU ($F(2,872) = 7.5594$, $p < .001$) and ITU ($F(2,872) = 10.6711$, $p < .001$). However, there were no interaction effects of VR ownership on PEOU. Regarding conditional direct effects, VR ownership positively impacted PU in 2020 ($\beta = .2863$, $p < .01$) and 2022 ($\beta = .3721$, $p < .001$), but not statistically significant in 2021 ($\beta = -.1664$, $p = .117$). The direct effect on ITU was negatively significant in 2021 ($\beta = -.3546$, $p < .001$), with non-significant positive effects in 2020 and 2022.

The conditional indirect effects through PEOU and PU varied annually. The indirect effect through PEOU was not significant across the three years. Through PU, the effect was significant in 2020 ($\beta = .1755$, 95% CI [.0305, .3518]) and 2022 ($\beta = .2281$, 95% CI [.0670, .4114]), but not significant in 2021. The combined mediators' effect was not significant across the three-year span.

These findings suggest a complex and fluctuating relationship between VR ownership and user perceptions across different years, especially highlighted by the contrasting results in 2021. Table 4 details VR ownership's conditional direct and indirect effects on the outcome variables.

In the second PROCESS analysis, the impact of COVID-19 was examined as the independent variable, with intention to use (ITU) VR as the dependent variable. The year of data collection was utilized as a moderator, while perceived ease of use (PEOU) and perceived usefulness (PU) were mediators. Additional covariates included demographic variables and VR ownership.

Our analysis indicated significant interaction effects of the COVID-19 impact on PU ($F(2,872) = 7.5594$, $p < .001$) and ITU ($F(2,872) = 10.6711$, $p < .001$), but not PEOU. Specifically, the conditional direct effects revealed a varying influence of the pandemic on users' perceptions and intentions to use VR across different years. In 2020, the impact of COVID-19 positively influenced PU ($\beta = .2986$, $p < .001$), suggesting an increased perception of VR's utility amidst the early pandemic. However, in 2021, this effect was not as pronounced, indicating a possible adjustment in perceptions as the pandemic progressed ($\beta = .0958$, $p < .001$). By 2022, the positive impact on PU re-emerged strongly ($\beta = .3140$, $p < .001$), reflecting a sustained or growing appreciation of VR's usefulness as the pandemic evolved.

Regarding the indirect effects of COVID-19 on users' intention to use VR (ITU) via perceived ease of use (PEOU) and perceived usefulness (PU), the results are different across three years. In 2020, the impact of COVID-19 on ITU through PEOU was notable (β = .1021, 95% CI [.0579, .1556]), highlighting the initial phase of the pandemic where the perception of VR's ease of use significantly influenced usage intentions. This pathway remained significant in 2021 (β = .0752, 95% CI [.0429, .1173]) and persisted in 2022 (β = .0654, 95% CI [.0234, .1194]), underscoring the sustained influence of ease-of-use perceptions on VR usage intentions as the pandemic changed.

Similarly, the indirect impact of COVID-19 on ITU via PU was significant across each year, with the effect being considerable in 2020 (β = .1197, 95% CI [.0392, .2037]), continuing in 2021 (β = .0592, 95% CI [.0161, .1094]), and becoming particularly strong in 2022 (β = .1941, 95% CI [.0995, .3046]). This trend indicates a growing recognition of VR's usefulness throughout the pandemic's progression.

Additionally, the combined effect of PEOU and PU as mediators was significant. In 2020, their combined influence on the relationship between COVID-19 and ITU was substantial (β = .1413, 95% CI [.0825, .2045]). This effect was again significant in 2021 (β = .1040, 95% CI [.0627, .1492]) and continued into 2022 (β = .0905, 95% CI [.0334, .1577]), highlighting the enduring, but potentially waning, impact of the pandemic on VR technology acceptance. See Table 5 below for the conditional direct and indirect effects of COVID-19 on TAM variables.

These findings demonstrate a complex interplay where both ease of use and usefulness perceptions significantly mediate the relationship between the pandemic and the intention to use VR, emphasizing how external events like COVID-19 can shape technology adoption over time. Table 6 summarizes the findings of the hypotheses and research questions.

Discussion

Summary and interpretation of findings

The study offers valuable insights into the acceptance and adoption of VR technologies, particularly within the evolving context of the metaverse. Our results confirm the role of perceived ease of use (PEOU) and perceived usefulness (PU) in shaping users' intentions to use VR (ITU), which is consistent with existing literature (Kim et al., 2020; Lee et al., 2019; Manis & Choi, 2019). However, the results also reveal more nuanced relationships. Specifically, while VR ownership predicts PU and ITU, it does not significantly influence PEOU. This finding challenges the assumption that VR ownership inherently translates into improved usability perception, which suggests that while owners recognize the utility of VR technology, usability remains a persistent barrier.

This study further showed the significant role of COVID-19 as an external factor that positively influenced PEOU, PU, and ITU. The perceived impacts of the pandemic demonstrate its role in accelerating VR adoption and reinforcing its role as a gateway technology to the metaverse. Our mediation analysis further revealed that the impact of VR ownership and COVID-19 on ITU is indirect, which is mediated by PU and PEOU. Notably,

the direct effect of VR ownership on ITU was significantly reduced when considering these mediating factors, indicating the importance of both ease and usefulness perceptions in shaping adoption behaviours.

Our focus on the temporal dynamics of VR technology acceptance revealed interesting patterns. The impact of VR ownership on TAM variables varied across the years, with 2021 presenting a unique scenario where VR ownership negatively correlated with intention to use VR devices. This could indicate a shift in user expectations during this period. Similarly, the indirect effects of COVID-19 on ITU via PEOU and PU were consistent across all three years, but the effects showed a gradual decline, suggesting an enduring, yet slowly diminishing, influence of the pandemic on VR acceptance.

In summary, our findings highlight a complex interplay between user perceptions, external influences, and temporal dynamics in shaping the adoption and acceptance of VR technologies (See Figure 2). While VR ownership drives perceived usefulness, usability concerns remain unresolved, signalling a need for enhanced user experiences. The pandemic's role as a catalyst for VR adoption remains evident but is slowly diminishing. These insights are particularly relevant in understanding VR's evolving role as a gateway to the metaverse and provide a foundational basis for future research in this rapidly changing field.

Theoretical contributions

The current study has three principal theoretical contributions. First, our study significantly contributes to the theoretical understanding of VR adoption within the technology acceptance model (TAM) framework, particularly in the context of the emerging metaverse. The findings corroborate prior research (Kim et al., 2020; Lee et al., 2019; Manis & Choi, 2019), emphasizing the vital influence of perceived ease of use and usefulness in determining users' intentions to use VR technology. This reiteration of TAM's foundational components in a novel context in which public awareness of the metaverse has flowed and ebbed, underlines the model's robustness and adaptability in explaining technology acceptance across evolving digital landscapes.

Second, our longitudinal approach provides insights into the evolution of VR acceptance, especially during and after the COVID-19 pandemic. This period, marked by substantial shifts in user behaviour and technology interaction, is a crucial backdrop for understanding the dynamic nature of VR acceptance. We extend traditional TAM models by integrating external factors, such as the ramifications of COVID-19, which aligns with recent studies investigating health anxiety and its impact on VR adoption (Ball et al., 2021; Huang et al., 2023). This extension reflects a broader scholarly trend of incorporating external environmental and psychological factors into TAM, offering a more holistic view of technology acceptance dynamics.

Third, our findings also shed light on the nuanced relationship between VR ownership and user perceptions over time. The distinct pattern observed in 2021, where VR ownership correlated with decreased intentions to use VR, challenges and enriches the existing literature. This deviation can be theoretically framed through the concept of hype cycles

(Dedehayir & Steinert, 2016; Grundmeyer, 2014; Prinsloo & Van Deventer, 2017). The apparent cycle of heightened acceptance in 2020, followed by disillusionment in 2021 and recovery in 2022, illustrates the complex interplay between technology adoption, societal trends, and marketing dynamics. This nuanced understanding of VR acceptance, influenced by hype dynamics, not only adds depth to TAM's applicability in new technological domains but also underscores the need for a temporal and contextual lens in technology adoption research.

Practical implications

Our findings offer vital insights for VR technology developers and manufacturers, especially in the context of the evolving metaverse. The fluctuating perceptions of VR's usefulness and ease of use, particularly noted in 2021, highlight the need for continuous innovation in user interfaces and overall user experience. Developers should focus on enhancing accessibility and providing robust support to address potential user frustrations and facilitate long-term engagement with VR technologies. Marketing professionals can leverage these insights to refine their strategies, focusing on the practicality and versatility of VR applications. During periods of decreased consumer interest, as observed in our study, emphasizing VR's diverse applications can help sustain user engagement and drive adoption.

The past decade has seen notable advancements in making VR more accessible, with a significant reduction in the price of high-quality VR devices and the simplification of setup processes. Our research confirms the positive impact of these advancements on users' intention to use VR technology. However, it also highlights the crucial role of usefulness as a consistent predictor of VR acceptance. Thus, while focusing on ease of use is vital, VR developers and designers should not overlook the importance of ensuring that VR applications are perceived as genuinely useful. Developing a "killer app" that showcases a unique and compelling use of VR could be a key driver for broader adoption and acceptance of VR in the mainstream market.

The consistent relevance of VR throughout the pandemic period signals a stable interest in immersive spatial computing technologies, presenting lucrative opportunities for investors and businesses. Strategic investments to bridge the gap between virtual and augmented realities could lead to significant advancements, contributing to a more immersive and cohesive metaverse experience.

Limitations and future directions

Our study contributes significantly to the understanding of VR adoption, yet it has limitations that need addressing in future research. A primary limitation lies in not accounting for the variability of VR devices used by participants. The type and quality of VR devices can greatly impact user experiences and perceptions. Hence, future studies should differentiate between various VR devices to provide a more nuanced understanding of VR adoption.

Second, relying on an MTurk panel sample may not fully represent the general population. MTurk samples tend to overrepresent younger individuals, potentially skewing results (Fleischer, Mead, & Huang, 2015; Huff & Tingley, 2015). Furthermore, this was a panel

study, so participants varied over time. Future research should thus employ different methods, such as a cohort panel design or more diverse sampling methods, like probability sampling, to enhance the generalizability of the findings.

Third, to explore the impact of hardware access on the intention to use VR, we examined user's VR ownership. However, other forms of access, such as borrowing a headset, may play a significant role. Future studies may wish to examine the impact of broader forms of access. Lastly, our study's focus on U.S. residents limits its global applicability. Given the diverse ways VR is used and perceived worldwide, future studies should explore VR acceptance across different cultures and geographical contexts to gain a more global perspective.

Conclusion

We find ourselves on the precipice of a potential paradigm shift in how we engage with the digital world. Our findings reveal a nuanced interplay between VR ownership, perceived utility, and ease of use, with variances across years. This shift indicates a broader evolution in user attitudes, transitioning from traditional applications of VR to envisioning it as an integral component of an immersive, three-dimensional internet experience. Our findings also highlight the need for continuous innovation and adaptation in VR technology to meet users' changing demands and expectations in the metaverse era.

Challenges and opportunities mark the journey of VR as we enter the metaverse. Our study emphasizes the critical role of perceived usefulness and ease of use in VR adoption, with usefulness emerging as the more influential factor. This insight is crucial for VR developers and stakeholders, who must focus not only on making VR accessible but also on enhancing its practical applications within the metaverse. As we enter the metaverse via spatial computing technologies, such as VR, understanding and addressing user-centric factors will be vital to ensuring the success of these technologies.

In conclusion, our research provides a valuable foundation for understanding VR's evolving role as a gateway to the metaverse. Positioned at the nexus of technological innovation and user experience, the insights gleaned from this study will be instrumental in guiding the future development and adoption of VR in the ever-expanding metaverse.

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References

AR Insider. (2020). New Report: 19% of U.S. Adults Have Tried VR. Retrieved from https://arinsider.co/2020/05/20/new-report-19-of-u-s-adults-have-tried-vr/

Ball C, Huang K-T, & Francis J (2021). Virtual reality adoption during the COVID-19 pandemic: A uses and gratifications perspective. Telematics and Informatics, 65, 101728. [PubMed: 34887619]

Bunz U, Seibert J, & Hendrickse J (2021). From TAM to AVRTS: development and validation of the attitudes toward Virtual Reality Technology Scale. Virtual Reality, 25(1), 31–41.

Castiblanco Jimenez IA, Cepeda García LC, Violante MG, Marcolin F, & Vezzetti E (2020). Commonly used external TAM variables in e-learning, agriculture, and virtual reality applications. Future Internet, 13(1), 7.

Clement J (2021). COVID-19 impact on digital games revenue 2020, by type. Retrieved from https://www.statista.com/statistics/190184/covid-19-impact-on-digital-games-revenue-type/

Davis FD (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results. Massachusetts Institute of Technology,

Davis FD (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319–340.

Davis FD, Bagozzi RP, & Warshaw PR (1989). User acceptance of computer technology: a comparison of two theoretical models. Management science, 35(8), 982–1003.

Dedehayir O, & Steinert M (2016). The hype cycle model: A review and future directions. Technological Forecasting and Social Change, 108, 28–41.

Duguay S, Dietzel C, & Myles D (2022). The year of the “virtual date”: Reimagining dating app affordances during the COVID-19 pandemic. New Media & Society, 14614448211072257.

Egliston B, & Carter M (2022). Oculus imaginaries: The promises and perils of Facebook’s virtual reality. New Media & Society, 24(1), 70–89.

Fagan M, Kilmon C, & Pandey V (2012). Exploring the adoption of a virtual reality simulation: The role of perceived ease of use, perceived usefulness, and personal innovativeness. Campus-Wide Information Systems.

Fishbein M, & Ajzen I (1977). Belief, attitude, intention, and behaviour: An introduction to theory and research.

Fleischer A, Mead AD, & Huang J (2015). Inattentive responding in MTurk and other online samples. Industrial and Organizational Psychology, 8(2), 196–202.

Goodman R, & Schulkin D (2020). Timeline of the coronavirus pandemic and US response. In: May.

Grennan D (2019). What is a Pandemic? Jama, 321(9), 910–910. [PubMed: 30835310]

Grundmeyer T (2014). Adopting Technology: Using Student Qualitative Data and Gartner’s Hype Cycle. Journal of Education and Training Studies, 2(1), 207–216.

Hayes AF (2018). Introduction to mediation, moderation, and conditional process analysis second edition: A regression-based approach.: New York, NY. In: Guilford Publications, Inc.

Huang K-T, Ball C, Cotten SR, & O'Neal L (2020). Effective experiences: A social cognitive analysis of young students' technology self-efficacy and STEM attitudes. Social Inclusion, 8(2), 213–221.

Huang K-T, Ball C, & Francis J (2023). The Perceived Impacts of COVID-19 on Users' Acceptance of Virtual Reality Hardware: A Digital Divide Perspective. American Behavioural Scientist, 00027642231156775.

Huff C, & Tingley D (2015). "Who are these people?" Evaluating the demographic characteristics and political preferences of MTurk survey respondents. Research & Politics, 2(3), 2053168015604648.

Hwang G-J, & Chien S-Y (2022). Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective. Computers and Education: Artificial Intelligence, 100082.

Jang J, Ko Y, Shin WS, & Han I (2021). Augmented reality and virtual reality for learning: An examination using an extended technology acceptance model. IEEE access, 9, 6798–6809.

Kim MJ, Lee C-K, & Preis MW (2020). The impact of innovation and gratification on authentic experience, subjective well-being, and behavioural intention in tourism virtual reality: The moderating role of technology readiness. Telematics and Informatics, 49, 101349.

Korucu AT, & Bicer H (2018). Investigation of post-graduate Students' attitudes towards Mobile learning and opinions on mobile learning. International Technology and Education Journal, 2(1), 21–34.

Lee J, Kim J, & Choi JY (2019). The adoption of virtual reality devices: The technology acceptance model integrating enjoyment, social interaction, and strength of the social ties. Telematics and Informatics, 39, 37–48.

Lin C (2022). If the metaverse is the future of social media, teens aren't convinced. Retrieved from https://www.fastcompany.com/90740073/if-the-metaverse-is-the-future-of-social-media-teens-arent-convinced

Luse A, Mennecke B, & Triplett J (2013). The changing nature of user attitudes toward virtual world technology: A longitudinal study. Computers in Human Behavior, 29(3), 1122–1132.

Manis KT, & Choi D (2019). The virtual reality hardware acceptance model (VR-HAM): Extending and individuating the technology acceptance model (TAM) for virtual reality hardware. Journal of Business Research, 100, 503–513.

Meta. (2014). Facebook to Acquire Oculus. Retrieved from https://about.fb.com/news/2014/03/facebook-to-acquire-oculus/

Meta. (2021). Introducing Meta: A Social Technology Company. Retrieved from https://about.fb.com/news/2021/10/facebook-company-is-now-meta/

Miller JD, Crowe M, Weiss B, Maples-Keller JL, & Lynam DR (2017). Using online, crowdsourcing platforms for data collection in personality disorder research: The example of Amazon's Mechanical Turk. Personality Disorders: Theory, Research, and Treatment, 8(1), 26.

Monaco-Vavrik. (2022). Video Game Sales Set to Fall This Year After Pandemic Boom, Predicts Ampere Analysis. Retrieved from https://www.cnet.com/tech/gaming/video-game-sales-set-to-fall-this-year-after-pandemic-boom-predicts-ampere-analysis/

Moss AJ, Rosenzweig C, Robinson J, & Litman L (2020). Is it Ethical to Use Mechanical Turk for Behavioural Research? Relevant Data from a Representative Survey of MTurk Participants and Wages.

Our World in Data. (2022). Coronavirus (COVID-19) Vaccinations. Retrieved from https://ourworldindata.org/covid-vaccinations

Paolacci G, & Chandler J (2014). Inside the Turk: Understanding Mechanical Turk as a participant pool. Current Directions in Psychological Science, 23(3), 184–188.

Petrov C (2021, March 18, 2021). 43 Virtual Reality Statistics That Will Rock the Market in 2020. Retrieved from https://techjury.net/blog/virtual-reality-statistics/#gref

Prinsloo T, & Van Deventer JP (2017). Using the Gartner Hype Cycle to evaluate the adoption of emerging technology trends in higher education–2013 to 2016. Paper presented at the Emerging Technologies for Education: Second International Symposium, SETE 2017, Held in Conjunction with ICWL 2017, Cape Town, South Africa, September 20–22, 2017, Revised Selected Papers 2.

Ross J, Irani L, Silberman MS, Zaldivar A, & Tomlinson B (2010). Who are the crowdworkers? Shifting demographics in Mechanical Turk. In CHI'10 extended abstracts on Human factors in computing systems (pp. 2863–2872).

Sagnier C, Loup-Escande E, Lourdeaux D, Thouvenin I, & Valléry G (2020). User acceptance of virtual reality: an extended technology acceptance model. International Journal of Human–Computer Interaction, 36(11), 993–1007.

Tull MT, Edmonds KA, Scamaldo K, Richmond JR, Rose JP, & Gratz KL (2020). Psychological Outcomes Associated with Stay-at-Home Orders and the Perceived Impact of COVID-19 on Daily Life. Psychiatry research, 113098. [PubMed: 32434092]

Van Deursen AJ, & Van Dijk JA (2019). The first-level digital divide shifts from inequalities in physical access to inequalities in material access. new media & society, 21(2), 354–375. [PubMed: 30886536]

Vardomatski S (2021). Augmented And Virtual Reality After Covid-19. Retrieved from https://www.forbes.com/sites/forbestechcouncil/2021/09/14/augmented-and-virtual-reality-after-covid-19/?sh=79161f302d97

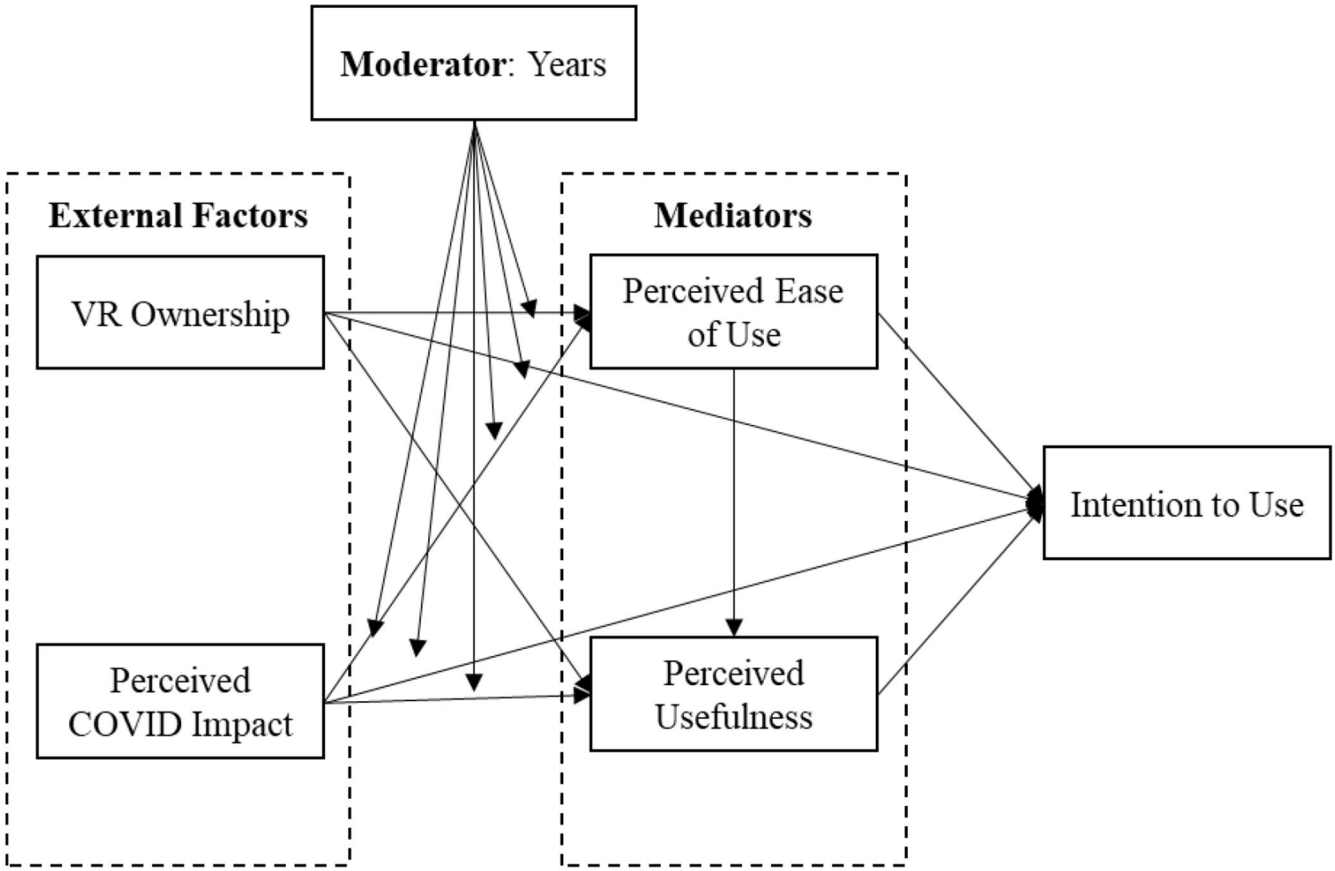

Figure 1.
Proposed conceptual model

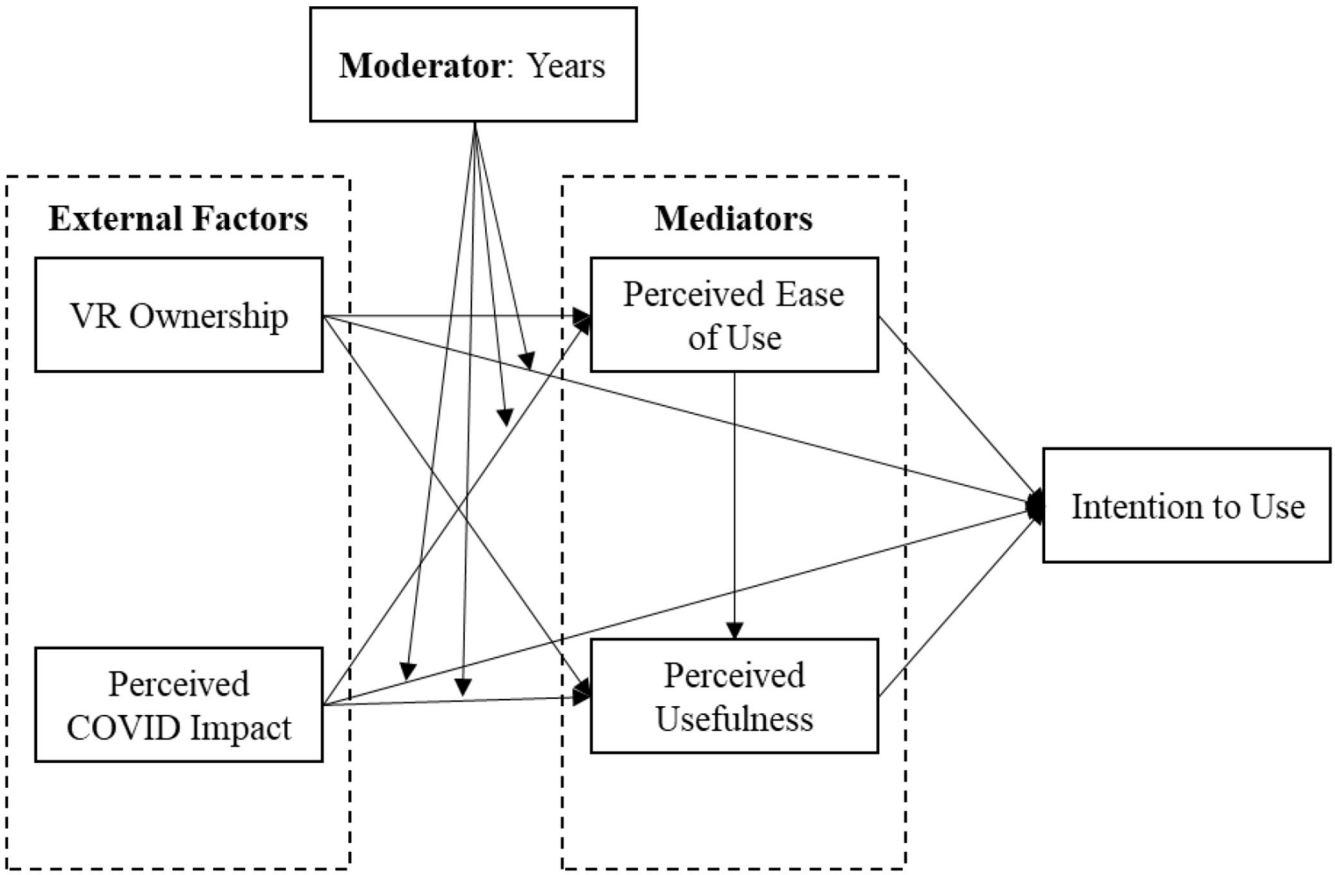

Figure 2.
Revised conceptual model

Table 1.

The demographic characteristics of the participants (N=902)

Variable	Categories	Number of Participants (%)
Year of Data Collected	2020	312 (33.6%)
	2021	303 (32.7%)
	2022	313 (33.7%)
Sex	Male	556 (61.6%)
	Female	344 (38.1%)
	Non-Binary/Third Gender	2 (0.2%)
Age	18-24	65 (7.2%)
	25-34	465 (51.6%)
	35-44	208 (23.1%)
	45-54	108 (12.0%)
	55-64	42 (4.7%)
	65 and above	14 (1.6%)
Household Income	Less than $10,000	41 (4.6%)
	$10,000-$19,999	63 (7.0%)
	$20,000-$29,999	88 (9.8%)
	$30,000-$39,999	93 (10.3%)
	$40,000-$49,999	146 (16.2%)
	$50,000-$59,999	162 (18.0%)
	$60,000-$69,999	74 (8.2%)
	$70,000-$79,999	82 (9.1%)
	$80,000-$89,999	53 (5.9%)
	$90,000-$99,999	49 (5.4%)
	$100,000-$149,999	41 (4.6%)
	More than $150,000	9 (1.0%)
Education Level	Less than high school	2 (0.2%)
	High school graduate	27 (3.0%)
	Some college	53 (5.9%)
	2-year degree	28 (3.1%)
	4-year degree	617 (68.9%)
	Master’s degree	161 (18.0%)
	Doctorate	8 (0.9%)
Race/Ethnicity	White	621 (69.2%)
	Black/African American	107 (11.9%)
	American Indian or Alaska Native	16 (1.8%)
	Asian	135 (15.0%)
	Others	19 (2.1%)

Variable	Categories	Number of Participants (%)
VR Hardware Ownership	No	234 (25.9%)
	Yes	668 (74.1%)
Types of VR Hardware (Check all that apply)	Google Cardboard	178 (19.7%)
	Samsung Gear VR	462 (51.2%)
	Oculus Go	55 (6.1%)
	Oculus Rift(s)	57 (6.3%)
	Oculus Quest	78 (8.6%)
	HTC Vive	53 (5.9%)
	PlayStation VR	132 (14.6%)
	Valve Index	38 (4.2%)

Table 2.

Means and standard deviations of the variables of interest

Construct (Numbers of Items; Cronbach's α)	Response Categories	Mean (Standard Deviation)
Perceived Impacts of COVID-19 (0.853)	1= None	3.79 (1.32)
Health Anxiety	2= A little	3.68 (1.50)
Financial Worry	3= A moderate amount	3.86 (1.60)
Lack of Social Support	4 = A lot	3.81 (1.56)
Loneliness	5= A great deal	3.79 (1.68)
Perceived Usefulness (PU) (4 items; 0.876)	From 1 to 7	5.47 (1.07)
Example Item: Using VR hardware would be useful in my life.	1= Strongly disagree 7=Strongly agree	
Perceived Ease of Use (PEOU)(4 items; 0.839)	From 1 to 7	5.61 (0.89)
Example Item: I believe using VR hardware would be easy for me.	1= Strongly disagree 7=Strongly agree	
Intention to Use (ITU)(4 items; 0.857)	From 1 to 7	5.43 (1.10)
Example Item: I will use VR hardware within the foreseeable future.	1= Strongly disagree 7=Strongly agree	

Table 3.

OLS regression analysis of technology acceptance variables regressed on perceived impact of COVID-19 and demographics

	Model 1		Model 2		Model 3		Model 4	
Dependent Variables	**Ease of Use**		**Usefulness**		**Use Intention**		**Use Intention**	
Sex (1=male, 0 = female)	.02		−.01		.01		.01	
Age	.01		−.03		.01		.02	
Race (1= white, 0=non-white)	.01		−.04		.00		−.02	
Household Income	.07	*	−.02		.07	*	.03	
Education Level	.00		.08	**	.08	*	.04	
VR ownership	.03		.12	***	.16	***	.07	***
COVID-19	.26	***	.15	***	.33	***	.07	***
Ease of Use			.65	***			.28	***
Usefulness							.59	***
F	10.39	***	126.78	***			291.92	***
Adjusted R^2	.07		.53				.75	

Table 4.

Conditional direct and indirect effects of VR ownership on TAM variables

Conditional Effect of VR Ownership on Perceived Ease of Use (PEOU)					
		Effect	**Se**	**T**	**p**
VR ownership ➔	PEOU				
	Year 2020	N/A			
	Year 2021	N/A			
	Year 2022	N/A			
Conditional Effect of VR Ownership on Perceived Usefulness (PU)					
		Effect	**Se**	**T**	**p**
VR ownership ➔	PU				
	Year 2020	**.2863**	**.0929**	**3.0810**	**.002*** **
	Year 2021	−.1664	.1060	−1.5700	.117
	Year 2022	**.3721**	**.1006**	**3.6989**	**.000*** **
Conditional Effect of VR Ownership on Intention to Use (ITU)					
		Effect	**Se**	**T**	**p**
VR ownership ➔	ITU				
	Year 2020	.1190	.0711	1.6742	.094
	Year 2021	**−.3546**	**.0807**	**−4.3913**	**.000*** **
	Year 2022	.0730	.0771	.9458	.345
Conditional Indirect Effect of VR Ownership on Intention to Use (ITU)					
		Effect	**BootSE**	**BootLLCI**	**BootULCI**
VR ownership ➔	PEOU ➔ ITU				
	Year 2020	.0287	.0405	−.0462	.1122
	Year 2021	−.0677	.0610	−.1976	.0421
	Year 2022	−.0532	.0460	−.1452	.0370
		Index	**BootSE**	**BootLLCI**	**BootULCI**
	Year 2021	−.0965	.0750	−.2570	.0396
	Year 2022	−.0819	.0627	−.2143	.0364
		Effect	**BootSE**	**BootLLCI**	**BootULCI**
VR ownership ➔	PU ➔ ITU				
	Year 2020	**.1755**	**.0818**	**.0305**	**.3518**
	Year 2021	−.1020	.0821	−.2693	.0536
	Year 2022	**.2281**	**.0881**	**.0670**	**.4114**
		Index	**BootSE**	**BootLLCI**	**BootULCI**
	Year 2021	−.2774	.1197	−.5256	−.0586
	Year 2022	.0526	.1166	.1755	.2895
		Effect	**BootSE**	**BootLLCI**	**BootULCI**
VR ownership ➔	PEOU ➔ PU ➔ ITU				
	Year 2020	.0396	.0543	−.0629	.1495

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Conditional Effect of VR Ownership on Perceived Ease of Use (PEOU)					
		Effect	**Se**	**T**	**p**
	Year 2021	−.0933	.0790	−.2452	.0602
	Year 2022	−.0733	.0611	−.1927	.0495
		Index	**BootSE**	**BootLLCI**	**BootULCI**
	Year 2021	−.1329	.0966	−.3243	.0560
	Year 2022	−.1129	.0832	−.2807	.0520

Table 5.

Conditional direct and indirect effects of COVID-19 on TAM variables

Conditional Effect of COVID-19 on Perceived Ease of Use (PEOU)					
		Effect	**Se**	**t**	**p**
COVID-19 ➔	PEOU				
	Year 2020	N/A			
	Year 2021	N/A			
	Year 2022	N/A			
Conditional Effect of COVID-19 on Perceived Usefulness (PU)					
		Effect	**Se**	**t**	**p**
COVID-19 ➔	PU				
	Year 2020	**.1937**	**.0524**	**3.6946**	**.000*** **
	Year 2021	**.0958**	**.0289**	**3.3141**	**.000*** **
	Year 2022	**.3140**	**.0475**	**6.6087**	**.000*** **
Conditional Effect of COVID-19 on Intention to Use (ITU)					
		Effect	**Se**	**t**	**p**
COVID-19 ➔	ITU				
	Year 2020	.0170	.0405	.4184	.676
	Year 2021	**.1132**	**.0223**	**5.0713**	**.000*** **
	Year 2022	.0237	.0374	.6336	.527
Conditional Indirect Effect of COVID-19 on Intention to Use (ITU)					
		Effect	**BootSE**	**BootLLCI**	**BootULCI**
COVID-19 ➔	PEOU ➔ ITU				
	Year 2020	**.1021**	**.0251**	**.0579**	**.1556**
	Year 2021	**.0752**	**.0192**	**.0429**	**.1173**
	Year 2022	**.0654**	**.0243**	**.0234**	**.1194**
		Index	**BootSE**	**BootLLCI**	**BootULCI**
	Year 2021	−.0270	.0255	−.0786	.0233
	Year 2022	−.0367	.0305	−.0988	.0227
		Effect	**BootSE**	**BootLLCI**	**BootULCI**
COVID-19 ➔	PU ➔ ITU				
	Year 2020	**.1197**	**.0428**	**.0392**	**.2037**
	Year 2021	**.0592**	**.0238**	**.0161**	**.1094**
	Year 2022	**.1941**	**.0525**	**.0995**	**.3046**
		Index	**BootSE**	**BootLLCI**	**BootULCI**
	Year 2021	−.0605	.046	−.1501	.0313
	Year 2022	.0744	.0636	−.0452	.2056
		Effect	**BootSE**	**BootLLCI**	**BootULCI**
COVID-19 ➔	PEOU ➔ PU ➔ ITU				

Conditional Effect of COVID-19 on Perceived Ease of Use (PEOU)					
		Effect	**Se**	**t**	**p**
	Year 2020	**.1413**	**.0308**	**.0825**	**.2045**
	Year 2021	**.1040**	**.0223**	**.0627**	**.1492**
	Year 2022	**.0905**	**.0320**	**.0334**	**.1577**
		Index	**BootSE**	**BootLLCI**	**BootULCI**
	Year 2021	−.0373	.0348	−.1054	.0314
	Year 2022	−.0508	.0411	−.1292	.0309

Table 6.

Findings of hypotheses and research questions

Hs/RQs	Description	Findings
H1a	VR Ownership to PEOU	Not supported
H1b	VR Ownership to PU	Supported
H1c	VR Ownership to ITU	Supported
H2a	COVID-19 to PEOU	Supported
H2b	COVID-19 to PU	Supported
H2c	COVID-19 to ITU	Supported
H3	PEOU to PU	Supported
H4a	PEOU to ITU	Supported
H4b	PU to ITU	Supported
H5	Indirect effect of VR Ownership on ITU via PEOU and PU	Supported
H6	Indirect effect of COVID-19 on ITU via PEOU and PU	Supported
RQ1	Moderation by Year on VR Ownership's direct and indirect effect on TAM variables	Yes, notably different in 2021
RQ2	Moderation by Year on Perceived COVID-19's direct and indirect impact on TAM variables	Yes, strongest in 2020 & 2022 for PU and ITU