Immersion, Presence, Interactivity: Towards a Joint Understanding of Factors Influencing Virtual Reality Acceptance and Use

Full Paper

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Abstract

Virtual Reality (VR) has started to diffuse into the market. Research can accompany this process by providing insights into adoption of the technology. However, although first studies have been conducted early, there are few empirical findings shedding light on issues of acceptance and use of VR. This is because the used models often suffer from omissions or only partially cover important variables for distinct characteristics of the technology, especially immersion, presence, and interactivity. Additionally, the applied variables are occasionally incorrectly specified. To lay a better foundation for investigating adoption and diffusion of VR, we explore relevant influence factors based on insights from previous works and a qualitative study with 20 participants. Besides issues of misspecification, our findings show that many contextual factors have been neglected. Moreover, we identify content quality, initial excitement, isolation, and distraction as new potentially relevant factors.

Keywords

Virtual reality, technology acceptance and use, influencing factors, nomological network.

Introduction

In recent years, virtual reality (VR) technology has matured, enabling novel private and corporate use scenarios. On the one hand, these encompass individual entertainment experiences similar to films and games with a hedonic use motivation. On the other hand, there are innovative offers for virtual collaboration with hedonic and utilitarian motivations. Virtual collaboration refers to processes utilizing virtual channels "in which two or more agents (individuals or organizations) share resources and skills to solve problems so that they can jointly achieve one or more goals" (Boughzala and de Vreede 2015, p. 133). Entertainment, collaboration, and communities in consumer and professional contexts have become promising application areas for VR, as demonstrated by multi-billion dollar investments by Facebook and a broad range of VR meeting software.

As it is unclear whether VR will accomplish to successfully diffuse into the market, these developments lead to questions regarding acceptance and use of VR by consumers and professionals. Acceptance and use is a mature area of IS research (Venkatesh et al. 2016). Because of this, there is a solid foundation of research on hedonic information systems, such as films (van der Heijden 2004) as well as on forms of professional collaboration, such as virtual teams (Lipnak and Stamps 1999). However, these works mostly focus on cases with traditional underlying technologies, such as TVs and computers. VR has defining characteristics that raise the question whether insights from previous acceptance and use research can be transferred easily. Three of these characteristics are *immersion*, *presence*, and *interactivity*, all said to potentially reach higher levels in VR than in any other kind of information system (Ryan 2015, Walsh and Pawlowski 2002). *Immersion* describes "a psychological state characterized by perceiving oneself to be enveloped by [...] an environment that provides a continuous stream of stimuli and experiences" (Witmer and Singer 1988, p. 227). *Presence* relates to "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer and Singer 1998, p. 225).

Interactivity "refers to the degree to which users of a medium can influence the form or content of the mediated environment" (Steuer 1992, p. 80).

Although the specific issues of acceptance and use of VR have been addressed early (da Costa and de Carvalho 2004) and these works could offer interesting insights into adoption and diffusion processes of the technology, research focusing on VR is limited and provides mixed results. This is because the applied models are frequently not adapted to the technology's characteristics (Bertrand and Bouchard 2008, Chen et al. 2012) and, if they are adapted, sometimes do not specify factors appropriately (Grabowski and Jankowski 2015). Even if appropriate constructs are used, the criteria for their selection are often not clear. This leads to a relatively high number of models that consider immersion and presence in some way, while a focus on interactivity is rare (e.g., Bailenson et al. 2008). In addition, there might be other relevant factors that have not yet been identified.

The implications of incorrect specifications of empirical models can be serious, e.g., low explanatory power, missing control variables, and omitted variable bias (Lee 1982). In addition, the variance in models makes it difficult to compare findings to shed light onto adoption and diffusion processes of the technology. This underlines that IS needs to understand influence factors on VR acceptance and usage better to build models that are appropriate to investigate the technology. One of the basic instruments for doing so is to list the constructs of a nomological network for the issue at hand (Cronbach and Meehl 1955), as has already been done with other technologies, such as cloud computing (Low et al. 2011). To provide an overview on important factors in VR research, we aim at creating such a list for VR acceptance and use. Thus, our research question is: Which factors are relevant for VR acceptance and use models?

To answer this research question, we first provide a short overview on models of technology acceptance and use, before we summarize the factors used in previous research on VR acceptance and use. In order to provide a concise summary, this literature review focuses on empirical works that investigate VR, not on works analyzing traditional technologies (e.g., Nah et al. 2011). Second, we describe our method to deepen and broaden findings from literature with 20 semi-structured interviews. Third, we explain our results on the basis of a list of relevant factors and discuss implications and limitations of our study. Fourth, we conclude with a short summary.

Our paper contributes to theory by providing a solid foundation to develop better and more appropriate models for VR acceptance and use research, thus increasing the quality and explanatory power of future empirical works. Most identified factors can be applied on the level of the individual and also in the contexts of collaboration and communities, others need to be adapted to the context. Models built on this foundation allow the comparison of results over time, which might lead to a better understanding of the adoption and diffusion processes of the technology. As shown in research on training, developments in VR seem to have changed its potential from no training effects in its early days (Kozak et al. 1993) to positive effects similar to real world training nowadays (Ganier et al. 2014). With a joint understanding of appropriately specified models, research could investigate which technology and content changes have supported the adoption and diffusion of VR besides actions by individuals during adoption (Jeyaraj and Sabherwal 2008). Regarding contributions for practice, firms can use our list of factors to identify relevant features in creating holistically appealing novel technology and content offers.

Theoretical Foundations

Models of Technology Acceptance and Use

Investigating consumers' acceptance and use of technology is a mature stream of IS research. One of the most influential acceptance models is the technology acceptance model (TAM; Davis et al. 1989), which stems from utilitarian acceptance contexts. Over time, it has been enhanced with other theories to a unified theory of acceptance and use (UTAUT; Venkatesh et al. 2003), then adapted to match hedonic contexts (UTAUT2; Venkatesh et al. 2012), and, most recently, expanded to a multi-level framework of acceptance and use (Venkatesh et al. 2016; see Figure 1).

This framework covers insights from previous technology acceptance models in its baseline model (BM). New conceptions of acceptance and use lead to new outcome phenomena, which is omitted from Figure 1 due to missing relevance for the line of argument of this paper. In addition, the framework highlights the importance of individual- and higher-level (IC and HC) contextual factors that influence the intention to accept and use a technology. Research has also applied other models to analyze acceptance and use, stemming, e.g., from the theory of planned behavior (Ajzen 1991) or expectation-confirmation theory (Bhattacherjee 2001). However, as the multi-level framework of acceptance and use is based on models that have also synthesized many of these theories, it is the most comprehensive and therefore the most suitable for our research. We use this framework to systematically analyze and categorize research on VR acceptance and use. The meaning of its important factors is clarified in the course of this paper. For future research, the framework serves as a foundation to design models and include the influence factors we identify from literature and interviews (see Table 1 and 2) appropriately.

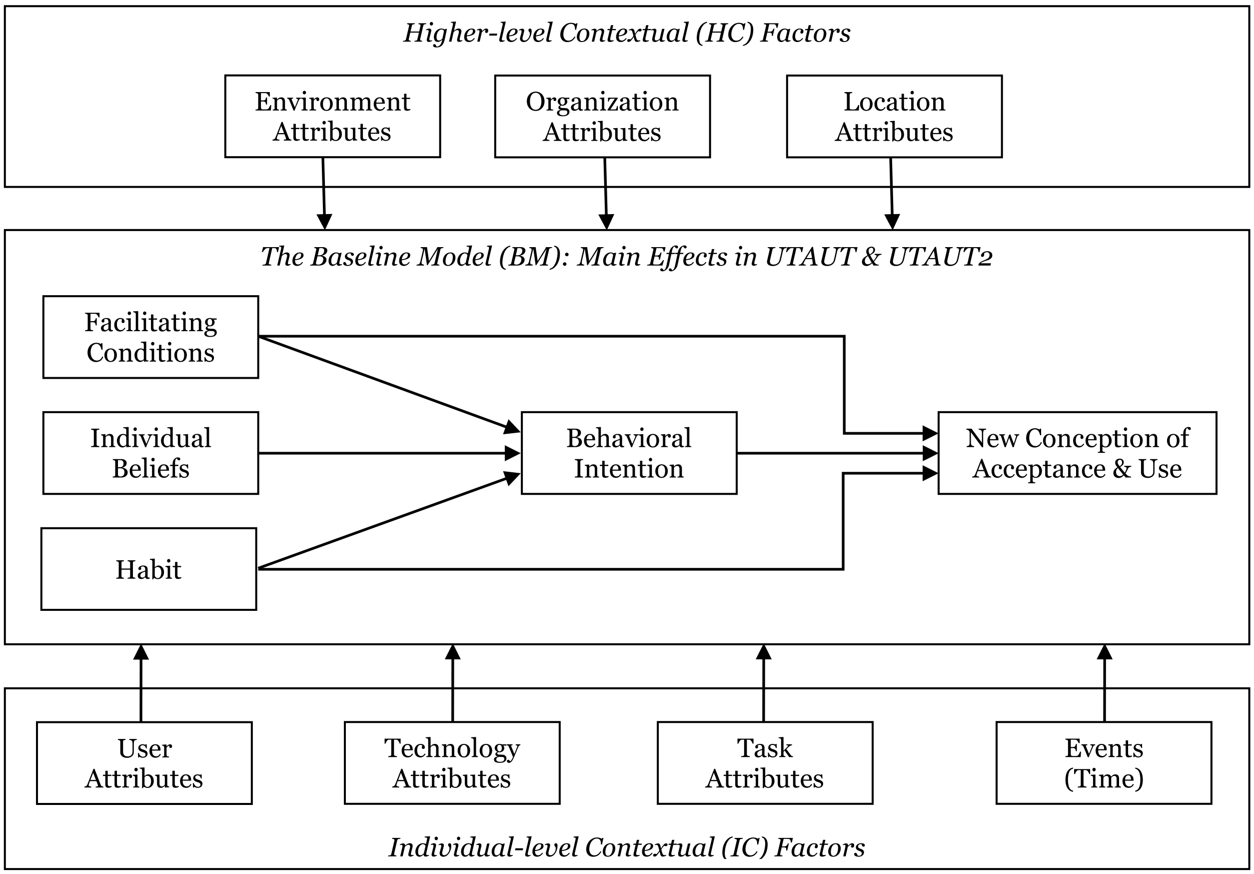

Figure 1. Multi-level Framework of Technology Acceptance and Use (adapted from Venkatesh et al. 2016)

Acceptance and Use of VR

VR is defined as "the sum of the hardware and software systems that seek to perfect an all-inclusive, immersive, sensory illusion of being present in another environment" (Biocca and Delaney 1995, p. 63). Although it has recently been named one of the emerging technologies with the largest impact for organizations coping with digital innovations (Gartner 2016), it is far from being new. The 1990s saw a similar VR trend with statements on the maturity of the technology (Walsh and Pawlowski 2002) but ultimately the technology was not ready for the mass market. This seems to have changed, as sales figures accumulate to many million devices sold worldwide in 2016 alone (SuperData and Unity 2017).

Although there is a large body of research on virtual environments and virtual worlds (e.g., Fetscherin and Lattermann 2009), the classic technology acceptance and use models mostly employed are not readily applicable to a VR context. One of the reasons for this is VR's large potential for immersion, presence, and interactivity (Ryan 2015, Walsh and Pawlowski 2002). These do not occur while using other information systems or, if they do, often to a far lesser extent. Therefore, they should be included in models of VR acceptance and use. However, these and other phenomena have been assessed inconsistently and sometimes incorrectly, as the following literature review shows.

We identified relevant articles searching for “virtual reality” and “VR” in Web of Science, Google Scholar, and the AIS online library. Only articles published in scientific journals or proceedings of scientific conferences were considered. To find influence factors relevant for acceptance and use, we then looked in detail at articles that conduct empirical research on VR (e.g., Kober & Neuper 2013) or describe empirical phenomena (e.g., LaViola Jr. 2000), but excluded works from design science (e.g., Galambos et al. 2015) and articles that focus solely on specific medical issues such as fear of heights (e.g., Rothbaum et al. 1995). Using the multi-level framework of technology acceptance and use (Venkatesh et al. 2016) as a foundation, influence factors from previous research can be structured as follows.

The BM is often covered. Several articles draw on TAM and its successors (Bertrand and Bouchard 2008, Chen et al. 2012, Fagan et al. 2012, Huang et al. 2016). However, insights are limited, as important factors, such as facilitating conditions and habit, are not considered. In other cases, the selection or specification of constructs raises doubts whether an issue is correctly measured (da Costa and de Carvalho 2004, Garcia-Palacios et al. 2007, Grabowski and Jankowski 2015). Selection and specification issues become especially apparent when it comes to individual beliefs, where most factors included in VR research relate to. Standard factors, such as perceived usefulness and perceived ease of use (Davis et al. 1989) or their successors (Venkatesh et al. 2003) are mostly specified appropriately. But VR-specific factors, usually included as new endogenous or exogenous mechanisms, i.e. mechanisms explaining behavioral intention or preceding variables (Venkatesh et al. 2016), show inconsistencies.

In the case of immersion and presence this is because both concepts are closely related. Presence is regularly included in empirical research (e.g., Nah et al. 2011, Suh and Lee 2005). It can be further divided in presence and telepresence. In the case of the latter, some form of medium is used to reach a state of presence (Steuer 1992). One strand of research claims that both immersion and presence have to be measured as individual beliefs (Witmer and Singer 1988), while another states that immersion can be assessed objectively as a technology attribute and only presence as an individual belief (Slater and Wilbur 1998). As a result, many different measures for immersion and presence exist. Perceived immersion is similar to some dimensions of flow, i.e. “a state of optimal experience where one is completely absorbed and immersed in an activity” (Nah et al. 2014, p. 85). Flow is frequently applied in VR (Nah et al. 2011) and non-VR contexts (e.g., Bilgihan et al. 2015) and suitable to assess perceived immersion when it is specified as a multi-dimensional construct. Presence measurements have already been shown to provide heterogeneous results in a VR context, depending on the personality of the user (Kober & Neuper 2013). Overall, this demonstrates that research focusing on presence, immersion, or flow in VR needs to select measures much more carefully to cover these factors appropriately.

The influence of interactivity has been investigated to a lesser extent (Bailenson et al. 2008, Roussou 2004, Wender et al. 2009, Vogel et al. 2006), but issues regarding measurement are similar. As research on interactivity shows, its influence has to be measured by considering different dimensions (Shin et al. 2013). While these apply quite well to interactivity with virtual representations of real persons in collaborations, they become problematic when users are placed in low-interactivity virtual environments, for example film-like VR experiences such as “Allumette” (2016). Here, users determine perspectives on scenes by moving in their real environment, but at the same time watch a story they cannot influence. Interactivity constructs usually do not match this context. In collaboration research related to VR, interactivity has been suggested to influence different outcomes (Briggs et al. 1997, Churchill and Snowdon 1998), but empirical evidence is scarce. In either context, measures of interactivity have to be argued and selected more carefully than they have been previously (McMillan and Hwang 2002).

In the very limited work on collaborations in VR, trust has played an important role (Jacques et al. 2009). More general factors that have been identified as important for VR acceptance and use include cybersickness, i.e. decreasing wellbeing induced by VR (LaViola Jr. 2000, Tyndiuk et al. 2007), and different personality traits, such as innovativeness (Jacques et al. 2009, Kober and Neuper 2013). Both can have strong effects on user perception of VR and at least need to be controlled for (Kiryu and So 2007), but this is rarely done. The same is true for IC factors such as demographics and technology attributes, e.g., screen resolution, field of view, and lag. Although mentioned occasionally (e.g., LaViola Jr. 2000), they are rarely included in models. Finally, although relevant especially for professional settings, HC factors are also almost non-existent in research on VR. Table 1 summarizes the results from this literature review. Beyond the selection and specification issues mentioned above, this summary shows that research on VR focuses heavily on individual beliefs, but other areas are considered rarely or never.

Factor	**Description/Definition**	**Category**
Perceived ease of use, etc.	Established general factors influencing technology acceptance and use	BM: Individual beliefs
Immersion	"Psychological state characterized by perceiving oneself to be enveloped by [...] an environment that provides a continuous stream of stimuli and experiences" (Witmer and Singer 1988, p. 227)	BM: Individual beliefs
Flow	"State of optimal experience where one is completely absorbed and immersed in an activity" (Nah et al. 2014, p. 85)	BM: Individual beliefs
Presence	"Subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer and Singer 1998, p. 225)	BM: Individual beliefs
Interactivity	"Degree to which users of a medium can influence the form or content of the mediated environment" (Steuer 1992, p. 80)	BM: Individual beliefs
Cybersickness	Decreasing wellbeing induced by VR (e.g., LaViola Jr. 2000)	BM: Individual beliefs
Trust	"Trust is based on the expectation that others will behave as expected" (Jarvenpaa et al. 1998)	BM: Individual beliefs
Personality traits	Habitual patterns of behavior, thought, and emotion that influence behavior (Kassin 2003)	IC: User attributes
Age, etc.	Demographics (e.g., LaViola Jr. 2000)	IC: User attributes
Lag, etc.	Technology attributes (e.g., LaViola Jr. 2000)	IC: Technology attributes

Table 1. Influence Factors Identified in Literature

Overall, on an aggregate level, previous research on acceptance and use of VR takes relevant specifics of the technology into account, but individual models lack systematic analysis. Furthermore, Table 1 highlights only those factors that have already been identified. There might be other factors in need of consideration that have not yet come to light. To provide a better foundation for future models of VR acceptance and use, we explore these empirically.

Method

When a topic is understood only partially, but should be explored in more depth and width, qualitative methods are appropriate (Patton 1990). Therefore, we decided to conduct semi-structured interviews that allow us to validate previous findings, but also leave room to identify gaps. In total, we interviewed 20 participants. These were chosen to create a sample that is heterogenous and roughly representative of the main target audience of VR. Accordingly, the gender distribution was 50% male, 50% female. Participants were predominantly 20-30 years old (17 persons), 2 were aged 30-40 years, and 1 participant above 50 years. Previous experience with VR was mixed with 9 persons having no experience, 4 persons having tested VR once or at a few occasions, and 7 persons using VR repeated or frequently. Our sample is composed in such a heterogeneous way to allow us to explore VR acceptance and use factors covering many different effects.

Each participant was interviewed individually in rooms without other sources of distraction. Before an interview, the participant tested three different VR experiences: a documentary, a film, and a gaming content. Each item was between three to five minutes in length, accumulating to a total testing time of roughly ten minutes. As a technological foundation, we used the Samsung Gear VR with a Samsung Galaxy S6 smartphone. We then conducted the actual interviews using our guideline and recorded each interview on tape. Our guideline included mostly questions on the user's experience. These were deducted from insights provided by previous theory, e.g., the question "While using the VR content, did you feel like the virtual environment was more present compared to the real world?" refers to telepresence (Animesh et al. 2011). The average interview had a duration of 13:12 minutes, with the shortest interview being 07:36 minutes and the longest interview being 21:12 minutes.

For data analysis, we transcribed each interview. Two researchers then coded all interviews independently from each other regarding influence factors found and compared results. Third, in cases where opinions of the two researchers differed, a third researcher was consulted who decided on the final coding. We then mapped the found factors similar to a thematic analysis (Braun & Clarke 2006) using the multi-level framework of acceptance and use (Venkatesh et al. 2016) as a foundation. Overall, this procedure and its documentation is in accordance with recommendations from general research on qualitative methods (Mayring 2014, Patton 1990) as well as from IS research (Dubé and Paré 2003, Paré 2004).

Results and Discussion

A selection of results is provided in Table 2. The selection followed the rule of quality over quantity. This means that we included a factor in the table when only one interviewee expressed feeling its influence, but feeling the influence strongly. When several interviewees named a factor, but all of them indicated negligible influence, we omitted it. Our procedure to analyze data according to this rule was similar to the coding of factors as described above.

Factor	**Exemplary Quote**	**Category**
Perceived ease of use, etc.	"It was easy. [...] Well, if it's too complicated I wouldn't use it." / "I would not spend a lot of money on buying it. [...] It depends on how much the price is." / etc.	BM: Individual beliefs
Enjoyment	"It was fun."	BM: Individual beliefs
Immersion	"I liked the immersive game, because I was in the central camera point of the game. That was amazing."	BM: Individual beliefs
Presence	"You can look around and you feel like you're in the actual place."	BM: Individual beliefs
Interactivity	"I liked the game because it was very immersive and you were able to interact with the scenery somehow."	BM: Individual beliefs
Cybersickness	"Whenever you take off the glasses everything gets very bright and you maybe feel a little bit dizzy."	BM: Individual beliefs
Personality traits	"I wanted to try this new thing and it was really interesting."	IC: User attributes
Lag, etc.	"I think the resolution is not very good. You can see the pixels. I think after a while it gets a bit annoying [...] I think I would definitely use it if the quality was better." / "The glasses are too heavy. I couldn't relax."	IC: Technology attributes
Content quality	"When it's like in the last video where you have just people talking – I don't see that VR is necessary there."	IC: Technology attributes
Initial excitement	"I think another thing is that I've tried VR for the first time and it was [...] exciting for me."	IC: Events (time)
Isolation	"You can't see what's happening around you and therefore I felt isolated."	HC: Environment attributes
Distraction	"I could not concentrate because I was afraid somebody would tickle me." / "I was afraid of falling off the chair."	HC: Environment attributes

Table 2. Influence Factors Identified in Interviews

Regarding individual beliefs, we could identify most factors from previous research. Differences were marginal. First, participants placed considerable emphasis on enjoyment, which has drawn little explicit attention in VR literature, but has been dealt with implicitly in other constructs such as flow. In addition, UTAUT2 covers this aspect in its hedonic motivation construct. Second, we found no statement of flow. This is due to a limitation of our study: Because we used three short types of content and had to interrupt participants while testing to explain how to switch content, reaching a state of flow was difficult. Nevertheless, immersion as a dimension of flow was mentioned frequently. Third, we did not find statements on trust, which can be explained with the missing experience of our interviewees regarding collaborative VR contents. Thus, overall, individual beliefs identified in literature could be confirmed.

The same can be said for user and hardware technology attributes. We could not identify effects of demographics, but this could be due to sample size. Nevertheless, evidence on their moderating effects from other contexts is strong (Venkatesh et al. 2012). In addition, our findings confirm the effects of personality traits and technological limitations found in literature.

New relevant factors from our empirical study refer to software technology attributes, event (time), and environment attributes. These have not been taken into account previously. Participants mentioned that not only the hardware's attributes, but also the quality of content influences their perception (labeled "content quality"). Furthermore, there seems to be a strong effect of the state of a user's adoption process, i.e. whether s/he tests VR for the first time or has been using VR for some time already. Our findings indicate that the more advanced the adoption process, the less easy a user can be surprised and impressed ("initial excitement") with a VR experience. Finally, while acceptance and use might benefit from being present and immersed in another environment, some participants are clearly restricted by their connection to the real environment. When many people are in the same real room, but only one of them is experiencing VR, s/he might either feel isolated from others and reality ("isolation") or distracted from the experience ("distraction"). Additionally, the design of the real environment can be highly relevant in a sense that furniture and other objects do not disappear when a VR user begins to leave reality. This might also lead to distraction. Settings of many people in one room, but only one or a few using VR are presumably quite common in VR studies. The influence of objects surrounding a user presumably increases the more interactivity a VR content offers, e.g., in room scale VR experiences. Thus, VR acceptance and use models should consider controlling for the influence of environment attributes.

Influence factors that have neither been identified previously nor in our study concern task attributes as an IC factor and organization and location attributes as HC factors. This does not mean that they are not relevant, but that our study is not designed to identify their influence. This is because we asked participants to conduct simple tasks, interviewed them when isolated from their formal or informal networks, and could not assess the influence of e.g., national culture (Venkatesh et al. 2016). We assume that the influence of users' networks is noticeably especially in collaborative VR settings. Additionally, task attributes might reach higher complexity there than in our study, which can also have an effect.

Overall, comparing findings from literature and our empirical study shows that on an aggregated level, research has covered individual beliefs, user attributes, and attributes of hardware rather comprehensively. However, there are several issues that have been neglected. Content quality, initial excitement, isolation, and distraction presumably have effects in many VR contexts. Task, organization, and location attributes might need to be controlled for as well. Besides specifying constructs more carefully, as called for in our literature review, future research has to consider these factors or should at least argue why they are omitted from models. Moreover, we call for further research to conduct qualitative studies to explore causality of variables and quantitative studies to show effect strength of factors identified in this paper. Finally, quantitative research is necessary which compares findings on VR acceptance and use at different stages of the adoption process, i.e. taking the effects of events (time) into account. This would help to understand processes of adoption and diffusion of VR technology better. Our overview on relevant factors enables comparisons by establishing a common foundation for such research.

For practice, our study provides several starting points to identify features of VR experiences that are important for users. Hardware and content creators can check to what extent their products cover the factors mentioned here. This would help to increase the market success of VR products as well as to identify gaps in technology development and find matching solutions. For example, issues of isolation are rarely addressed. In the long term, techniques to analyze users' real environment and integrating real objects in the virtual reality (Sra et al. 2016) could help to better cope with such issues.

Conclusion

Based on a literature review and 20 semi-structured interviews, we have identified factors that are relevant for VR acceptance and use models. Our results show that there is a clear imbalance of factors covering individual beliefs that have been applied inconsistently and sometimes even specified incorrectly in previous research. Thus, we call for more attention in identifying and specifying influence factors. The latter is of particular importance for the characteristics of immersion, presence, and interactivity. At the same time, there are gaps when it comes to covering HC factors and some IC factors. This concerns issues of content quality, initial excitement, isolation, and distraction, which have been identified as new potentially relevant VR factors in our study, as well as task, organization, and location attributes.

Including these factors in empirical research or at least controlling for them would enable research to compare results on VR acceptance and use over time. Such comparisons could lead to interesting insights into adoption and diffusion processes of VR technology and content, which would additionally need to consider actions by individuals during adoption (Jeyaraj and Sabherwal 2008). However, there is no one-size-fits-all-model. Instead, research has to take the context of VR acceptance and use into account. For individual VR entertainment experiences and VR collaborations, many factors are similarly relevant, but others might have less effect or show their effect only when specified according to the context. This affects particularly interactivity, trust, isolation, task attributes, and organization attributes.

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