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Acceptance of Virtual Reality Games:
A Multi-Theory Approach

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ABSTRACT

As virtual reality (VR) games are getting more widespread, the need to understand the interaction between players and the VR games is gaining prominence. The present study examines player endorsement of virtual reality games from an amalgamation of technology acceptance, self-determination, and flow theory perspectives. A survey was carried out with participants (N = 396) who had played a VR game at least once and at most five times. Structural equation modeling analyses showed that perceived ease of use was the primary predictor for satisfaction of self-determination constructs (autonomy and competence) and flow constructs (immersion and concentration), which in turn predicted player enjoyment. Accordingly, the results suggest the importance of including self-determination constructs in addition to the flow perspective within the context of technology acceptance model, for explaining the acceptance of VR gaming. Findings also showed that enjoyment resulted in positive attitudes towards VR gaming, and these attitudes predicted intention to play VR games.

KEYWORDS

Flow Theory, Gaming, Player Acceptance, Player Perception, Self-Determination Theory, Structural Equation Modeling, Technology Acceptance Model, Virtual Reality

INTRODUCTION

Virtual Reality (VR) is defined as "A high-end user-computer interface that involves real-time simulation and interactions through multiple sensorial channels." (Grigore and Coiffet, 1994). Providing a higher display and interaction fidelity with respect to regular devices, VR creates a heightened presence and engagement in humans, which make this technology attractive (McMahan et al., 2012; Steed et al., 2016). In general VR is identified with head mounted displays and it was found that head mounted displays are different than desktop monitors in terms of user satisfaction (Santos et al., 2009), arousal, task performance or presence (Kim et al., 2012). These differences signify the prominence of studying the use of VR in addition to the use of traditional devices. In addition to head mounted displays, olfactory stimulation is being integrated to VR systems as well

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(Feelreal, 2018). VR market is growing (Grand View Market, 2017) and with the investments of key players such as Microsoft, Sony or Nintendo, the cost of the technology will be diminishing in time making the hardware more affordable and VR technology will be reaching a broader audience (Kozlova, 2017). More people are interacting with the VR technology than ever making it important to delineate the factors associated with VR use. VR devices require software to run on them to be functional and the content provided on the software is critical for the overall VR market success (Martin, 2018). Therefore, companies provide software development kits (SDK) for developers to build their own content and contribute to the VR market (i.e. Google VR API).

Gaming is viewed as one of the main driving force for the development and adoption of VR technology in general (Sackville, 2018). Although VR technology can be used for non-leisure purposes such as training or treatment, currently users are more likely to adopt VR devices and consume VR games for leisure use such as gaming. It is reported that VR gaming market is at an increasing trend (Statista, 2016). In present day, VR games come in a variety of genres such as horror games (i.e. Edge of Nowhere), first-person shooter games (i.e. Doom) or role-playing games (i.e. Fallout 4) (Gurwin, 2018) where this variety attracts more players. In addition to personal spaces such as homes, these games are being experienced at VR gaming centers which are places where people can rent VR devices and play (Xiong, 2019; Castillo 2018). This might be another enabler for mass adoption of VR technology for society, resembling internet cafes helping the wide adoption of internet (Lee, 1999).

Hardware for VR is already with us for several decades now (O'Boyle and Willings, 2019). Nevertheless, VR game practitioners and potential investors are facing a major challenge. This challenge is referred as the "content problem" in VR domain and it is described as the scarcity of software and applications that support VR equipment (Matney, 2018). Once end users buy VR equipment, they can quickly exhaust what is available on the market. The shortage of VR applications creates opportunities for businesses. However, it is also a challenge to enter the market since it is a relatively unexplored territory. The lack of knowledge on how VR can be engaging, hinders the proliferation of VR gaming market. For VR gaming to break its current boundaries and become more prevalent, mainstream adoption is required and the users should be encouraged for continued use (ARVRtech, 2019). For that, the "content problem" needs to be solved (Bilyk, 2018). At this point, developers and managers need assistance to make informed decisions on what content should be produced and how this content translates to user motivations, enjoyment and positive player experiences (Bilyk, 2018). With this knowledge, they would feel less hesitant and can enter the market more courageously. Therefore, to create knowledge on VR gaming adoption, this study aimed to bring a perspective on VR gaming player experiences and reveal the factors which might be essential for VR gaming acceptance.

To be able to understand the intentions to use VR in general, researchers adopted the Technology Acceptance Model (TAM, Davis et al., 1989), which provides a helpful foundation and some of these studies have added enjoyment as a predictor in addition to the fundamental constructs of TAM (i.e. perceived ease of use; Huang et al., 2016; Chen et al., 2012; Mütterlein and Hess, 2017). Although enjoyment is relevant to VR gaming as well, VR gaming is fundamentally different than other VR applications in terms of user motivations and experiences. The reason is that, depending on whether a system is designed with hedonic purpose or utilitarian purpose in mind, the reasons for adoption might differ (Van der Heijden, 2004). It was shown that different motivations (hedonic vs utilitarian) can be related to different intentions (hedonic vs utilitarian) and context is important in acceptance (Cai et al., 2018; Childers et al., 2001). Although it is agreeable that some systems might have both hedonic and utilitarian values incorporated in them (e.g. gamified systems), VR applications that are solely designed for entertainment purposes (i.e. gaming) would substantially appeal to hedonic motivations of users. Therefore TAM extensions to non-gaming VR settings might not be directly applicable to the VR gaming domain. The literature on virtual reality gaming is scarce at best, and it is critical to understand what drives players to adopt this emerging technology for gaming purposes. The existing literature on virtual reality gaming is dominantly on learning/training (Vogel et al., 2006; Xu and Ke, 2016), display fidelity (McMahan et al., 2012), pain modulation (Das et al., 2005), traumatic brain injury (Pietrzak et al., 2014), stroke rehabilitation (Saposnik et al., 2010), physical activity (Brütsch et al., 2010; Levac et al., 2010), dynamic body balance (Rendon et al., 2012), prosocial behaviors (Rosenberg et al., 2013), anxiety treatment (Van Rooij et al., 2016), aging with disabilities (Lange et al., 2010) or emotion elicitation (Pallavicini et al., 2018). Although these are important areas, they are not targeted for VR adoption for pure entertainment purposes. It is crucial to understand why VR games are appealing in the first place. It is not clear if VR gaming affords separate player motivations with respect to other forms of gaming and if traditional video gaming motivations are directly applicable in VR gaming as well (Pallavicini et al., 2017). Thus the current study focuses on the leisure use of virtual reality, more specifically on virtual reality games and adopts TAM as its foundation. Main research question of this study is: What are the factors contributing to intention to play virtual reality games? To answer this question, first the literature is reviewed and then a motivational model that is based on technology acceptance model (TAM), self-determination theory (SDT) and flow theory is tested to examine player experience and endorsement of VR games.

BACKGROUND AND HYPOTHESES

Technology Acceptance Model

Technology Acceptance Model (TAM) (Davis et al., 1989), based on the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980) proposes that people's attitude towards acceptance of a technology predicts their intention to use. It also proposes that the people's attitudes are predicted by the perceived ease of use and perceived usefulness of the technology. Several studies provided support for this basic premise of TAM (i.e. Porter and Donthu, 2006; Dishaw and Strong, 1999; Vijayasarathy, 2004). Although, attitudes might not fully mediate the effect of perceived ease of use and perceived usefulness on intention (Davis, 1989; Lederer et al., 2000), research on VR adoption shows that attitude towards the VR technology is important (Liao et al., 1999; Bertrand and Bouchard, 2008). Also positive attitude was found to be higher in more interactive systems (Goh and Ping, 2014).

Majority of research on TAM focuses on utilitarian information systems. Utilitarian information systems can be defined as information systems that are mainly designed to accomplish business-oriented work with effectiveness (Van der Heijden, 2004). For instance, researchers tested TAM in the context of physicians' acceptance of telemedicine technology and found that perceived usefulness and perceived ease of use predicts attitude and attitude predicts intention to use (Hu et al., 1999). Another study found similar associations in the adoption of information technology in business settings (Hernandez et al., 2008). Several other studies supported TAM in adoption of utilitarian information systems (Legris et al., 2003; Marangunić and Granić, 2015).

On the other hand, information systems that are created for entertainment purposes are called hedonic information systems (HIS) (Van der Heijden, 2004). These systems may include games (desktop, console or mobile), mobile applications used for entertainment, music streaming services, gamified apps and so on. In a pioneering study that applied TAM to hedonic information systems, it was suggested that although TAM is a useful theory in explaining acceptance; it is a limited model for explaining the acceptance or adoption of entertainment based information systems, in its basic form (Van der Heijden, 2004). In fact, same study found that enjoyment was the main predictor of intention to use these systems rather than perceived usefulness. Therefore, TAM was updated for hedonic information systems while preserving its other relationships such as attitude-intention to use relationship. For instance, it was found that enjoyment and social image both predicted attitude, which in return, predicted intention to use online video games (Lin and Bhattacherjee, 2010). Another video game study on Massively Multiplayer Online Role-Playing Games found that enjoyment predicted behavioral intentions (Wu and Holsapple, 2014). Similarly, enjoyment and perceived playfulness predicted attitudes toward and intention to use social network games (Shin and Shin, 2011). Direct effect of enjoyment on intention to use was also shown in other but similar contexts such as 3D Worlds

(Nah et al., 2011), social networking websites (Rosen and Sherman, 2006), mobile games and music streaming services (Merikivi et al., 2016; Hechler et al., 2016). A recent meta-analysis shows that enjoyment predicts attitude toward HIS, which in turn, predicts the intentions to use (Wu and Lu, 2013), providing support for the predictions on TAM in hedonic information systems. Despite not being in the hedonic context, there are also studies showing that enjoyment of using virtual reality predicts positive attitudes towards using virtual reality technology (Lee et al., 2018; Manis and Choi, 2018).

Consequently, it is also hypothesized that these basic associations of TAM would be also applicable to virtual reality games:

[H1] Positive attitude towards VR gaming positively impacts intention to play VR games.
[H2] Enjoyment positively impacts intention to play VR games.
[H3] Enjoyment positively impacts positive attitude towards VR gaming.

Flow Theory and TAM

Flow is defined as the psychological state when one experiences optimal mental states and experiences (Csikszentmihalyi, 1990). It is the mental state where the individual is fully immersed in an activity and is perfectly concentrated on the task. It is also described as when a person loses the sense of time and space during an activity. This state is associated with greater life quality and absence of boredom and anxiety in the literature (Csikszentmihalyi, 1997).

Although there is robust support for the basic predictions of TAM, researchers also expanded the model with flow (Treiblmaier et al., 2018). In one study (Agarwal and Karahanna, 2000), it was found that cognitive absorption, a construct based on flow (Csikszentmihalyi and LeFevre, 1989) significantly predicted intention to use, along with perceived ease of use in the world wide web context. For hedonic information systems, including games, flow seems to play an important role as well (Cowley et al., 2008; Nah et al., 2014). In a study on online games, flow was found to significantly predict intention to use (Hsu and Lu, 2004). Similarly, it was found that flow plays a pivotal role in mobile game adoption as well (Zhou, 2013). In an extension of TAM, called Hedonic-Motivation System Adoption Model, it was proposed that flow mediates the relationship between perceived ease of use and intention to use (Lowry et al., 2012). Similarly, it was found that flow significantly predicted attitude towards using online games (Wang and Scheepers 2012). Flow is also an essential predictor of enjoyment in games context (Chen, 2007; Sweetser and Wyeth, 2005; Sherry, 2004). Flow-enjoyment relationship was shown to be significant in several gaming settings as well such as MUD games (multi-user dungeon; Voiskounsky et al., 2004), pervasive games (Jegers, 2007), e-learning games (Fu et al., 2009), exercise games (Huang et al., 2018), role-playing games, racing games and jump and run games (Weibel and Wissmath, 2011). Flow was also found to be predicting game enjoyment in games with human-controlled opponents as well as computer-controlled opponents (Weibel et al., 2008). In addition, flow is claimed to be an important factor in online 3D virtual world experiences (Nah et al., 2010; Hoffman and Novak, 2009). For instance, telepresence, one of the key component of flow (Skadberg and Kimmel, 2004), predicts enjoyment in virtual tours in Second Life (Nah et al., 2011). Similarly, research shows that flow is an important factor on fostering enjoyment and positive affect in games with virtual worlds (Faiola, 2013; Chiang et al., 2011). Therefore, it can be hypothesized that flow would predict greater enjoyment in VR games.

GameFlow was selected as the operationalization of flow which is a model developed to explain player enjoyment in games (Sweetser and Wyeth, 2005). It is based on the original theory of flow (Csikszentmihalyi, 1990), where immersion and concentration are two of the major constituents.

Research shows that immersion plays a key role in flow (Draper et al., 1998). Furthermore, a key aspect of virtual reality systems that separates them from other digital systems is their facilitation of high levels of immersion (Slater and Wilbur, 1997). High interactivity and vividness –that are some of the main properties of VR games- results in higher immersion and emotional responses (Sheng and

Joginapelly, 2012). Thus, it is important to focus on the role of immersion in endorsement of virtual reality games. Immersion was found to be a construct that is related to loss of self-consciousness, merging of action and awareness and an altered perceiving of time which are also elements of flow (Fang et al., 2013). Although immersion is sometimes referred to as the hardware properties and “presence” to be the measure of subjective experience (Slater, 2018), GameFlow treats immersion as the subjective experience of the player, similar to presence. Overall, it is postulated that immersion would be a unique contributor to enjoyment in VR games:

[H4a] Immersion positively impacts enjoyment in VR games.

At the same time, intense concentration is a key characteristic in achieving flow states (Ghani and Deshpande, 1994; Shin, 2006). Research states that concentration is focused attention and it was found as an antecedent of flow in several game genres such as simulation and avatar-based narrative-driven games (Jinn, 2011). Concentration was also found as a major factor in predicting task engagement in VR settings (Lackey et al., 2016). Furthermore, focused concentration is referred as a requirement in media enjoyment (Sherry, 2004). Consequently, it is hypothesized:

[H4b] Concentration positively impacts enjoyment in VR games.

Self-Determination Theory and TAM

Self-determination is a grounded theory, comprised of 6 mini-theories, with more than 40 years of research background (Ryan and Deci, 2017). The theory makes the distinction between extrinsic motivation and intrinsic motivation. The former refers to doing an activity for obtaining the gains separate from the activity, and the latter refers to doing something for its own sake since one enjoys the process (Ryan and Deci, 2000a; Ryan and Deci, 2000b). Intrinsic motivation leads people to be more persistent, effective, efficient and satisfied (Deci and Ryan, 2002). The theory also posits that autonomy, competence, and relatedness are the three basic psychological needs, satisfaction of which is essential for intrinsic motivation and well-being. Autonomy is the need to act in accordance with one’s true self, as opposed to being controlled and pressured. Competence refers to the need for mastery and feeling optimally challenged. Relatedness is the need to feel connected to others and having a sense of belongingness.

There are studies that incorporated SDT constructs in TAM, for utilitarian information systems. In one recent study, it was found that basic needs (autonomy, competence and relatedness) predicted perceived ease of use and perceived usefulness in mobile-based assessment context (Nikou and Economides, 2017). Similarly, another study found that basic need satisfaction predicted perceived usefulness, which then predicted intention to use (Sørebø et al., 2009). Another study found that basic needs predicted enjoyment which predicted intention to use online knowledge sharing system that is web-based discussion boards (Lee et al., 2015). Also, in the context of e-learning in work settings, autonomy, competence and relatedness significantly predicted perceived usefulness and perceived playfulness (Roca and Gagné, 2008). Therefore in general, satisfaction of autonomy and competence needs positively influences the intentional use of new technologies (Bakke and Henry, 2015).

Although, there is also literature examining TAM and SDT in hedonic or mixed (hedonic and utilitarian) information systems such as virtual worlds (Verhagen et al., 2012), gamified applications (Treiblmaier et al., 2018), computers (Fagan et al., 2008) or internet (Zhao et al., 2011); studies examining TAM and SDT specifically in the gaming context are scarce. Although past studies on the adoption of hedonic information systems, especially games, provides useful foundations, they have not considered need satisfaction in their models where need satisfaction is a vital determinant of gaming motivation (Ryan et al., 2006). According to SDT literature, satisfaction of autonomy and competence needs in games predicts players’ enjoyment (Ryan et al., 2006; Przybylski et al., 2010).

This is based on the idea that players seek to satisfy their basic psychological needs in games. Thus, it is hypothesized that basic need satisfaction would positively influence enjoyment in VR games:

[H5a] Competence positively impacts enjoyment in VR games.
[H5b] Autonomy positively impacts enjoyment in VR games.

Although the authors posit that relatedness also positively impacts immersion and concentration, because of the design of this study, the authors did not include it in the hypotheses and analyses. Since it was expected that participants to have played VR games at most 5 times (to capture the essence of initial acceptance), it was thought that for the ones who played only single player games, relatedness would be hard to assess if not completely irrelevant.

Intrinsically motivated behavior results in flow experiences and this behavior rises from self-determined actions (Deci, 1992). When basic needs are satisfied during an activity, the individual becomes more and more immersed into and concentrated on that activity and eventually becomes one with that activity entering the flow state. There is ample evidence that self-determined behaviors foster flow states (e.g. Schüler et al., 2013). Research shows that satisfaction of basic psychological needs enhances flow experiences in work settings (Bakker and Woerkom, 2017). Several studies in sports domain also suggest that self-determined behavior and intrinsic motivation predict flow states (Moreno et al., 2010; Kowal and Fortier, 1999; Jackson et al., 1998; Schüler and Brandstätter, 2013). In games context, self-determination and flow are investigated as major constituents of player experiences (Johnson et al., 2013). Similar to other contexts, need satisfaction is stated to be closely related to flow experiences in games as well (Johnson et al., 2018). This is because, by definition, flow requires players to be in control (resembling autonomy need satisfaction) and optimally challenged (resembling competence need satisfaction) during a game. Following this argument and in line with the literature, it is posited that satisfaction of basic psychological needs (i.e. autonomy and competence) enhances the flow states experienced by players.

Research shows that immersion, sub construct of flow, is a construct that is highly correlated with player experience of need satisfaction in video games (Bormann & Greitemeyer, 2015). It was found across different game types and content that as the player experience of need satisfaction increase, immersion levels experienced by the players are enhanced as well (Ryan et al., 2006; Przybylski et al., 2009). In addition, as VR technology is usually characterized with increased immersion levels, it was thought that the immersion-need satisfaction relationship holds for VR games as well. Therefore, the hypotheses become:

[H6a] Competence positively impacts immersion in VR games.
[H6b] Autonomy positively impacts immersion in VR games.

Similar to immersion, satisfaction of basic psychological needs were also found to be associated with higher levels of focused concentration, which is a sub-construct of flow. Studies show that self-determined motivations predict concentration of the individual in the context of sports (Kowal and Fortier, 1999) and school physical education (Ntoumanis, 2005; Standage et al., 2005). This is the case in work (Bakker and van Woerkom, 2017) and schoolwork settings as well (Bassi and Delle Fave, 2012) as well. Similarly, in VR game context, as players feel more competent and autonomous, they would be more concentrated on the game. Therefore, it is hypothesized that:

[H6c] Competence positively impacts concentration in VR games.
[H6d] Autonomy positively impacts concentration in VR games.

With these, it is also inferentially hypothesized that:

[H6e] Immersion mediates the relationship between autonomy, competence and enjoyment.
[H6f] Concentration mediates the relationship between autonomy, competence and enjoyment.

Finally, it can also be suggested that perceived ease of use would facilitate satisfaction of autonomy and competence needs which result in enjoyment. There are studies showing that enjoyment predicts perceived ease of use in utilitarian information systems (Venkatesh, 2000; Sun and Zhang, 2006), however, the authors posit that perceived ease of use would be an antecedent of enjoyment in hedonic information systems, in line with the gaming literature. In video games context, perceived ease of use is determined as the 'backbone' of positive gaming experiences and therefore precedes enjoyment (Shen et al., 2009). Therefore, ease of use is a fundamental requirement for fostering satisfaction in video games. The argument follows that a game that is easy to use may (i.e. easy to use and fun) or may not foster satisfaction (i.e. easy to use but boring) however a game that is not easy to use will likely diminish satisfaction (i.e. not easy to use therefore frustrating). When a game system/interface is hard to use, it is likely to frustrate users, leading to feelings of incompetence. Moreover, not being able to do what they want to do because of a hard to use system would also lower users' feelings of autonomy. In fact, research shows that 'intuitive controls' in games are positively associated with satisfaction of autonomy and competence needs (Ryan et al., 2006) where intuitive controls are considered similar to perceived ease of use in the IS literature (Mantymaki and Merikivi, 2010). Moreover, perceived ease of use was shown to be a major factor in virtual reality adoptions as well (Fagan et al., 2012). Therefore, it is hypothesized that:

[H7a] Perceived ease of use positively impacts competence in VR games.
[H7b] Perceived ease of use positively impacts autonomy in VR games.

Self-Determination Theory and Flow

As explained above, flow is operationalized as in GameFlow which consists of 8 sub constructs: Concentration, Challenge, Player Skills, Control, Clear Goals, Feedback, Immersion and Social Interaction. However, it is also posited that among these 8 sub constructs, 6 of them are already explained by the self-determination constructs. More specifically, challenge ("games should be sufficiently challenging") and player skills ("games should support skill development and mastery") are explained by competence whereas control ("players should feel a sense of control over their actions"), clear goals ("games should provide the player with clear goals") and feedback ("players must receive appropriate feedback at appropriate times") are covered in the concept of autonomy. In addition, social interaction ("games should support social interaction") resembles relatedness. The associative and overlapping nature of these two theories were also mentioned in the literature studying self-determination and flow in an integrative way (Bakker and van Woerkom, 2017; Bassi and Delle Fave, 2012; Fortier and Kowal, 2007). Therefore, flow was operationalized as the remaining two sub-constructs which are immersion and concentration. Previous research also supports the conceptualization of flow as immersion and concentration (Mekler et al., 2014).

CONTROL VARIABLES

It is decided to include age, gender and education as controlling variables, since studies show that these variables can influence technology acceptance attitudes (Kuo et al., 2009; Wang and Wang, 2010; Burton-Jones and Hubona, 2006, respectively). In addition, total years of video game play and hours of video game play weekly are included as well to control for the effects of prior video gaming experiences and video gaming habits of participants. The authors did not want participants' prior (non-VR) gaming experiences or (non-VR) gaming habits to influence the VR gaming acceptance.

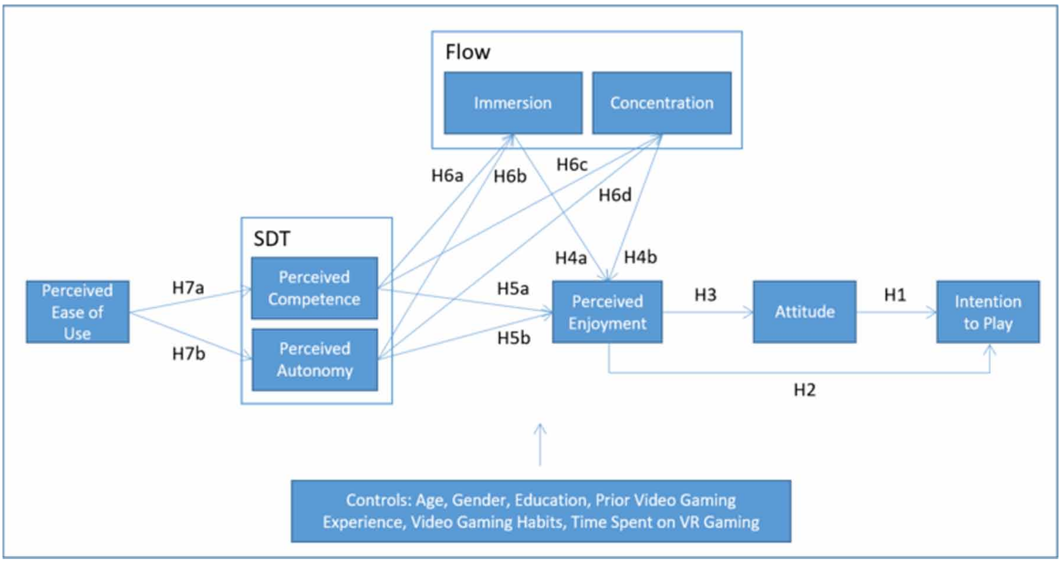
Finally, hours spent on VR gaming is included to be able to control for the VR gaming experience of players, which could affect their VR gaming acceptance assessment.

The Overall Model

In brief, it is hypothesized that basic need satisfaction would mediate the link between perceived ease of use and enjoyment, as well as the link between perceived ease of use and flow in VR games.

The final research framework is provided in Figure 1.

Figure 1. Proposed model for acceptance of VR games



METHOD

Participants

The data is collected from Amazon's Mturk website. The survey was open to the participants residing in USA, and those who had played a VR game at least once were eligible. 400 participants completed the survey. The sample consisted of at least "10 cases per variable" in line with the recommendations of SEM literature (Bentler & Chou, 1987; Kline 2015). Data from four participants were found to be extreme outliers (e.g. 20000 hours of VR play) and were not included in the analyses.

Therefore, there were 396 participants in the dataset (183 male and 213 female). The participants were between 19 and 64 years old (M = 33.78, SD = 9.67). There were 285 white, 46 African American, 6 American Indian or Alaska Native, 36 Asian, 2 Native Hawaiian or Pacific Islander participants, whereas 21 participants preferred not to disclose their ethnicity. The most reported education level was 4-year degree were with 151 participants, and most of the participants (N=263) were full-time employees (Table 1).

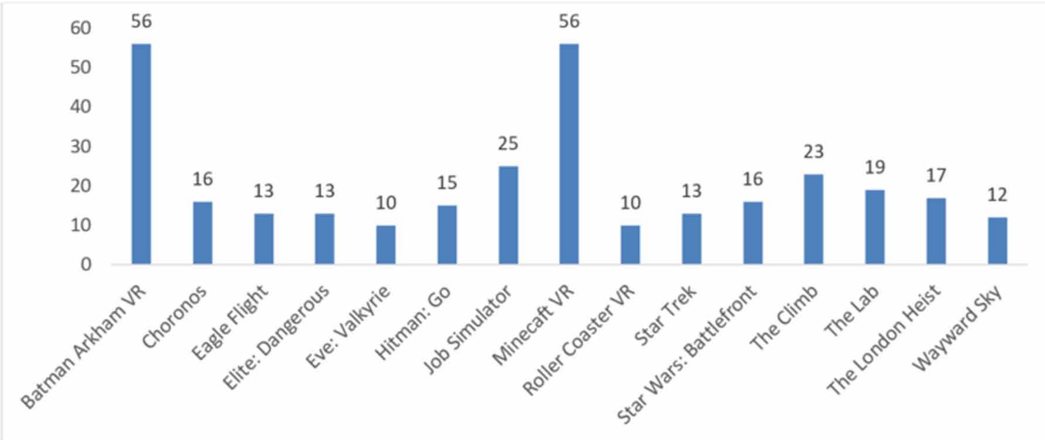
Weekly video game play hours varied from 0 to 60 (M = 9.68, SD = 8.45). Years of video game play varied from 1 to 40 (M = 18.50, SD = 8.95). 154 participants claimed that they have played a VR game once. 98 stated that they have played twice, 54 stated that they have played three times, 19 stated that they played four times and 71 stated that they have played five times. To be able to accurately study the "acceptance" of VR games, a threshold of "at most 5 times VR game play" was decided, so that participants would not already be in a continued use state or too experienced to assess their acceptance

Table 1. Participant demographic information (N= 396)

Age	18-25	84	21.2%
	26-35	164	41.4%
	36-45	97	24.5%
	>=46	51	12.9%
Gender	Male	183	46.2%
	Female	213	53.8%
Education	High School Graduate	49	12.4%
	Some College	99	25.0%
	2-year degree	57	14.4%
	4-year degree	151	38.1%
	MSc level degree	32	8.1%
	Doctorate	8	2.0%
Ethnicity	White	285	72.0%
	African American	46	11.6%
	American Indian or Alaska Native	6	1.5%
	Asian	36	9.1%
	Native Hawaiian or Pacific Islander	2	0.5%
	Preferred not to say	21	5.3%
Hours Spent on VR gaming	1-25	297	75.0%
	26-50	42	10.6%
	>=51	57	14.4%
Times VR Played	Once	154	38.9%
	Twice	98	24.7%
	Three Times	54	13.7%
	Four Times	19	4.8%
	Five Times	71	17.9%
Total Years of Video Game Play	1-10	93	23.5%
	11-20	161	40.6%
	21-30	116	29.3%
	31-40	26	6.6%
Hours of Video Game Play Weekly	0-20	369	93.2%
	21-40	23	5.8%
	41-60	4	1.0%

attitude. However, no participant has played a VR game more than 5 times, therefore no participant was discarded according to the threshold. Most of the participants stated that they have played VR games at home (267). 10 participants claimed that they have played VR games in the office and 36 at the conventions. 83 participants marked "Other" option. Lastly, the participants were asked which three VR games they played the most. As can be seen from the graph in Figure 2, Batman Arkham VR

Figure 2. VR games played by participants



and Minecraft VR were the most played VR games among the participants. Only the games that are mentioned 10 or more times were included in the graph.

Measures

All of the measures used in the study are adapted from previous studies in video games context and are rephrased to fit in to the VR gaming context. All constructs are measured on a 1-7 Likert scale ranging from "strongly disagree" to "strongly agree".

Perceived Ease of Use

Perceived ease of use is measured with 8 items from perceived ease of use in gaming scale (Lowry et al., 2012). The internal reliability of the scale was 0.92.

Basic Need Satisfaction

Satisfaction of autonomy and competence needs are measured using the Player Experience of Need Satisfaction Scale, PENS (Ryan et al., 2006). 3 items measure autonomy and 3 items measure competence. Both subscales showed good internal reliability ($\alpha = 0.89$ and $\alpha = 0.88$).

Flow

GameFlow scale is used to measure flow in gaming context (Sweetser and Wyeth, 2005). The immersion (4 items) and concentration (6 items) subscales are used. The internal reliability of the subscales are $\alpha = 0.80$ and $\alpha = 0.81$, respectively.

Enjoyment

For the enjoyment, the scale is used from another study consisting of 3 items (Wang and Scheepers, 2012). The internal reliability is 0.93.

Attitude

Attitude is measured by a previously developed scale (Wang and Scheepers, 2012). It consists of 3 items ($\alpha = 0.90$).

Intention to Play

Lastly, intention to play is measured by a scale consisting of 4 items ($\alpha = 0.94$) (Wang and Scheepers, 2012).

The scales, items of the scales that correspond to the constructs and their citations are summarized in the Appendix.

Procedure

The study was announced on Amazon's Mechanical Turk (MTurk). Mturk is an online platform offering recruitment tools for researchers. It was shown that using Mturk for survey data collection is a valid method provided that rigorous exclusions are employed (Thomas and Clifford, 2017). For that, the participants were required to have an approval rate of at least 95%. After completing the consent form and the demographics measures, participants completed the study measures. The survey took approximately 15 minutes to complete. Those who completed the survey received 30 cents on MTurk.

RESULTS

Preliminary Results

First, the internal reliabilities of the scales are checked. Minimum Cronbach's alpha value was 0.80 and the others were well above the threshold of 0.7 (Nunnelly, 1978). Therefore all of the reliabilities of the scales were within acceptable limits (Table 2).

Table 2. Internal reliabilities of the scales

	Cronbach's Alpha
Perceived Ease of Use	0.92
Autonomy	0.89
Competence	0.88
Immersion	0.80
Concentration	0.81
Enjoyment	0.93
Attitude	0.90
Intention to Play	0.94

Next, the normality of the data is checked. Although there are formal normality tests such as Kolmogorov-Smirnov or Shapiro-Wilk tests, they are unreliable for greater than medium sized samples ($n > 300$; Kim, 2013). Therefore, the skewness and kurtosis of the data are checked. The maximum value of skewness was -1.5 and the maximum value of kurtosis was 3.1 which were within the acceptable limits for moderate normality (skewness < 2,-2 and kurtosis < 7,-7; Curran et al., 1996; Hair et al., 2010). These limits are also considered critical levels for 'Maximum Likelihood' estimation (Ryu, 2011). 'Maximum Likelihood' estimator was used in the subsequent path analyses, which is also a robust technique against the assumptions of violations of normality (Bollen, 1989; Diamantopoulos et al., 2000).

The factor structure of the model was examined by carrying out confirmatory factor analysis (CFA) using SPSS AMOS software. A model is regarded as acceptable in CFA and structural equation modeling (SEM) analyses, if it satisfies the following fit index conditions: TLI > .90, CFI > .90, RMSEA < .08 and SRMR < .09 (Hu & Bentler, 1999). After dropping the low loading items (CONC4 – 0.38 and CONC6 – 0.45; using the 0.50 cutoff criteria; Hair et al., 2010), the confirmatory factor analysis showed acceptable fit indices (RMSEA = 0.057, %90 CI [0.052, 0.062], CFI = 0, SRMR = 0.049). All of the composite reliabilities were above 0.70 (Hair et al., 2010) and all of the average variance extracted (AVE) values were above 0.50 (Hair et al., 2010) indicating good convergent validity (Table 3). All of the square root of the AVE values of

Table 3. Correlations, means and standard deviations of constructs

	PEOU	COMP	AUT	IMM	CONC	PENJ	ATT	ITP
PEOU	-							
COMP	0.76*	-						
AUT	0.55*	0.69*	-					
IMM	0.32*	0.38*	0.47*	-				
CONC	0.43*	0.50*	0.67*	0.53*	-			
PENJ	0.56*	0.68*	0.76*	0.45*	0.65*	-		
ATT	0.53*	0.62*	0.73*	0.40*	0.62*	0.88*	-	
ITP	0.44*	0.61*	0.69*	0.42*	0.56*	0.85*	0.87*	-
Age	-0.17*	-0.19*	-0.07	-0.04	-0.02	-0.04	-0.05	-0.02
Gender	-0.12*	-0.09	0.01	-0.02	0.08	0.07	0.05	0.01
Education	-0.00	-0.02	-0.00	0.07	0.01	-0.03	-0.05	-0.05
Play Years	-0.11*	-0.10*	0.02	-0.01	-0.04	0.04	0.07	0.11*
Hours/Week	0.17*	0.16*	0.15*	0.13*	0.13*	0.13*	0.13*	0.12*
VR Play	0.03	0.11*	0.05	-0.04	0.02	0.11*	0.10*	0.12*
Mean	4.82	5.14	5.57	4.81	5.07	5.80	5.84	5.77
SD	1.11	1.20	1.03	1.20	0.91	1.08	1.06	1.16
CR	0.92	0.89	0.84	0.80	0.81	0.93	0.90	0.94
AVE	0.60	0.72	0.63	0.51	0.53	0.82	0.76	0.81

*: $p < 0.001$

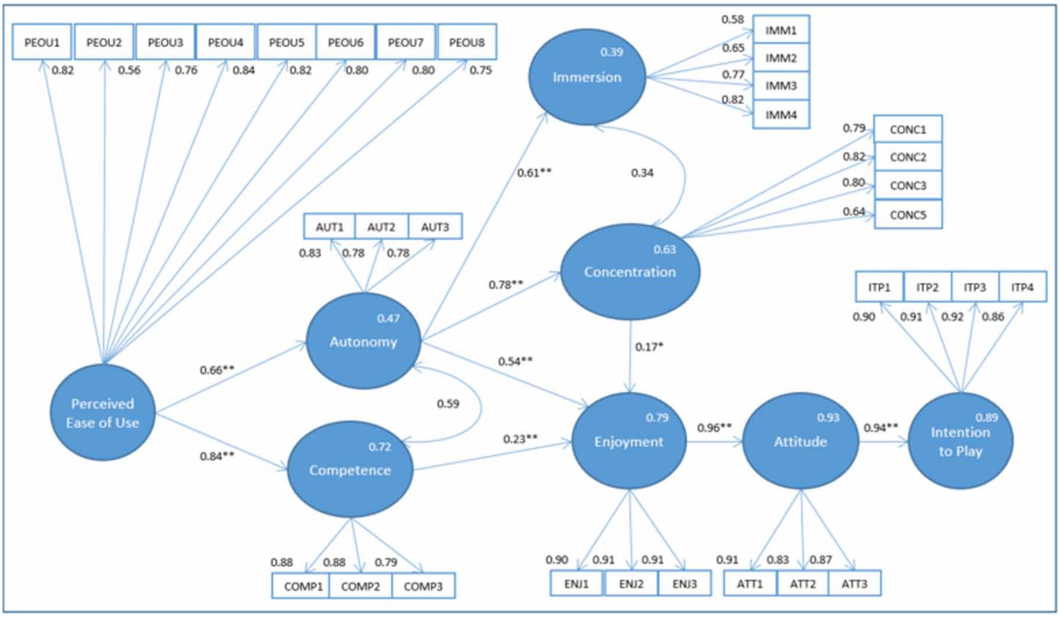
constructs were above their inter-construct correlation values and all the VIFs (variance inflation factors) of autonomy, competence, immersion and concentration were all less than 3, indicating good discriminant validity (Hair et al., 2010). Also, all of the correlations were in the expected direction (Table 3).

Zero-order correlations between enjoyment, attitude and intention to play were relatively high (0.88, 0.85 and 0.87). Although these are not more than 0.90 (which indicates common method bias evidence; Bagozzi et al., 1991), a common methods variance test is conducted. Several methods are suggested to conduct common method variance test however Harman's single factor test is the most commonly used by researchers (Edwards and Billsberry, 2010). Although the Harman's single factor accounted for a large variance (46.5%), it was less than 50% which is the heuristic threshold (Podsakoff et al., 2003). Therefore, it is concluded that the dataset did not suffer from common method bias.

Primary Results

SEM analysis is conducted to test the model. After dropping the non-significant paths from the model, the results showed acceptable fit (Figure 3); RMSEA = 0.054, %90 CI [0.050, 0.059], CFI = 0.94, TLI = 0.93, SRMR = 0.056. It is found that the model explains (R2) 89% of the variance

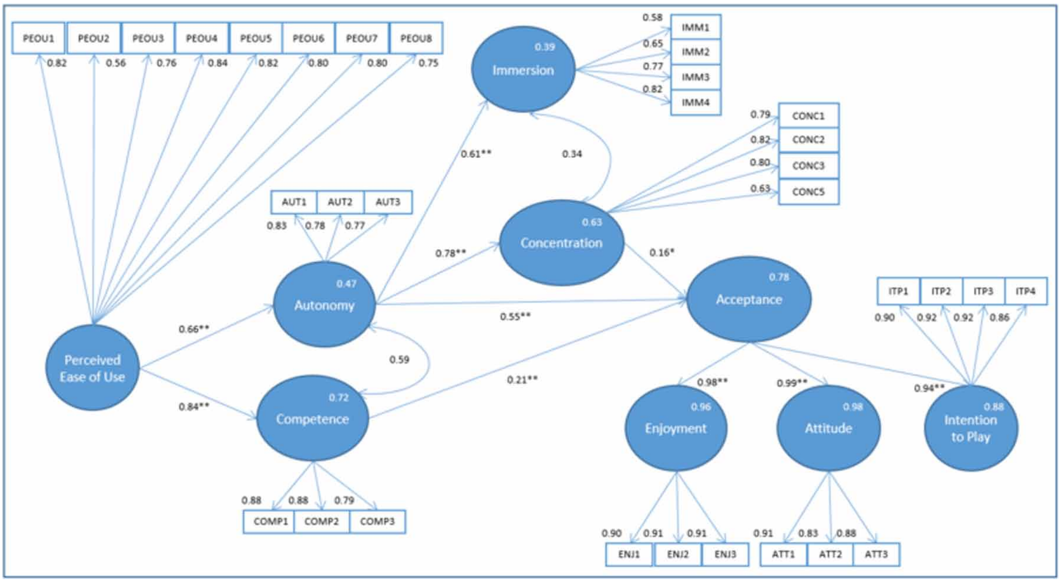
Figure 3. Structural and measurement model of VR gaming acceptance



in intention to play VR games. In general, the results showed that perceived ease of use predicted autonomy and competence where autonomy predicted flow as well as enjoyment. Competence predicted enjoyment and enjoyment was an antecedent of attitude and intention to play. These results were mostly in line with the hypotheses. The results are found controlling for age, gender, education, hours spent on VR gaming, total years of video game play and hours of video game play weekly. There were several significant associations between the controlling variables and core variables in the model as well: gender-enjoyment, gender-autonomy, hours spent VR gaming-competence, years playing video games-autonomy, years playing video games-enjoyment associations. Enjoyment and autonomy levels of females were more than the males ($\beta = 0.07$, $p = 0.02$ and $\beta = 0.12$, $p = 0.006$, respectively). People who played more VR games were more competent ($\beta = 0.09$, $p = 0.006$). People who played more video games had more autonomy and enjoyment scores ($\beta = 0.12$, $p = 0.005$ and $\beta = 0.07$, $p = 0.04$, respectively).

As the path estimates between enjoyment and attitude, and attitude and intention to play were extremely high (0.96 and 0.94 respectively). Such high estimates might imply tautology. Nevertheless, enjoyment, attitude and intention to play are separate constructs representing different phenomena. Therefore, a new model was created with the second order latent variable "acceptance", which includes enjoyment, attitude and intention to play as first order variables. The new model showed acceptable fit as well (Figure 4); RMSEA = 0.055, %90 CI [0.051, 0.059], CFI = 0.93, TLI = 0.92, SRMR = 0.062. It was found that this final model explains (R2) 78% of the variance in acceptance of VR games.

Figure 4. Structural and measurement model of VR gaming acceptance (acceptance as 2nd order latent variable)



DISCUSSION

In this study, technology acceptance model, self-determination theory and flow theory constructs are used to test a unified motivational model for virtual reality gaming. Results show that perceived ease of use significantly predicted higher autonomy and competence satisfaction, which in turn, predict greater flow and enjoyment. Finally, enjoyment predicts higher intention to play VR games via positive attitudes toward VR games.

Association between perceived ease of use and enjoyment in the gaming context were shown before (Merikivi et al., 2016), however current study proposes a mechanism for the association between perceived ease of use and enjoyment based on self-determination theory. That is, when games are easy to use people are more likely to feel autonomous as they are able to do what they want, rather than struggling with the controls. Similarly, this also provides and enables a sense of mastery, satisfying competence needs. This finding suggests that VR games should provide frictionless interfaces so that players can easily transfer their intentions to actions, otherwise their feelings of competency and autonomy, which are essential for enjoyment (Ryan et al., 2006) are likely to be frustrated.

The role of flow in acceptance of VR games is also examined. Only autonomy satisfaction significantly contributed to the experience of flow in VR games. This is in line with the research which found that autonomy predicts flow and not competence in a VR setting (Huang et al., 2019). More specifically, players experience more immersion and better concentrate on the game when their autonomy needs are satisfied. Also, autonomy satisfaction contributed to enjoyment more than competence satisfaction. Satisfaction of competence needs could be less important for VR games compared to other digital games, as VR games are more oriented toward providing an immersive experience, rather than challenging the player. Thus, satisfaction of competence needs could be less important for flow in VR games currently.

The rest of the findings are in line with the past research on TAM in gaming contexts (Lowry et al., 2012). Enjoyment predicted intention to play VR games via positive attitudes toward VR games. Nevertheless, they were integrated under the "acceptance" latent variable as the path estimates between these constructs were remarkably high. Although there are several studies which applied TAM in the VR context (Huang et al., 2016; Chen et al., 2012; Bertrand and Bouchard, 2008); to the best of authors' knowledge, this is one of the first study to test TAM in modern "VR Gaming" context with the perspectives of self-determination and flow. Overall, these findings suggest that TAM also provides a valid framework for acceptance of VR games. However, the model is improved by introducing constructs from self-determination theory and flow theory.

Although immersion was found to be associated with positive gameplay experiences (Örtqvist and Liljedahl, 2010) and engagement (Dede, 2009) in the literature; it did not contribute to the prediction of enjoyment in this study. This might be an indication that immersion does not necessarily contribute to enjoyment in VR settings especially when autonomy and competence needs are satisfied. For instance, using immersive VR for treatment of phobias/anxiety or for horror games may not always foster enjoyable experiences. However, explanations on why immersion does not contribute to enjoyment in gaming context should still be researched further. Absence of immersion effect on enjoyment might also be due to choice of the measurement tool. Future studies might consider using an alternative scale to test this. Using standalone immersion scales instead of the flow subscale might reveal alternative findings. In addition, although immersion was assumed as the sub-process of flow in this study, some studies posit that immersion is an objective property of a system and the "presence" construct better captures the subjective perception of being absorbed (Slater, 2018; Slater, 2003). This means that immersion level is independent of the individual and it depends on the modality of the system whereas presence is about the user's subjective feeling of "being there". Therefore, future studies might consider incorporating presence construct rather than immersion in their models when psychological processes in VR use are of interest.

Lastly, some of the control variables were associated with the core variables in the model. For instance, gender was correlated with enjoyment and autonomy where females scored significantly higher than males. Future studies might consider looking into gender differences in terms of VR gaming experiences. Also, prior experience in VR gaming and video gaming in general seem to have an effect on self-determination and enjoyment. Future studies might also consider focusing on the prior experience of players.

Limitations

In the SEM analyses, the path coefficients between attitude, enjoyment and intention to play were very high (i.e. 0.94 and 0.96). These three constructs also showed high zero-order correlations. However, high correlations and high path coefficients around attitude construct were found in other studies on gaming as well (e.g. Hsu and Lu, 2004; Hsiao and Chiou, 2012). Although the developed model passed the tests for discriminant validity and common method bias, these variables could be an indicator of a general acceptance factor (as shown in the final model). Also, some studies do not incorporate attitude in their acceptance models at all (Chesney, 2006; Im et al., 2008). Attitude might be less relevant to adoption (and too similar to intention to play) in the gaming contexts. Future studies might consider dropping some of these constructs (e.g. attitude) or try using different measurements for these constructs.

In addition, two of the concentration items were found to be low loading which were then discarded and not included in the analyses. Still, future studies might consider using alternative scales to avoid measurement problems.

It should be noted that the study is correlational. Although SEM is used to simultaneously test the associations, the findings do not provide evidence for causal associations. The proposed causal associations are theoretical, and it is possible to construct equivalent alternative models. Thus, experimental studies are needed to test causal associations between the constructs. Similarly, longitudinal studies may also provide further insight about the model for long-term endorsement of VR games. Moreover, data collection for the survey was employed through Mturk. Although Mturk is a powerful tool for participant recruiting, it has limitations such as the difficulties of assessing participant qualifications and ensuring data validity (Hunt and Scheetz, 2018). Future studies should corroborate the findings here with other data collection methods. Also, our sample solely consisted of US citizens which might be a threat to external validity of the study. Future studies might consider including participants from different countries as well.

In the current study, there is no relatedness satisfaction in the model. This decision was made due to the fact that it might have been irrelevant for some players who only tried a VR game in a single player mode. Future studies testing this model in other hedonic information systems that involve interacting with other individuals (or more specifically VR games with multiplayer components) might consider examining the role of relatedness satisfaction as it was found that social needs are important in adopting emerging technologies such as social media (Coursaris et al., 2013). Similarly, immersion and flow might be important in VR games context but they might not be essential for other hedonic information systems (Kosa and Uysal, 2018). Thus, whether these constructs in the model are context dependent need to be examined in future studies.

There are several VR hardware brands in the market and different VR systems might have different fidelities which might affect user perception and appreciation. Investigating the differences in terms of VR technology (e.g. Oculus, Vive, Sony) might bring new perspectives to the associations examined here. Future studies might also examine the associations between system characteristics such as objective usability of the system (Venkatesh, 2000), interactivity of the system (Merikivi et al., 2016), appeal and visual aesthetic of the system (Merikivi et al., 2016), novelty of the system (Merikivi et al., 2016), curiosity that the system invokes (Hechler et al., 2016), technical and interaction quality of the system (Lin and Bhattacherjee, 2010) and the model constructs.

Implications

The findings of this study might be important to virtual reality game designers and developers. First, VR game developers need to make sure that the game is user friendly. More specifically, the controls should be consistent and adhering to common conventions. For instance, if a certain button is causing the in-game avatar to jump in similar titles for years, then the designers should seriously reconsider when changing these traditional conventions. These conventions should be consistent throughout the experience as well. It is also often best practice in games to allow users to start interacting within the game effortlessly, without having to refer to the documentations. Ease of use can also be enhanced by providing feedback and informing players on the system statuses. To ensure usability of a game, it is argued that usability heuristics developed for websites and apps can be adapted to games as well (Joyce, 2019). After making sure that the game controls are intuitive and easy to use, VR game designers/developers should focus on supporting the autonomy and competence of players, which consequently will result in higher levels of flow and enjoyment. For autonomy, designers should make sure that the players are in absolute control. Players should be provided with meaningful options and paths to freely choose from, and be able to see the results of their actions. In addition, designers should create obstacles for players to overcome, to boost the feelings of competence. However, designers should set the difficulty of these obstacles mindfully, since extremely hard challenges might frustrate players rather than supporting their competence. Therefore, the challenges in the game need to be beatable with some effort. Moreover, according to the findings, VR game designers should focus more on supporting autonomy and competence satisfaction of players rather than on the immersion considerations. Because this study shows that in the end, immersion itself is not the main contributor to the enjoyment of VR game players but satisfaction of psychological needs is. This study creates knowledge for VR game practitioners and investors, informing them about what they need to focus on during the development of these applications. Although virtual reality hardware related aspects (form factor, price etc.) could be an important aspect of VR technology endorsement, this study shows that the content of VR games and user perception plays a major role in its acceptance as the final model explains 78 percent of the variance in acceptance of VR games.

CONCLUSION

Main contribution of the current study is the creation of a new model, which brings the satisfaction of psychological needs perspective into the VR gaming context. It integrates the self-determination theory constructs with the flow theory and technology acceptance model in the context of virtual reality gaming to explain the player endorsement of VR games. The study also tests the upgraded TAM model in the context of VR games. In brief, it was found that perceived ease of use increases endorsement of virtual reality games via satisfaction of autonomy and competence needs, and concentration experienced through flow. This study shows that, self-determined players, whose psychological needs are satisfied, are likely to play VR games.

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APPENDIX

Table 4. Scales used for VR gaming survey

Constructs	Items	Descriptions	Source
Perceived Ease of Use	PEOU1	My interaction with VR games is clear and understandable.	Lowry et al. (2012)
	PEOU2	Interacting with VR games does not require a lot of my mental effort.	
	PEOU3	I find VR games to be trouble free.	
	PEOU4	I find it easy to get VR games to do what I want it to do.	
	PEOU5	Learning to operate VR games is easy for me.	
	PEOU6	It is simple to do what I want with VR games.	
	PEOU7	It is easy for me to become skillful at using VR games.	
	PEOU8	I find VR games easy.	
Enjoyment	ENJ1	I have fun when I am playing VR games.	Wang and Scheepers (2012)
	ENJ2	Playing VR games provides me with a lot of enjoyment.	
	ENJ3	I enjoy playing VR games.	
Attitude	ATT1	I like playing VR games.	Wang and Scheepers (2012)
	ATT2	I like the idea of playing VR games.	
	ATT3	I have a positive attitude toward playing VR games.	
Intention to Play	ITP1	I think I will continue to play VR games.	Wang and Scheepers (2012)
	ITP2	I plan to play VR games in the future.	
	ITP3	I intend to continue playing VR games.	
	ITP4	I predict I will play VR games in the future.	
Autonomy	AUT1	VR games provide me with interesting options and choices.	Ryan et al.(2006)
	AUT2	VR games let you do interesting things.	
	AUT3	I experienced a lot of freedom in VR games.	
Competence	COMP1	I feel competent at VR games.	Ryan et al.(2006)
	COMP2	I feel very capable and effective when playing VR games.	
	COMP3	My ability to play VR games is well matched with the game's challenges.	
Immersion	IMM1	I become unaware of my surroundings while playing VR games.	Sweetser and Wyeth (2005)
	IMM2	I temporarily forget worries about everyday life while playing VR games.	
	IMM3	I feel emotionally involved in VR games.	
	IMM4	I feel viscerally involved in VR games.	
Concentration	CONC1	VR Games provide a lot of stimuli from different sources.	Sweetser and Wyeth (2005)
	CONC2	VR Games provide stimuli that are worth attending to.	
	CONC3	VR Games quickly grab my attention and maintain my focus throughout the game.	
	CONC4	I am not burdened with tasks that don't feel important in VR games.	
	CONC5	VR Games have a high workload, while still being appropriate for my perceptual, cognitive and memory limits.	
	CONC6	I am not distracted from tasks that I want / need to concentrate on in VR games.	

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