Continuous Usage Intention Toward Interactive Mixed Reality Technologies

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ABSTRACT

Through the theoretical lens of perceived characteristics of innovations (PCI) framework, the main purpose of this research was to examine whether perceived characteristics of interactive technologies—interactivity, hypertextuality, modality, connectivity, and virtuality—were related to user involvement, which in turn were related to the intention to continue using interactive mixed reality platforms. An e-survey questionnaire was administered to active mixed reality technology users (n = 268) across the US. Findings revealed that interactivity, modality, connectivity, and virtuality were positively related to user involvement, whereas hypertextuality showed no significant impact. Furthermore, the hypothesized relationships between perceived characteristics of interactive technologies and user involvement and between user involvement and continuous usage intention were greater for mixed reality platform users with high digital literacy than for those with low levels.

KEYWORDS
Digital Literacy, Perceived Characteristics of Innovations (PCI) Framework, User Involvement

INTRODUCTION

Recently, several studies have been conducted by researchers and scientists on the virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies by showing their practical significance, innovative features and application purposes in many different industries (e.g., Bonetti, Warnaby, & Quinn, 2018; Freeman et al., 2017). As a result, these technologies have enticed the attention of entrepreneurs, financiers, gamers, and the general community (Castelvecchi, 2016). Consequently, huge funds, trades, and investments are being carried out by big tech organizations to advance and profit on such innovations (e.g., Microsoft, Google, Amazon, Sony, etc.) (Castelvecchi, 2016).

It has been reported in the Information Systems (IS) discipline that such technologies are the next “big thing” or “stepping stone” in technological innovation since the rise of the internet (e.g., Cipresso, Giglioli, Raya, & Riva, 2018). In 2017, the AR-VR-MR industry has been estimated to generate in the next two to three years around 2.9 billion to 61.5 billion worth of sales and revenues (Superdata Research, 2017). Nevertheless, more recent reports by Fortune (2019) and TheAppSolutions (2019) reported that because of the poor quality of content, bad design, and/or low technical development standards, tech organizations within the “digital reality” industry have started to lag. Hence, users are losing interest to remain involved and to continue using these types of technologies. Because of such radical and unexpected outcomes, it would be interesting to empirically investigate if such challenges...
may be linked to an inadequate design of a specific characteristic of interactive technologies. This research attempts to do so.

Through the theoretical lens of perceived characteristics of innovations (PCI) framework, the current research empirically examines i) whether users’ perceptions of the characteristics of interactive technologies (i.e., interactivity, hypertextuality, modality, connectivity, virtuality) were related to their involvement with MR technologies, which in turn were related to their intention to continue using them; ii) the moderating influence of users’ digital literacy on the users’ perceptions of the characteristics of interactive technologies and user involvement relationships; and iii) the moderating influence of users’ digital literacy on the link between user involvement and intention to continuously use MR technologies. To test the twelve proposed hypotheses, an e-survey questionnaire was implemented by surveying 268 active users of MR technologies across the US.

The importance and relevance of this research are two-fold and equally contribute to creating new knowledge for the existing body of literature and building awareness for tech organizations. First, to the authors’ knowledge, this research is the first empirical study to investigate the effects of perceived characteristics of interactive MR technologies on user perception or behavior. In comparison to other types of emerging technologies (e.g., AR or VR), MR technology has been recently introduced to the research community which makes it a hardly explored topic. Therefore, the empirical findings of this research can add substantial value and content to the existing body of literature. Second, the current research exposes a possible flaw in the design and functionality of a certain type of characteristics of interactive technologies (i.e., hypertextuality). The research further suggests for augmenting the role of another - but similar - type of a technology characteristic (i.e., intertextuality). As such, the research attempts to raise awareness for tech organizations that are losing competitive advantage in this cutting-edge industry, and thus guide them in discovering new grounds for further developing their technological products and services.

The rest of this research is structured as follows: the next section expands on the concepts of digital realities and user involvement. Then, the research presents arguments for the proposed research model and the hypotheses development preceded by the PCI theoretical perspective. This is followed by the section on the research methodology. Finally, the authors elaborate on the findings and conclude with implications for future research.

BACKGROUND

Digital Realities

VR has been defined as a technology-generated and real-time 3D simulation where the user can navigate and interact through the use of their five senses (Guttentag, 2010), thus providing a sensory immersive experience. On the other hand, AR has been generally defined as a human-computer interaction tool that modifies the user’s actual physical surroundings by overlaying virtual elements (Yim, Chu, & Sauer, 2017).

Despite their similarities, the VR experience depends on full virtual and digital immersion whereas the AR consists of virtual images combined with real-world objects and environment (i.e., partial immersion). However, only recently, MR has emerged as a combination of both experiences in which the user can experience more depth and perspective (Brigham, 2017). The user perceives both the physical and virtual environments/elements through semi-transparent displays (i.e., merging real and virtual objects). Thus, MR attempts to combine the best characteristics of both AR and VR to deliver richer experiences (Curtin, 2017).

MR technology has been adopted in a wide range of industries (e.g., automotive, medical, education, construction/design, machines maintenance, etc.). Nevertheless, rather than focusing on a specific type of context or industry, this research attempts to examine the concept of MR technology related to its general use in any work-related or privately-related environment. The devices that support such digital experiences have been categorized as smartphones/tablets (e.g., Pokémon Go
apps), wearables/head-mounted hardware (e.g., Google Glass, Rift, Oculus, Hololens) and/or fixed interactive screens (digital screens/displays) (Carmigniani et al., 2011). Academic and scientific studies mainly focused on examining one of these digital devices rather than a combination of their use.

Therefore, this research focuses on investigating Microsoft’s Windows Mixed Reality platform as a novel operating system and portal that provides MR experiences with the use of hardware displays, digital apps, and interactive screens altogether. Such a technology has shown to be the only existing and complete MR software/platform/interface currently available in the market (De Guzman, Thilakarathna, & Seneviratne, 2018). Others have limited features, low tracking-detection systems, and support either AR or VR technologies (e.g., Vuforia, Wikitude, OSVR). To clarify the intentions of the research, the authors are not attempting to support or criticize the functionality of Microsoft’s Windows Mixed Reality platform. The general interest lies in investigating which MR technological characteristic may be perceived as liable for the challenges encountered by tech organizations in the market.

**User Involvement**

Involvement refers to an individual’s perceived connection with a certain item based on intrinsic necessities, beliefs, and interests (Zaichkowsky, 1986). Involvement has been extensively examined in numerous literature (e.g., consumer behavior and marketing) (Liu & Shrum, 2002; McMillan, Hwang, & Lee, 2003) and identified under two types (i.e., affective and cognitive involvement) (Zaichkowsky, 1994).

Affective involvement involves perceived emotional feelings and motives (stimulation, attractiveness, fascination) associated with any object. Cognitive involvement is an individual’s perceived rational/cognitive approach and practical motives (need, usefulness, practicality) associated with any object. This research does not differentiate between the two types of involvement.

**RESEARCH MODEL & HYPOTHESES DEVELOPMENT**

The investigated relationships in the present research are shown in Figure 1. The perceived characteristics of innovations (PCI) framework (Rogers, 1995) was used as a theoretical model. According to the PCI theoretical framework, there are five characteristics of innovations (i.e., relative advantage, compatibility, complexity, trialability, and observability) that may influence user involvement, adoption, or decisions to continue using a certain technology.

However, the term interactive technology has been used for various types of digital environments (Javornik, 2016). It shares similar aspects with media characteristics (Stewart & Pavlou, 2009), describes the functional features of technologies which allow understanding of user responses to specific experiences related to such technologies (Pagani & Mirabello, 2011), and is a crucial driver for user involvement and immersion in virtual and augmented realities (Hoffman & Novak, 1996).

As such, because this research is specifically investigating the perceived effects of interactive technologies rather than conventional types of innovations, five types of perceived media characteristics of interactive technologies (i.e., interactivity, hypertextuality, modality, connectivity, and virtuality) were measured. These five characteristics are considered as essential factors for evaluating digital and virtual media (Lister, Dovey, Giddings, Grant, & Kelly, 2008).

**Interactivity – User Involvement Relationship**

Interactivity, as an objective characteristic, refers to the extent to which two or more entities communicate through a medium with synchronized degrees of influences (Liu & Shrum, 2002); and the ability to interact within any given interface (Sundar, 2009). Such characteristic is linked to user response through i) how much control the user is perceived to have over a certain technology; ii) the extent to establish a two-way communication; and iii) the responsiveness of the technology (Sundar, 2009; Van Noort, Voorveld, & Van Reijmersdal, 2012). Thus, perceived or featured interactivity can be defined as a human-computer interaction composed of multi-way communication, control, and
responsiveness (Song & Zinkhan, 2008). AR/VR devices are considered as interactive as they allow the flow of communication between the user and the medium (Billinghurst & Kato, 2002).

Interactivity has been considered a vital characteristic of successful e-commerce, marketing, communication, and advertising (Cyr, Head, & Ivanov, 2009). Interactivity (internet, online shopping, and mobile use) has been shown to influence operational performance (Gu, Oh, & Wang, 2013), to predict pleasant sense of total involvement (Sicilia, Ruiz, & Munuera, 2005), and has affective and cognitive effects (Kim & Niehm, 2009; Yoo, Lee, & Park, 2010). The higher the degree of interactivity, the greater the perceived level of enjoyment, usefulness, control, and satisfaction, which in turn affects the flow of experience and behavioral usage intentions (Zhou & Lu, 2011; Coursaris & Sung, 2012). Based on these studies, it was expected that users who interactively connect may believe that using such technologies is attractive and stimulating (affective involvement) and necessary and significant (cognitive involvement). Besides, confirmed consumer responses brought forward by the interactivity characteristic have been found to positively relate to flow (van Noort et al., 2012), loyalty, trust (Cyr et al., 2009; Chu & Yuan, 2013), positive attitude (Gao, Rau, & Salvendy, 2009), and affective-cognitive involvement (Huang, 2012; van Noort et al., 2012), which in turn lead to future behavioral intentions (Chang & Wang, 2008; Sundar, Bellur, Oh, Jia, & Kim, 2014). Thus, the following hypothesis is formulated:

**Hypothesis 1a:** Interactivity is positively related to user involvement with interactive MR technologies.

**Hypertextuality – User Involvement Relationship**

Hypertextuality has been referred to as the high number of linked sources of content (Hoffman & Novak, 1996) and non-sequential connections among different information paths (Sundar, 2009). In literature, hypertextuality has been investigated in the frame of navigability (navigation) in which an exploratory association is formed between user actions and the interface (Hoffman & Novak, 2009).

Such a characteristic provides the ability to swiftly switch between connections, icons, and/or links across websites, interfaces, screens, etc. Thus, hypertextuality may be linked with time convenience as a relative advantage. Time convenience has been found to positively influence perceived and experiential value of technology usage (Tojib & Tsarenko, 2012) and stimulates users’ emotional and utilitarian motives (Kang, Mumb, & Johnson, 2015). Thus, users may perceive the technologies as attractive and motivating (affective involvement) and vital and significant (cognitive involvement).

Besides, confirmed consumer responses brought forward by the hypertextuality characteristic have been found to positively relate to affective states of user experience which lead to positive emotions and attitude (Flavian-Blanco, Gurrea-Sarasa, & Orus-Sanclemente, 2011); hedonic and effective browsing which may lead to intentions to buy or use (Park, Kim, Funches, & Foxx, 2012); and exploratory behavior which may lead to positive user involvement (Richard, Chebat, Yang, & Putrevu, 2010). Hence, it is plausible for the hypertextuality characteristic to have positive effects on user involvement concerning interactive MR technologies. Thus, the following hypothesis is formulated:

**Hypothesis 1b:** Hypertextuality is positively related to user involvement with interactive MR technologies.

**Modality – User Involvement Relationship**

Modality refers to the audio and visual contents (e.g., music, images, videos, texts) provided by the technology (Hoffman & Novak, 1996; Sundar, 2009) which influence the communication process. Thus, modality can be defined as a diversity of content display and representation (Sundar, Xu, & Dou, 2012). Contents found in interactive technologies may consist of 3D and animated formats.

Research has shown that online content (i.e., data, information, and knowledge) creates positive user involvement and responses which may lead to purchase and use intentions (Li & Meshkova,
Besides, confirmed consumer responses brought forward by the modality characteristic have been found to positively relate to cognitive (information) and affective (attitude) responses which in turn lead to behavioral intentions (Park, Stoel, & Lennon, 2008). High media richness related to AR/VR experiences has shown to positively influence user interest and perceptions which ultimately leads to a stronger user involvement with the technology (Huang & Hsu Liu, 2014). Thus, based on earlier evidence, the following hypothesis is formulated:

**Hypothesis 1c**: Modality is positively related to user involvement with interactive MR technologies.

**Connectivity – User Involvement Relationship**

Connectivity (network), as a technological capability, is a type of communication network that connects two or multiple users (senders and receivers) through different means of interactions to exchange information (Varadarajan et al., 2010). Such a characteristic may range from business video-calls to social media activities. Confirmed consumer responses brought forward by the connectivity characteristic have been found to positively relate to attitude towards intentions to use (Calder, Malthouse, & Schaedel, 2009); individual use, flow, enjoyment, engagement, involvement, and commitment (Pagani & Mirabello, 2011; Huang, 2012). Thus, based on earlier evidence, the following hypothesis is formulated:

**Hypothesis 1d**: Connectivity is positively related to user involvement with interactive MR technologies.

**Virtuality – User Involvement Relationship**

Virtuality refers to the capability of the technology in displaying virtual settings experienced by the user through immersion (Lister et al., 2008). Such characteristic creates user experience through VR (Blascovich & Bailenson, 2011). Immersion has been interchangeably used as a synonym for presence that enables a certain degree of user involvement and engagement (McMahan, 2003). Confirmed consumer responses brought forward by the connectivity characteristic have been found to positively relate to user enjoyment (Lee & Chung, 2008; Nah, Eschenbrenner, & Dewester, 2011), product involvement (Jin & Bolebruch, 2009), cognitive involvement (Huang & Liao, 2014), hedonic and utilitarian values (Merle, Senecal, & St-Onge, 2012), and presence, which ultimately lead to behavioral intentions (purchase, willingness to pay, use) (Huang & Liao, 2014). Thus, based on earlier evidence, the following hypothesis is formulated:

**Hypothesis 1e**: Virtuality is positively related to user involvement with interactive MR technologies.

**User Involvement – Continuous Usage Intention Relationship**

Involvement with the internet and mobile applications use was found to be an antecedent of positive attitude (McMillan et al., 2003), adoption intention (Jiang, Chan, Tan, & Chua, 2010), download and use intention (Kang et al., 2015), and purchasing intention (Grace & O’Cass, 2004).

In the context of interactive MR technologies, involvement (affective and cognitive) may be amplified when the user is experiencing affective and utilitarian indications/motives. Thus, positive emotions may lead to high levels of user involvement (affective and cognitive) and are expected to prompt the intention to use and continue using such technologies. On the other hand, negative emotions may lead to lower levels of user involvement (affective and cognitive) in case the technology is perceived as non-beneficial, non-practical, and unattractive. Hence, they are expected to decrease the desires and intentions to use or continue using interactive MR technologies. As such, the following hypothesis is formulated:
Hypothesis 2: User involvement (affective &/or cognitive) is positively related to continuous usage intention toward interactive MR technologies.

Moderator: Digital Literacy

Digital literacy was first coined as an individual knowledge of software and hardware; consequently, been referred to as an individual ability to comprehend hypertextuality and multimedia texts (Bawden, 2001); and later evolved to involve skills, knowledge, and proficiency in the mechanical use of devices for different purposes (Chisholm, 2006). Nevertheless, scholars have recently stressed on the idea that digital media or technologies should not be regarded as only machines and software, but rather as intellectual, social, and ethical communication mediums (Buckingham, 2008).

Therefore, in this research, digital literacy is referred to as the attentiveness, attitude, and capability of individuals to properly use technical devices for assessments of resources, establishments of new knowledge, creation of media terminologies, and construction of social communication processes (Martin, 2005). As such, digital literacy is inclusive of the concepts of information and media literacies which are processed within a digital environment (Bunz, Curry, & Voon, 2007).

In Information technology (IT) literature, digital literacy has been conceptualized into 5 sub-dimensions of skills (i.e., technological, communication, information, critical, and security) (Rodríguez-de-Dios & Igartua, 2016). All dimensions fall under the umbrella of digital or ICT (Information & Communication Technology) skills. Lack of ICT skills may cause an obstacle to benefit from the use of technologies (Van Deursen, Van Dijk & Peters, 2011) which may eventually lead to termination of the use.

ICT skills have been shown to reflect on user interactivity, participation, attachment, identification, and involvement (Islam, Islam, Bakar, & Mat, 2017). Similarly, digital or ICT skills have been found to influence users’ ICT adoption behavior (Click & Petit, 2010). Furthermore, in a recent study conducted by Yu, Lin, & Liao (2017), the impact of media experience on ICT adoption behavior was found to be moderated by digital skills.

In this research, it is expected that i) the impact of perceived media characteristics of interactive technologies on user involvement may be stronger for users with high levels of digital skills than those with low levels of digital skills, and ii) the impact of user involvement on the intention to continuously use interactive MR technologies may be stronger for users with high levels of digital skills than for those with low levels of digital skills. Thus, the following hypotheses are formulated:

Hypotheses 3a – 3e: The relationships between all perceived media characteristics of interactive technologies and user involvement are moderated by the level of digital skills, that is, the relationships are weaker under conditions of low digital skills and stronger under conditions of high digital skills.

Hypothesis 4: The relationship between user involvement and continuous usage intention toward interactive MR technologies is moderated by the level of digital skills, that is, the relationship is weaker under conditions of low digital skills and stronger under conditions of high digital skills.
To examine the twelve proposed hypotheses, an online survey method was implemented. Two different sources of data were employed. The first source involved participants from a U.S. online survey panel directed towards interactive technology users. By using such types of services, certain advantages (e.g., greater control over the selected attributes (i.e., location), cost-effectiveness, larger accessibility to participants, and effective time management) were achieved (Nimrod, 2018). The second source involved surveying MR technology users from multiple U.S. blogs, sites, online reports, media posts, and online review panels. The selection of the participants was random and anonymity was guaranteed (see Figure 2 for a detailed research method flowchart).

Two main motives for gathering data from two different sources. First, a sufficient number of observations should be collected to achieve reliable results. The first source provided a modest number of observations, thus another source was needed. Second, participation was limited to individuals who are currently using MR technologies. Users who never used or stopped using such technologies have been excluded in order to avoid any bias or misperception in the observations or any misinterpretation of the results. Such conditions led to restrictions in the number of participants and thus different sources of data were utilized.

The final sample size (n=268) is considered sufficient for this research. According to Sekaran (2003), i) sample sizes between 30 and 500 are appropriate for most research, and ii) in multivariate research, the sample size should be several times (10 times or more) as large as the number of variables in the study. In this research, both requirements have been met. Thus, the sample size is considered acceptable. Furthermore, to determine the sample size for a moderation analysis, a power analysis was conducted using G*Power (Faul, Erfelder, Buchner, & Lang, 2014). The analysis was based off the hierarchical linear regression (i.e., small effect size (f2) of .045, alpha of .05, a standard power level of .80; confidence level 90%; population proportion 50%; population size > 20,000; margin of error 5%). The results showed that an estimated 270 participants would be needed to achieve an appropriate power level. Thus, the current sample size may be considered as acceptable and satisfactory for this research.
The survey consisted of 29 items (see Table 1) with four demographics (gender, age, general technology experience, and current employment) (see Table 2). All of the items in the questionnaire followed a 5-point Likert scale (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree). To ensure the development of reliable and valid measures all items were adopted from previously validated studies, hence showing good internal consistency.

Table 1. Questionnaire items

<table>
<thead>
<tr>
<th>User Involvement (Zaichkowsky, 1994)</th>
<th>Cronbach’s alpha (0.851); Mean (3.338); Standard deviation (0.991)</th>
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<tbody>
<tr>
<td>UI 1 Using this MR technology is relevant</td>
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<tr>
<td>UI 2 Using this MR technology is appealing</td>
<td></td>
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<tr>
<td>UI 3 Using this MR technology is fascinating</td>
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</table>

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<thead>
<tr>
<th>Interactivity (Yuping, 2003)</th>
<th>Cronbach’s alpha (0.826); Mean (3.061); Standard deviation (0.992)</th>
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<tbody>
<tr>
<td>INT 1 I felt that I had a lot of control over my experiences with this MR technology</td>
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<tr>
<td>INT 2 This MR technology facilitates two-way communication between the user and others</td>
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<td>INT 3 I was able to obtain the information I want without any delay (easy response)</td>
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<tr>
<td>INT 4 When using the MR technology, I felt I was getting instantaneous information</td>
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<tr>
<th>Hypertextuality (Deuze, 2001; Chung, Nam, &amp; Stefanone, 2012)</th>
<th>Cronbach’s alpha (0.850); Mean (3.647); Standard deviation (0.881)</th>
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<tbody>
<tr>
<td>HYPT 1 The MR technology is easy to access via simple procedures</td>
<td></td>
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<tr>
<td>HYPT 2 The MR technology presents other texts and features simultaneously</td>
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</tbody>
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Table 1 continued on next page
Table 1 continued

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<thead>
<tr>
<th>Measure</th>
<th>Items</th>
<th>Cronbach’s alpha</th>
<th>Mean</th>
<th>Standard deviation</th>
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<tr>
<td><strong>User Involvement (Zaichkowsky, 1994)</strong></td>
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<tr>
<td>HYPT 3</td>
<td>The MR technology can easily share information with others via hyperlinks</td>
<td>0.851</td>
<td>3.338</td>
<td>0.991</td>
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<tr>
<td><strong>Modality (adapted from Multimediality (Paulussen, 2004))</strong></td>
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<tr>
<td>MOD 1</td>
<td>The MR technology uses photos, drawings, slideshows, and audio and video cues</td>
<td>0.852</td>
<td>3.779</td>
<td>0.899</td>
</tr>
<tr>
<td>MOD 2</td>
<td>The MR technology is equipped with high-resolution pixels</td>
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<td>MOD 3</td>
<td>The MR technology is showy and flashy</td>
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<td><strong>Connectivity (adapted from overall (social) connectedness (Lee &amp; Robbins, 1995; Van Bel, Smolders, Ijsselsteijn, &amp; De Kort, 2009))</strong></td>
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<tr>
<td>CONN 1</td>
<td>The MR technology entitles me to socially get in contact with other users</td>
<td>0.874</td>
<td>2.593</td>
<td>1.056</td>
</tr>
<tr>
<td>CONN 2</td>
<td>The MR technology has a wide range of connectivity channels</td>
<td></td>
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<tr>
<td>CONN 3</td>
<td>The MR technology is equipped with multiple communication models</td>
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<td>CONN 4</td>
<td>The MR technology allows for the simultaneous exchange of messages</td>
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<td><strong>Virtuality (adapted from the Immersion Tendency Questionnaire (ITQ) (Witmer &amp; Singer, 1998; Tcha-Tokey, Christmann, Loup-Escande, &amp; Richir, 2016))</strong></td>
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<td>VIR 1</td>
<td>I felt stimulated by the MR environment</td>
<td>0.796</td>
<td>3.924</td>
<td>0.806</td>
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<tr>
<td>VIR 2</td>
<td>I become so involved in the MR environment that I was not aware of things happening around me</td>
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<tr>
<td>VIR 3</td>
<td>I felt physically fit in the MR environment</td>
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<tr>
<td>VIR 4</td>
<td>I become so involved in the MR environment that I lose all track of time</td>
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<td><strong>Digital literacy (Rodríguez-de-Dios, Igartua, &amp; González Vázquez., 2016)</strong></td>
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<tr>
<td>DL 1</td>
<td>I always know how to connect to networks, no matter what is the device/platform</td>
<td>0.857</td>
<td>3.566</td>
<td>0.720</td>
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<tr>
<td>DL 2</td>
<td>I know how to determine if the information I find is reliable</td>
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<td>DL 3</td>
<td>I know how to use this MR technology to detect and remove viruses</td>
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<tr>
<td>DL 4</td>
<td>I know how to compare different sources to decide if the information is true</td>
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<tr>
<td><strong>Continuous usage intention (Lee &amp; Kwon, 2011)</strong></td>
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<tr>
<td>CUI 1</td>
<td>I intend to continue using this MR technology</td>
<td>0.917</td>
<td>2.622</td>
<td>1.091</td>
</tr>
<tr>
<td>CUI 2</td>
<td>I expect to continue using this MR technology in the future</td>
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<tr>
<td>CUI 3</td>
<td>I expect to increase my usage of MR technology in the future</td>
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<tr>
<td>CUI 4</td>
<td>I intend to re-use this MR technology whenever the need arises</td>
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</table>

*Technology also refers to platform, software, interface

*Mahalanobis test (Tabachnik & Fidell, 2013)
RESULTS

Data were primarily analyzed using SPSS 23.0 and AMOS 23.0. Other tools were also used to double-check the results (e.g., STATA and smartPLS 3). Several tools were utilized because a) each software delivers information on diverse aspects of validity, and b) there is yet no agreement on types of tests that reflect adequate validity standards (Lombard et al., 2015). In this research, adopting various statistical tests supports gaining inclusive insights from different types of validity analyses and sources. The moderation effects were tested in the form of two-way interaction analysis (Aiken & West, 1991) to know the direction of the relationships and if the slopes of the lines were significantly different from each other. Further measures were undertaken (i.e., simple slope tests) to know more about the specific relationships at particular levels of the independent variables (Cohen, Cohen, West & Aiken, 2003).

Because of the relatively small-to-moderate sample size, tests for normality were conducted by using normal Q-Q plotting as a graphical method of assessment. All results were satisfactory. Furthermore, tests for the assumption of homoscedasticity were carried out (user involvement as a dependent variable for the first test; and continuous usage intention as a dependent variable for the second test). Assumptions were met, thus the variance of the residuals seemed to be constant for both dependent variables.

Since the data was self-reported and collected over a specific time, then common method variance may cause measurement error. To overcome such an issue, exploratory factor analysis (EFA) was conducted by showing the presence of eight (more than one) distinct factors (eigenvalues > 1.0; cumulative 74.668%). Hence, since no single or general factor emerged for most of the variance, thus common method variance is not a concern.

Moreover, the content was tested multiple times for consistency between the instrument, measurement items, and the existing literature (Haynes, Richard, & Kubany, 1995). The factor loading values exceeded 0.30 (Yusoff, Esa, Mat Pa, Mey, & Aziz, 2011), which are considered as significant values showing robust indicators-construct correlations. Cronbach’s alphas of the constructs were above 0.70 (Nunnally, 1978), thus, showing good-to-excellent internal consistency. Convergent validity

<table>
<thead>
<tr>
<th>Measures</th>
<th>Descriptions</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>18 - 24</td>
<td>66</td>
<td>24.6</td>
</tr>
<tr>
<td></td>
<td>25 - 31</td>
<td>138</td>
<td>51.5</td>
</tr>
<tr>
<td></td>
<td>32 - 38</td>
<td>46</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>&gt;38</td>
<td>18</td>
<td>6.7</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>174</td>
<td>64.9</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>94</td>
<td>35.1</td>
</tr>
<tr>
<td>Technology experience</td>
<td>0 - 5</td>
<td>88</td>
<td>32.8</td>
</tr>
<tr>
<td></td>
<td>6 - 11</td>
<td>137</td>
<td>51.5</td>
</tr>
<tr>
<td></td>
<td>12 - 17</td>
<td>37</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>&gt;17</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>Current employment</td>
<td>Student</td>
<td>90</td>
<td>33.6</td>
</tr>
<tr>
<td></td>
<td>Unemployed</td>
<td>23</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>Employee</td>
<td>107</td>
<td>39.9</td>
</tr>
<tr>
<td></td>
<td>Employer</td>
<td>10</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Private</td>
<td>38</td>
<td>14.2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>268</td>
<td>100</td>
</tr>
</tbody>
</table>
was assessed by examining the composite reliability (CR) and average variance extracted (AVE) for the measures. Both had minimum scores of 0.70 and 0.50, respectively, which are considered acceptable levels (Fornell & Larcker, 1981). Furthermore, the discriminant validity of the constructs was checked by showing that the estimates of MSV are less than AVE (MSV < AVE) (Fornell & Larcker, 1981).

Appropriateness of the model was assessed providing an average-to-good overall measurement model fit (see Table 3). Furthermore, multicollinearity issues were investigated by examining the variance inflation factors (VIF = (1/1-R²)) through the R, R², & adjusted R². Results were satisfactory with VIF estimate (1.57) < 5. (Gruber et al., 2010), thus, multicollinearity is not an issue in this research.

**Hypotheses Testing**

Table 3 shows that INT (t= 2.291; β= 0.139; p< 0.05); MOD (t= 4.583; β= 0.271; p< 0.01); VIR (t= 3.596; β= 0.215; p< 0.01) and CONN (t= 5.007; β= 0.293; p< 0.01) significantly and positively relate to user involvement. On the other hand, HYPT (t= .383; β= .023; p> 0.05) showed no correlation with user involvement. Hence, H1a, H1c, H1d and H1e are supported, whereas H1b is not supported. In addition, user involvement showed a positive correlation with continuous usage intention (t= 3.261; β= .990; p< 0.01), thus H2 is supported. Furthermore, digital literacy showed to be a significant and positive construct related to the outcome user involvement (t= 7.414; β= 0.414; p< 0.01) and a significant moderator to the INT-Ul (t= 4.772; β= 0.281; p< 0.01), HYPT-Ul (t= 4.738; β= 0.279; p< 0.01), MOD-Ul (t= 7.430; β= 0.415; p< 0.01), VIR-Ul (t= 6.919; β= 0.391; p< 0.01), CONN-Ul relationships (t= 6.849; β= 0.387; p< 0.01). Hence, H3a-H3e are fully supported. Similarly, digital literacy showed to be a significant moderator to the UI-CUI relationship (t= 2.850; β= 1.207; p< 0.01). Hence, H4 is fully supported.

Figures 3 to 7 show that the relationships between perceived characteristics of interactive technologies and user involvement were greater for mixed reality platform users with high digital literacy than for those with low levels. At low levels of digital literacy, low levels of perceived characteristics of interactive technologies lead to low levels of user involvement, whereas high levels of perceived characteristics of interactive technologies lead to higher levels of user involvement (except for HYPT (Figure 4)). Figure 4 uniquely shows that high levels of HYPT lead to lower levels of user involvement rather than higher levels (i.e., a decreasing rather than an increasing slope).

Whereas, at high levels of digital literacy, low levels of perceived characteristics of interactive technologies lead to moderate-to-high levels of user involvement, whereas high levels of perceived characteristics of interactive technologies lead to even higher levels of user involvement (except for HYPT (Figure 4)). Figure 4 showed a relatively constant trend rather than an incremental effect. Nevertheless, high levels of digital literacy lead to high levels of user involvement irrespective of the levels of perceived characteristics of interactive technologies.

Furthermore, Figure 8 shows that digital literacy strengthens rather than dampens the positive relationship that already exists between user involvement and continuous usage intention. Thus, the relationship between user involvement and continuous usage intention was greater for mixed reality platform users with high digital literacy than for those with low levels. At low levels of digital literacy, low levels of user involvement lead to low levels of continuous usage intention, whereas high levels of user involvement lead to higher levels of continuous usage intention. At high levels of digital literacy, low levels of user involvement lead to moderate-to-high levels of continuous usage intention, whereas high levels of user involvement lead to even higher levels of continuous usage intention. Thus, high levels of digital literacy lead to high levels of continuous usage intention irrespective of the levels of user involvement.
Table 3. Regression Analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>User involvement (UI)</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
<td>Stnd β</td>
</tr>
<tr>
<td>Interactivity (INT)</td>
<td>2.291**</td>
<td>.139**</td>
</tr>
<tr>
<td>Hypertextuality (HYPT)</td>
<td>.383</td>
<td>.023</td>
</tr>
<tr>
<td>Modality (MOD)</td>
<td>4.583*</td>
<td>.271*</td>
</tr>
<tr>
<td>Connectivity (CONN)</td>
<td>5.007*</td>
<td>.293*</td>
</tr>
<tr>
<td>Modality (MOD)</td>
<td>3.596*</td>
<td>.215*</td>
</tr>
<tr>
<td>Digital Literacy (DL)</td>
<td>7.414*</td>
<td>.414*</td>
</tr>
<tr>
<td>DL x INT</td>
<td>4.772*</td>
<td>.281*</td>
</tr>
<tr>
<td>DL x HYPT</td>
<td>4.738*</td>
<td>.279*</td>
</tr>
<tr>
<td>DL x MOD</td>
<td>7.430*</td>
<td>.415*</td>
</tr>
<tr>
<td>DL x CONN</td>
<td>6.849*</td>
<td>.387*</td>
</tr>
<tr>
<td>DL x VIR</td>
<td>6.919*</td>
<td>.391*</td>
</tr>
</tbody>
</table>

* <.01; **<.05;
*** CMIN/DF (Hair et al., 2010); CFI (Hair et al., 2010); RMSEA (Hooper et al., 2008)

Figure 3. Moderating effects of DL on the INT-UI relationship

![Figure 3](image1.png)

Figure 4. Moderating effects of DL on the HYPT-UI relationship

![Figure 4](image2.png)
Figure 5. Moderating effects of DL on the MOD-UI relationship

Figure 6. Moderating effects of DL on the CONN-UI relationship

Figure 7. Moderating effects of DL on the VIR-UI relationship
The results showed that users’ perceived modality and connectivity were the most influential antecedents that shaped the users’ affective and cognitive involvement with interactive MR technologies, which in turn influenced their behavioral intentions. Perceived virtuality and interactivity came as comparatively influential antecedents, whereas, perceived hypertextuality showed no significant correlation. Thus, the focus of the discussion will be on the hypertextuality characteristic which was found not to be supported.

First, user involvement was a significant determinant of intention to continuously use interactive MR technologies. This result supports previous studies that showed the positive influence of user involvement on behavioral intentions (e.g., Jiang et al., 2010). Tech organizations need to consider users’ emotional responses to newly introduced/upgraded innovative products/services (Grace & O’Cass, 2004). As such, tech organizations need to strengthen the affective and cognitive factors of their products/services, thus making them more appealing, useful, and practical.

Second, perceived hypertextuality is still an underdeveloped characteristic of interactive technologies (Javornik, 2016). Thus, the results confirm such claims and also oppose studies which suggest that hypertextuality is the most influential characteristic in terms of internet-related technologies (e.g., Google and Yahoo index search engines and websites) (e.g., Chung, Nam, & Stefanone, 2012). Hence, tech organizations should enhance the credibility of their hypertextuality features since lack of such characteristics may lead to failure of choosing multimedia options, failure of information flow, and weak content response (Chung et al., 2012).

Third, the role of digital literacy as a moderator showed that digital skills are essential for almost all types of professions and occupations. Acquiring such technological abilities are found to be compulsory and crucial in our modern society (Bunz et al., 2007). This research supports such claims in the context of MR. However, and unexpectedly, digital literacy showed to have different moderating effects on the HYPT-UI relationship when compared to all the other relationships. The analysis showed that at low levels of digital literacy, high levels of HYPT lead to lower levels of user involvement rather than higher levels (i.e., a decreasing rather an increasing slope), whereas at high levels of digital literacy, a relatively constant trend was observed rather than an incremental effect.

In a recent study conducted by Narine (2018), it was mentioned that earlier studies related to hypertextuality & literacy research areas have shown contradicting findings concerning whether hypermedia (technology-related) or printed text (traditional paper) is superior for learning and remembering practices. As such, hypertextuality has been referred to as a new form of nonlinear literacy that displaces traditional textual forms (Bazerman, 2009). Based on the present research, it is argued that hypertextuality characteristic is still not to be considered as superior to traditional
methods or when compared to other interactive characteristics because of existing flaws in design and barriers to access (e.g., complexity in reading texts, multiple hyperlinks within a single text, blurring of the navigation chart, separation from the actual content, opinion polarization, etc.). All such obstacles have been reported to lead to cognitive and mental overload (Narine, 2018), which may eventually cause the user not to be involved in any related activities. This statement also supports the absence of a positive relationship between hypertextuality and user involvement as was shown in H1b. To conclude, irrespective of the level of digital literacy, because of the existent barriers, it is not necessary for high levels of hypertextuality to lead to high user involvement. On the contrary, user involvement might be negatively affected either way and thus users will tend to discontinue their involvement & use of the technologies.

**IMPLICATIONS**

Hypertextuality characteristic developed to be the main focus of this research. The findings reveal a new level of understanding for tech organizations dealing with MR technologies. The research argues that hypertextuality characteristics should be fundamentally developed. Although the MR industry is shaping up the future of technology, it is now apparent that perhaps because of this specific characteristic, organizations are encountering challenges in maintaining or attracting new customers as recently reported by the media (e.g., Fortune, 2019; TheAppSolutions, 2019).

For that reason, this research calls for introducing intertextuality. Intertextuality is a linguistic network connecting the existing text with other preexisting texts, thus acting like a guide rather than a distraction (as found in hypertextuality) (Riffaterre, 1994). Textuality is inseparable from intertextuality. Because of their practical and useful purposes, texts should give meaning. Hypertextuality has been shown to expose the user to irrelevant information, whereas intertextuality excludes irrelevant data while providing the relevant ones. Hypertextuality is derived from the text to summarize the ideas, whereas intertextuality is produced by textuality and remains beyond the text’s limits. Therefore, IS designers and engineers are recommended for augmenting the role of intertextuality into their software design systems rather than fixating on the hypertextuality characteristic. This way organizations may discover new grounds for further developing their technological products and services.

**Limitations & Future Research Directions**

Each research has few limitations. First, the sample followed a uniform composition which did not permit for proper separation of types of users and their activities. Second, the study did not examine all of the perceived characteristics of interactive technologies (i.e., location-specificity and mobility). Mobility is related to wearable-portable-smart devices, whereas location-specificity allows tracking of personal smart devices. Both characteristics apply to mobile interactive technologies rather than on fixed interactive screens or platforms. Future research can replicate the same study with the inclusion of these two characteristics based on different types of interactive tools and devices. For instance, there are types of MR platforms that are business-oriented rather than individual-oriented (e.g., RE’FLEKT). Focusing on such types of interactive MR technologies may have higher significance and practical implications for tech organizations.

**CONCLUSION**

This research has delivered new understandings on how the concept of interactive MR technologies is perceived among different types of users in the US. The main purpose was to empirically examine whether the five perceived characteristics of interactive technologies were related to user involvement, which in turn were related to the user’s intention to continue using interactive MR platforms. Findings revealed that only hypertextuality had no significant effects on user involvement. Furthermore, unique moderating effects were observed for hypertextuality and user involvement relationship. Results showed that regardless of the level of digital literacy, high levels of hypertextuality would eventually lead to lower (or relatively constant) levels of user involvement. This research may serve as a wake-
up call for tech organizations that are struggling in gaining momentum in the MR industry. Thus, by shedding light on a specific technological characteristic that may be hindering organizations in realizing their achievements, this research contributes to creating new knowledge for the existing body of literature and building awareness for tech organizations.

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