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VIRTUAL REALITY AS A TRANSFORMATIVE TECHNOLOGY: A LITERATURE REVIEW AND RESEARCH OPPORTUNITIES

Research full-length paper

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Abstract

Virtual reality (VR) provides unique visualization capabilities rendering it a potentially transformative digital technology. Rapid consumerization of VR has triggered an interest in organizations to explore diverse value creation opportunities. However, VR scholarship is currently dominated by technical and psychological perspectives. This paper therefore examines the current state of research on VR with a particular focus on organizational aspects to investigate its role in digital transformation (DT). The analysis reveals that it focuses on three key areas: user experience design, e-commerce and retail, and collaboration. Placing these areas in a context of DT, the paper articulates several opportunities for IS research.

Keywords: Virtual reality, Digital transformation, Value Creation, Digital innovation.

1 Introduction

Firms' digital transformation (DT) efforts are typically triggered by challenges and/or opportunities associated with emerging technologies (Hanelt et al., 2021; Vial, 2019). Virtual reality (VR) is a prime example of such a technology: Its recent mass market introduction has triggered firms in manufacturing industries to consider its use throughout the value chain (Haj-Bolouri, 2023; Kostis and Ritala, 2020). New low-cost and user-friendly devices (e.g., Oculus Rift and Google Daydream) have increased consumer adoption of VR solutions. As the exponential growth in computational capacity continues, VR is likely to present an increasing amount of digital innovation opportunities (Hund et al., 2021). The outcomes of such digital innovation efforts may in turn accelerate firms' DT, encompassing digitally driven changes in their processes, products, and business models (Matt et al., 2015).

VR is a computer-generated 3D environment that has the ability to generate users' sense of immersion and presence in that environment (Steuer, 1992; Suh and Lee, 2005). It does so by stimulating one or more of the five senses. VR thus reflects an "actual world" environment on the virtual world, allowing users to navigate (i.e. move around and explore) and interact (select and move objects) (Guttentag, 2010). Therefore, the potentials associated with consumerized VR are particularly pronounced in traditional industries with products and services that can never be fully digitized (Kostis and Ritala, 2020).

In both research and practice, VR is traditionally associated with entertainment and education, and the video game industry continues to play a significant role in its evolution (Gutierrez et al., 2008). Past VR research has focused on technical designs that can prepare users for the "actual task" at hand in the physical world (e.g. Bhagat et al., 2016; Sveistrup, 2004). Such studies often apply pedagogical, psychological, behavioral, and engineering perspectives. Scholars have repeatedly called for more information systems (IS) studies on VR. For example, Walsh and Pawlowski (2002) suggested a focus on immersion, interactivity and presence in VR contexts. Several authors have since contributed to such understanding (e.g., Dincelli and Yayla, 2022; Haj-Bolouri, 2023; Saunders et al., 2011; Schultze,

2010). However, most of these studies focus on human perception, affordances, and sensemaking, neglecting strategic, managerial, and operational concerns in the design and use of VR.

The continued expansion of VR and its capabilities will likely increase the potential for digital innovation (Kostis and Ritala, 2020). In turn, persistent digital innovation efforts with VR will have implications on a firm's digital transformation journey, affecting how it does business. VR's novel capabilities should not be neglected (Schultze, 2010) but should most certainly be understood and leveraged within a context of DT. Therefore, this paper reviews previous IS research (including broader organizational literature) on VR to position it in a context of DT to illuminate new research opportunities for IS scholarship. Drawing on a systematic literature review (Templier and Paré, 2015; Webster and Watson, 2002), this paper explores the following research question: *How can current IS research on VR be understood within a context of DT, and what new research opportunities does such an understanding generate?* Our review identifies three categories in the literature – user experience design, e-commerce and retail, and collaboration emerged. Relating these categories to DT, the paper offers multiple research opportunities for IS scholarship.

2 Methods

This literature review follows a systematic approach (Templier and Paré, 2015; Webster and Watson, 2002) in a four-step process: (1) identifying relevant outlets, (2) identifying literature, (3) selecting and evaluating literature, and (4) coding and thematizing the selected literature (see Figure 1).

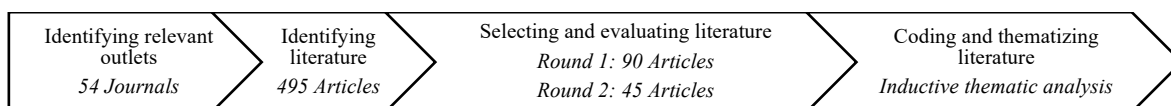


Figure 1. Systematic review process.

In step 1, we started by locating the top-ranked IS journals as the first relevant outlets (Webster and Watson, 2002). The AIS senior scholars' basket of eight¹ is considered to represent top-tier peer-reviewed and mature IS journals. After an initial search in these journals using the keyword "virtual reality", we decided to explore additional databases: ProQuest, Taylor Francis, Wiley, PubMed, ScienceDirect, Sage, Jstor and AIS. We considered these to be essential databases holding critical IS journals. The keywords "information", "system", "technology", "management", "organization", "innovation" and "business" were used as search terms to locate the relevant journals within each database. Since IS is an interdisciplinary field, the three latter keywords were included to capture broader organizational research investigating VR. Indeed, organizational research has been shown to be at the forefront of IS research (cf. Malone and Crowston, 1994; Robey et al., 2000). Journal descriptions were read in order to understand their scope and focus. The journal selection process resulted in the inclusion of 54 journals.

In step 2, we searched in each identified journal for peer-reviewed articles in the period 1990–2020 using the keyword "Virtual reality" with the criteria of "everywhere" being in the article. The rationale behind the 30-year timeframe was to capture as many articles as possible that addressed VR. The "everywhere" criteria were used because the goal was to capture broader contributions that addressed "virtual" concepts and the other two parameters, "in abstract" or "in title", rendered limited results. The search was performed on 14 April 2020 and resulted in 495 articles. Figure 2 below illustrates how these articles were distributed over the 54 journals.

¹ Since conducting the literature search, the AIS senior scholars' list of premier journals has been extended to include a total of 11 journals.

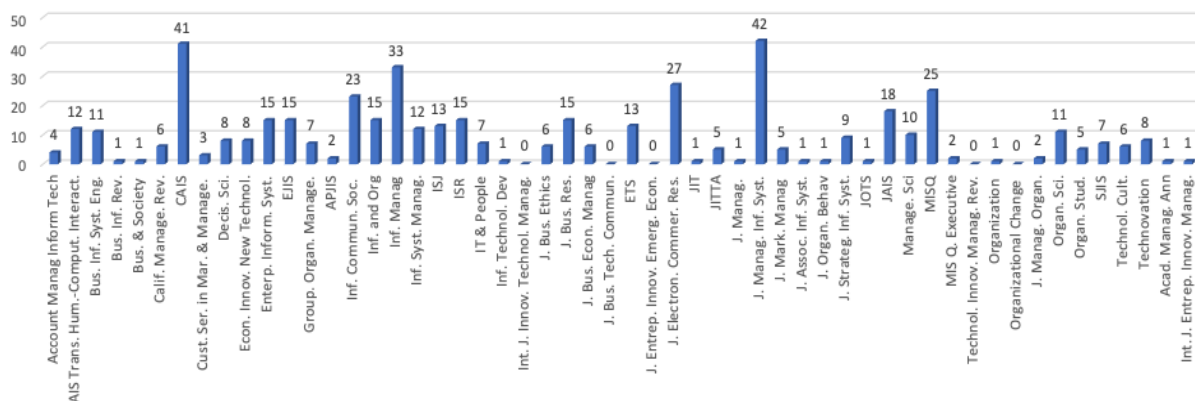


Figure 2. Journals included and initial article volume.

In step 3, we selected relevant articles among those 495 articles retrieved in the initial search (Templier and Paré, 2015). Titles and abstracts were screened to determine whether the articles were worthy of review. We developed an exclusion-inclusion criteria (Table 1) in line with our research focus: To find articles that investigate VR from, and in relation, to organizational aspects to understand the current state of IS contributions in relation to DT. During the first round, the inclusion criteria were used iteratively among the author team to evaluate bias and interpretations in the selection processes. Articles focusing on low-immersion VR settings covering “virtual aspects” (e.g., virtual environments, virtual worlds, virtual teams, virtual communities) were evaluated as being essential contributions. However, several of these articles were excluded as they did not meet the review criteria. 90 articles passed the first selection and evaluation round. The second round involved a more detailed review of the 90 articles to evaluate why they had passed the first selection round, which resulted in the removal of 25 articles that did not meet the criteria. An additional 20 articles were removed as they used the notion of “virtuality” synonymously with web-based collaborative IT systems without addressing VR’s immersive capabilities. Hence, after the second selection and evaluation round, 45 articles remained for inclusion in the literature review.

Inclusion	Exclusion
1. Investigates VR use within organizational boundaries.	- Duplicates
2. Addresses organizational implications of VR.	- Non-research articles (e.g., notes, special issues, commentaries)
3. Provides theoretical implications concerning VR in organizations.	- Articles only using VR as a future descriptive example without addressing it as a technology, application, or artifact.

Table 1. Inclusion-exclusion criteria.

In step 4, we conducted in-depth analysis of the selected articles. We applied iterative thematic analysis to codify the articles into broader conceptual themes (Templier and Paré, 2015). The aim was to identify patterns and similarities in what was under study, and how VR was addressed and situated. The analysis revealed three salient categories: user experience design, e-commerce and retail, and collaboration.

3 Results

The analysis of the 45 papers shows that most IS research on VR concerns user experience design, e-commerce and retail, and collaboration in different forms. The scope of each category is explained in the following results section.

3.1 User experience design

The articles in this category focus on the social dimensions of VR to better understand and improve user experience design (see Table 2). Thus, the focus lies on VR's immersive and interactive capabilities (Nah et al., 2011; Riedl et al., 2014; Saunders et al., 2011; Zhou et al., 2012) and the role of human sociality, cognition and embodiment during VR use (Mennecke et al., 2011; Schultze, 2014; Schultze and Brooks, 2019). They also cover user attitudes (Suh et al., 2011), intentions to use (Shen and Eder, 2009), perceptions and experiences of virtual currencies (Jung and Pawlowski, 2014), and virtual goods (Ke et al., 2012). The category is dominated by conceptual and quantitative approaches.

The articles in this category either investigate virtual worlds (VW) or Second Life (SL) which are Internet-based 3D-social networking environments that allow users to do things that are impossible in real life, such as flying (Shen and Eder, 2009), the ability to interact, navigate and manipulate 3D objects and socialize with other people in real time with global reach (Nah et al., 2011; Saunders et al., 2011). Several articles in this category pay specific attention to comparing and theorizing physical interaction and socialization with its virtual counterparts to increase our understanding of virtual experiences (Riedl et al., 2014; Schultze, 2014; Schultze and Brooks, 2019; Suh et al., 2011). Overall, this research stream offers a broad spectrum of theoretical contributions concerning the relationship between VR's interactive capabilities and humans as social beings.

Authors	Journal	Summary
Dholakia and Reyes (2013)	Journal of Marketing Management	Investigates virtuality as a process and contributes by highlighting the role of transmediation and information management practices in the age of big data.
Jung and Pawlowski (2014)	Journal of Business Research	Investigates users' experience of consuming virtual goods. The authors identify and visually map key concepts and relationships representing the collective perceptions of virtual consumption.
Mennecke et al. (2011)	Decision Sciences	Generate a process theory of five stages of embodied social presence to be used by researchers seeking to understand how socio-cognitive aspects play out in VR contexts.
Nah et al. (2011)	MIS Quarterly	Examine the effects of using 2D versus 3D VWs. They show that 3D VW environments have the potential to increase brand equity by offering an immersive and enjoyable virtual product experience. However, the rich environment can also be a distraction.
Riedl et al. (2014)	Journal of Management Information Systems	Investigate the differences and similarities of avatar versus human interaction. The study shows that while interaction on the Internet may have benefits, the lack of real human faces in communication may serve to reduce these benefits, in turn leading to reduced levels of collaboration effectiveness.
Saunders et al. (2011)	MIS Quarterly	Draws on SL's interactive capabilities in developing and testing a theory distinguishing between space, place, presence, and their interrelationships in VW. Offers design implications for spatial design of VW meeting places.
Schultze (2010)	Journal of Information Technology	Reviews the literature on embodiment and presence in VW. Presents seven tentative research opportunities for IS researchers focusing on the role of the avatar as an IT artifact.
Schultze (2014)	European Journal of Information Systems	Investigates identity embodiment by SL entrepreneurs revealing that they intentionally represented some attributes of their own physical bodies in their avatars.

Schultze and Brooks (2019)	Information Systems Journal	Offer a model of social presence in VVs which underscores the necessary material and social conditions for users to perceive virtual users in the present.
Shen and Eder (2009)	Journal of Electronic Commerce Research	Proposes and tests a model of users' intention to use SL revealing that perceived usefulness and perceived enjoyment have a significant impact on users' behavioral intentions to use SL. However, the perceived ease of use was not a significant direct antecedent to behavioral intentions.
Ke et al. (2012)	Decision Sciences	Studies permission rights and pricing strategies in SL. They identify the permission rights of virtual goods as non-random because creators strategically set them for their virtual creations.
Suh et al. (2011)	Journal of Management Information Systems	Shows that the more an avatar resembles its user, the more likely the user will have positive attitudes towards it. The goals of using avatars should thus be to balance real and virtual interactions and design the avatars as close to reality as possible.
Zhou et al. (2012)	Journal of Management Information Systems	Develops a model of VV continuance usage. They find affective commitment (being attracted to) and calculative commitment (being locked in) as two mechanisms affecting continuance usage of VVs.

Table 2. User experience design articles.

3.2 E-commerce and retail

This category explores the virtualization of organizations' customer-facing dimensions by focusing on the transition from physical commerce and retail to Internet-based virtual commerce (see Table 3). In contrast to the previous research stream, this category shifts focus from *user* to *customer*, and from experience and presence to product visualization. It pays specific the utilization of 3D virtual representations on e-commerce sites to increase sales and brand awareness. For example it addresses how virtual product uncertainty can be managed (Dimoka et al., 2012; Hong and Pavlou, 2014), and how e-commerce sites can improve brand attitude through VR (Hooker et al., 2019). It also covers how VR affects product-related consumer learning (Suh and Lee, 2005), purchasing intentions (Papagiannidis et al., 2013; White Baker et al., 2019), and sales results (Yang and Xiong, 2019). Most of the articles are conceptual and quantitative. Only a few draw on empirical data.

A general concern in the category is whether 3D virtual product representations fulfill customers' real-world expectations. Four articles investigate how such challenges can be addressed (Dimoka et al., 2012; Featherman et al., 2006; Harwood and Garry, 2010; Hong and Pavlou, 2014). In this context, the differences between 2D and 3D representations are explored to generate design and strategy implications (Gadalla et al., 2013; Hassouneh and Brengman, 2015; Hooker et al., 2019; Jiang and Benbasat, 2007, 2004). The majority of articles explore web-based VR on PCs and smartphones. However, three articles include VR hardware and other haptic devices (i.e., head-mounted displays, gloves, glasses) to compare and explore its immersive implications in increasing sales (Bigné et al., 2016; Liu et al., 2019; Peukert et al., 2019). In sum, this category offers valuable knowledge on how the interactive capabilities of 3D representations can be leveraged by organizations to improve e-commerce and retail.

Authors	Journal	Summary
Bigné et al. (2016)	Journal of Business Research	Explores consumer choice, customer experience, and shopping behavior in a virtual supermarket. Discovers that the

		amount of time buyers spend on their first choice of brand drives their decisions on other brands.
Dimoka et al. (2012)	MIS Quarterly	Shows how eBay Motors utilized 3D and VR representations to mitigate product uncertainty (a buyer's difficulty in evaluating a product's characteristics).
Featherman et al. (2006)	Information Systems Journal	Conceptualizes consumer perceptions of risk in e-commerce service encounters. They find that user-friendliness is an effective way of making customers trust e-commerce websites.
Gadalla et al. (2013)	Journal of Marketing Management	Presents a framework that shows how 3D service quality involves customer service, product dimension, store dimension and a 3D platform dimension, in which human contact, emotional expressiveness, virtual trail and fantasy products extend and proceed 2D.
Harwood and Garry (2010)	Journal of Marketing Management	Illustrates how VR services enable value co-creation around purely digital products as consumers can take ownership, define, and create their own post-product consumption experience by continuously modifying and co-evolving the product.
Hassouneh and Brengman (2015)	Journal of Electronic Commerce Research	Develops a typology of virtual retail, which can be used by researchers and practitioners to better understand how to improve design of virtual shopping.
Hong and Pavlou (2014)	Information Systems Research	Shows that the degree to which a consumer can assess whether product attributes match their preferences strongly correlates with customer satisfaction in VR online markets.
Hooker et al. (2019)	Information Technology & People	Focuses on how online 3D shopping environments can improve brand attitude and purchase intent, arguing that to influence purchase intentions, organizations should design their 3D shopping environment to be as enjoyable as possible, causing customers to feel a loss of sense and time.
Jiang and Benbasat (2004)	Journal of Management Information Systems	Shows how virtual product experience (the ability for customers to experience a product virtually) increases customers' perceived product understanding from picture-based product presentations.
Jiang and Benbasat (2007)	Management Information Systems	Extends the virtual product experience concept by investigating product understanding and task complexity in a 3D online shopping environment. Their results show that video and virtual product experience improve product understanding and task complexity compared to static pictures.
Liu et al. (2019)	Journal of Management Information Systems	Discovers that touchscreens outperform mid-air gestures and mouse-based interactions in inducing haptic imagery. Mid-air gestures exceed the other two in terms of producing spatial imagery.
Papagiannidis et al. (2013)	Journal of Marketing Management	Examine the determinants of users' experience in virtual stores. Engagement and enjoyment were found to influence user satisfaction positively when choosing clothing products and, in turn, user satisfaction was found to influence purchasing intention positively for these products.
Peukert et al. (2019)	Journal of Management Information Systems	Compares the effects of head-mounted display use (high immersion) versus desktop computers (low immersion) in a 3D shopping environment. They find that the immersion level does not affect the customers' intention to reuse the shopping environment.

Suh and Lee (2005)	MIS Quarterly	Investigates if VR enhances consumer learning about physical products. Their findings show that VR interfaces increase consumer learning about products.
White Baker et al. (2019)	Information & Management	Investigates consumer behavior in e-commerce VW environments by particularly focusing on perceived social presence and telepresence, and their effects on attitudes toward e-commerce and intentions to purchase.
Yang and Xiong (2019)	Journal of Management Information Systems	Explore whether virtual fitting rooms (VFR) influence sales and post-sales outcomes. They find that VFR can have a sizeable positive effect on sales, it can be counterproductive when used improperly. However, VFR did enhance customer satisfaction and reduce product return rate.

Table 3. E-commerce and Retail articles.

3.3 Collaboration

The articles in this category explore VR's interactive capabilities to improve collaboration and learning in organizations (see Table 4). In contrast to the two previous categories, the focus here is *organizational members* rather than on *customers* or *users*. Consequently, it addresses for example how VR improves and changes work practices (Bailey et al., 2012; Stampe and Müller, 2018), team dynamics (Schmeil et al., 2012; Venkatesh and Windeler, 2012), innovation (Bhagwatwar et al., 2017; Chandra and Leenders, 2012; Kohler et al., 2009), and learning (Dodgson et al., 2013; Richardson, 2007). The category contains qualitative studies and conceptual contributions.

To achieve efficient virtual work, organizations need to understand VR's capability to enable different types of representations, customization, integration, and immersion (Steffen et al., 2019). These capabilities will affect how work can be conducted in various new ways. Five articles provide insights on how VR can trigger new digital practices that give rise to new opportunities for innovation processes and outcomes (Bailey et al., 2012; Bhagwatwar et al., 2017; Chandra and Leenders, 2012; Kaapu et al., 2013; Kohler et al., 2009). As VR environments such as VWs and SL provide unique interaction capabilities, there are vast opportunities to exploit for organizational learning. Two articles provide rich insights into how VW can be designed and leveraged for organizational learning (Dodgson et al., 2013; Richardson, 2007). The individual level social advantages of VWs may also be aggregated and utilized for collaborative purposes within organizations. Three articles investigate how SL's social and interactive benefits can be leveraged for organizational collaboration (Davis et al., 2009; Nardon and Aten, 2012; Schmeil et al., 2012). In sum, this category offers a diverse set of theoretical and empirical insights concerning the use of VR's collaborative capabilities to enable novel learning and innovation opportunities.

Authors	Journal	Summary
Bailey et al. (2012)	Organization Science	Investigates how different representations affect organizational work distinguishing between virtual teams, remote control, and simulations. These are classified based on whether work is done with, on, through or within representations.
Bhagwatwar et al. (2017)	Information Systems Research	Explores how VR can be used in idea generation showing that 3D priming stimuli in a virtual environment enhances brainstorming activity.
Chandra and Leenders (2012)	Technovation	Shows how SL's affordances (i.e., low cost, no legal constraints of real life, and user-friendly tools) enable innovation opportunities. Users' innovation processes in SL broadly resemble those in real life, but the outcomes often breed new

		opportunities in the real world, further triggering entrepreneurial acts in SL.
Davis et al. (2009)	Journal of the Association for Information Systems	Develop a conceptual model of Metaverses comprising five constructs: (1) the metaverse itself, (2) people/avatars, (3) metaverse technology capabilities, (4) behaviors, and (5) outcomes. By applying a socio-technical view they recognize the potential for variation in emergent interaction and in outcomes.
Dodgson et al. (2013)	Organization Science	Shows how a VW came to be accepted at IBM and resulted in organizational learning. IBM's settlement process occurred through mutually reinforcing ways, as it learned to engage with and use new technologies.
Fernandes et al. (2006)	Technovation	Identifies six factors that affected VR adoption within top UK construction firms: Utilizing a champion and top management support, articulating internal needs and business competition, coordinating organizational resources, and involving a high level of user participation.
Kaapu et al. (2013)	Scandinavian Journal of Information Systems	Tests high-immersive VR (head-mounted display) in different physical locations showing how the physical location affects users' interception of 3D representations. To maximize value creation, organizations should consider the physical location when setting up their VR application.
Kohler et al. (2009)	Technovation	Argues that if organizations seek to leverage VWs for innovation, they need to create a compelling open innovation experience and consider VW's peculiarities.
Lee et al. (2019)	Information & Management	Explore highly immersive VR (Samsung Gear VR) in museum VR tour. They find that the VR supported education, entertainment and experiences by immersion that increased the likelihood of intentions to visit the museum.
Nardon and Aten (2012)	Journal of the Association for Information Systems	Studies organizational members' interpretation of VWs and identifies three mental categories: VWs as a medium, VWs as a place, and VWs as an extension of reality
Richardson (2007)	Communications of the Association for Information Systems	Introduces non-verbal communication traits (i.e., face-to-face interaction between users and virtual pedagogical agents) arguing that it is critical to understand these traits because of humans' natural tendency to rely on them when interacting and learning with others.
Schmeil et al. (2012)	Journal of the Association for Information Systems	Develops an avatar-based collaboration framework highlighting the importance of both formalizing structural elements and VWs for collaborative work.
Seymour et al. (2018)	Journal of the Association for Information Systems	Investigate the future role of natural face technology (NFT) in online environments. Contributes by providing a research agenda consisting of terminology, conceptual work, ideas for research projects, and RQ's.
Stampe and Müller (2018)	Scandinavian Journal of Information Systems	Investigates the use of Google Glass (GG) in agriculture. They show how GG enabled the simultaneous performance of situation-specific and information-related work practices with recursive mobility, voice control, information storage and retrieval.
Steffen et al. (2019)	Journal of Management Information Systems	Provides a conceptual framework of the different affordances of VR and compares with augmented reality capabilities.

	mation Systems	
Venkatesh and Win- deler (2012)	Journal of the As- sociation for Infor- mation Systems	Investigates the relationship between team disposition toward IT, their general disposition (personality), and VW's influence on team cohesion and performance. They find that VWs positively influence the relationship between technology use and team cohesion which, in turn, improved team performance.

Table 4. Collaboration articles.

4 Discussion and Research Opportunities

This review focused on articles that covered the organizational aspects of VR to better understand its role in DT. The review results revealed that IS research on VR covers three emerging themes: user experience design, e-commerce and retail, and collaboration. However, the scholarship is fragmented and lacks cohesive contextual and organizational depth. Below, we identify several research opportunities for the IS community to generate new knowledge on the role of VR in DT.

First, we need to emphasize that VR continues to evolve, giving organizations the possibility to recombine resources to drive digital service innovation and new value creation outcomes (Baiyere et al., 2023; Yoo et al., 2010). Three papers approach VR from a service perspective (Featherman et al., 2006; Gadalla et al., 2013; Zhou et al., 2012). However, all of them investigate SL, which is an online display-based experience. It could be argued that we are starting to see wide VR consumerization beyond entertainment and gaming services (Hooker et al., 2019). VR services can also be tightly coupled with novel hardware and software (Peukert et al., 2019) and constitute relatively radical digital innovations (Baiyere et al., 2023; Baskerville et al., 2020). Only two studies in the review approached VR from a sociotechnical perspective (Davis et al., 2009; Stampe and Müller, 2018) whereby only Stampe and Müller (2018) engage with the digital innovation literature. We therefore need more research on how organizations can leverage novel VR technology, including extra-peripheral devices such as goggles, sensor gloves and other haptic devices to enable new digital innovations. Future IS research should focus on how organizations attempt to combine such technology with physical elements, and how such combinatory activity may influence the contextual situation and organizational structures which are key elements in DT (Soluk and Kammerlander, 2021). In this context, IS researchers should complement the dominant technological focus of VR research by studying VR systems (including humans, customers, processes, activities, environment and technology) as a driving force of change, innovation, and ultimately the DT of organizations (Vial, 2019).

The ability of VR systems to stimulate the human senses effectively will have varying degrees of importance depending on how and where the systems are used (Gutierrez et al., 2008). Thus, VR should be studied in a variety of physical contexts (Kaapu et al., 2013). However, we argue that IS scholars should target product-based and physically rooted firms (e.g., construction, manufacturing, forestry, and mining), because (1) they will potentially undergo a more complex change (Sandberg et al., 2020) while integrating VR capabilities, and (2) their interest in exploring VR for innovation and efficiency gains has significantly increased (Boland et al., 2007; Kostis and Ritala, 2020; Lundberg et al., 2020). Regarding these factors, more research is needed on VR adoption (Fernandes et al., 2006). The organizational adoption of VR may require surface-level structural change, and for some organizations profound transformative change of deep structures that give rise to a new organizational identity (Wessel et al., 2021). Considering the increasing consumerization of VR and its unique visualization, interactive, collaborative and learning capabilities, researchers should be aware of the innovation potential (Lundberg et al., 2020; Wessel et al., 2021) affecting work structures (Bailey et al., 2012) that contribute to redefining an organization's value propositions (Wessel et al., 2021). Hence, future work might seek to understand how organizational members generate meaning, restructure work practices, appropriate or reject VR during the process of DT.

At a micro level, IS researchers can focus on what work practices that could be improved by leveraging VR's capabilities (Orlikowski, 2000). In line with such a practice-based focus, IS research may emphasize the "virtual" as a process (Dholakia and Reyes, 2013), adopting a longitudinal perspective (Venkatesh and Windeler, 2012). Such an approach may not only allow the capturing of cumulative dependencies and management tensions that potentially enable or constrain new practices, but also the role of digital technology's serendipitous and unbounded nature in generating new innovations (Nambisan et al., 2017; Nylén and Holmström, 2019). At an organizational level, IS scholars may trace and situate how firms plan, orchestrate and initiate VR projects in their DT process: What is the role of VR in a DT process, and how does VR facilitate DT? However, not all firms are fully committed to VR in their DT efforts. In this respect, it would be interesting to study barriers or prerequisites for VR. For example, what capabilities or skills are required for adopting VR? How do organizational or contextual dependencies affect VR adoption?

It has been demonstrated that VR improves organizational learning (Dodgson et al., 2013), brainstorming activities (Bhagwatwar et al., 2017), and idea generation (Kohler et al., 2009). Since DT often involves highly dynamic processes of iterating between learning and doing, future work might explore how organizations leverage VR's unique visualization capabilities to develop product innovations. For example, most manufacturing firms use 3D-based computer-aided design (CAD) to create technical drawings of their physical products. Here, it would be interesting to investigate the process of integrating VR in CAD practices, which is at the heart of the digital twin concept (Van der Valk et al., 2020). In this context, the ontological reversal of digital technology is evident: design and engineering work is almost exclusively initiated in the digital space (i.e., Excel, CAD, VR) and later manifested in the physical world (Baskerville et al., 2020). Future IS scholars may explore such ontology in VR-enabled contexts. What would be the implications of such an ontology, and what types of theories or concepts could be generated in relation to the organizational application of VR?

5 Conclusions

Given that contemporary VR systems continue to evolve and inspire organizations, we summarize this research by highlighting that IS has made vital contributions to our understanding of VR's transformative potentials. However, IS would benefit by shifting focus from studying web-based VR from a user and customer perspective to approach VR as a transformative and high-immersive technology with the potential to redefine organizational practices, structures, and value propositions. We suggest that future IS research that anticipates VR should build on existing theories and concepts captured in this review. Thereby, a cumulative tradition can be stimulated as IS scholarship seeks to better understand VR's transformative role in the age of digitalization. That being said, this literature review comes with some limitations. While publications outside IS have been excluded, future IS scholars should also identify VR studies outside of the IS discipline's purview, as very little of this literature has found its way into the IS field. Since VR is an emerging and evolving topic, conference articles could be of interest to further recognize patterns for future research.

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