Exploring Metaverse: Affordances and Risks for Potential Users

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Short Paper

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Abstract

Metaverse is a post-reality universe, a permanent and persistent multi-user environment that combines physical reality and digital virtuality. These technologies realize seamless embodied user communication in real-time and dynamic interactions with digital objects, shape users' perceptions of reality and can be widely utilized for various applications. However, it is still in an infant stage, and a minimal amount is known about why and whether users will adopt such fully immersive technology. The purpose of this article is to develop a theoretical model and validate it by a survey to examine what affordances and challenges affect metaverse adoption. Our study potentially contributes to the literature on IS adoption research, and to practitioners on what needs to pay special attention to when designing metaverse.

Keywords: Metaverse, affordance, perceived risk, immersion

Introduction

ICT (Information and Communication Technology) innovations play an important role in daily life as they transform and enrich human interaction, communication, and social transactions. After the first three waves of ICT innovation (I.e., personal computers, the Internet, and mobile devices), the fourth wave of ICT innovation is unfolding around spatial and immersive technologies such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and Extended Reality (XR). This wave gives rise to virtual worlds and promises to revolutionize the way of interactions between the users and their surrounding environment (Cakmakci and Rolland 2006). Moreover, these technologies exhibit the potential to trigger attractive applications, including but not limited to health care, education, engineering design, manufacturing, retail, and entertainment. Although it is still in an infant stage, they are in a peak hype cycle, with sales and investments in the area growing exponentially over the recent years. Technology companies, investors, businesses, and consumers face many challenges and uncertainties.

Meanwhile, this new wave is shaping the next ubiquitous computing paradigm, known as the metaverse. Since Facebook officially changed its name to Metaverse in Oct. 2021, metaverse has become a new norm of social networks and an integrated network of three-dimensional (3D) virtual worlds. It's a catch-all term that refers to the entire digital and virtual world. In other words, the metaverse is a post-reality universe, a permanent and persistent multiuser environment that merges physical reality with digital virtuality

(Mystakidis 2022). From the technical perspective, the metaverse is the solution that brings immersive and personalized experiences to users by leveraging and amalgamating all emerging technologies (Gadekallu et al. 2022). From the end users' perspective, metaverse would be massive communal cyberspace, enabling avatars to hop seamlessly from one activity to the next. The virtual environment of the metaverse is not fixed and can be modeled and designed by users who inhabit it (Han et al. 2021).

There are many prototypes of the metaverse has been developed in recent years, such as NVIDIA Omniverse and Microsoft Mesh. However, it is a huge undertaking that would require standardization and cooperation among tech giants and legislative organizations, with the issues of integrating to existing systems, compatibility, interoperability, legal, and ethical discrepancies. Therefore, it is crucial to understand what factors facilitate or hinder the future adoption of the metaverse. Past studies focused mainly on technical development, such as resource allocation (Han et al. 2021) and blockchain applications (Gadekallu et al. 2022). Empirical research on consumer acceptance of the metaverse has received limited attention. The goal of this paper is to provide a basis for theoretical understanding of the affordances and risks behind user adoption of Metaverse.

Theoretical Background and Hypothesis Development

Immersion

The most prominent feature that describes VR/AR systems is the degree of immersion (Suh and Lee 2005). Berg and Vance (2017) define virtual reality as an immersive computing technology that incorporates a "set of technologies that enable people to immersive experience a world beyond reality." Although this initial definition of VR mainly focuses on the applied hardware, it also raises concerns about subjective immersion. In reviewing the features of a virtual world, Gilbert (2011) mention that it should be immersive, which can enhance users' psychological experience.

Immersion describes to what extent technological features of the virtual environment "are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant" (Slater and Wilbur 1997). Also, immersion determines the degree to which users feel cognitively teleported to an alternative and synthetic world (Mystakidis 2022). Mütterlein et al. (2018) demonstrate that immersion plays a decisive role in users' intentions to collaborate in VR. Chang et al. (2018) also indicate that immersion serves as the crucial predictor for VR-supported technology adoption. Therefore, we hypothesize that a high level of immersion will also lead to a higher behavioral intention to use metaverse.

H1: Immersion is positively related to usage intention.

Affordance of Metaverse

The term "affordance" was first introduced by Gibson (1977), and it is used to interpret the actionable properties between the world and an actor (a person or animal) from the viewpoint of ecological psychology. In product design, Norman (1988) define affordance as the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could be used. A product's affordance can provide strong clues to its operation. Affordances are chosen because they form a generalizable lens through which user goals and technical features are combined (Orlikowski and Scott 2008). Hence, our assertion is that users adopt the metaverse because they afford impossible or advantageous activities compared to the activities afforded by physical reality. The affordance theory has been extended to the field of Information Systems to explain IT effects, particularly why the implementation of particular IT artifacts can produce various outcomes with different actors (Markus and Silver 2008).

Examining metaverse through the lens of what they afford is useful for two reasons. First, affordances help examine user goals. By linking technology features and user capabilities and goals, affordances create a lens to examine why users would use the technologies. So, identifying relevant affordances helps to understand the motives driving usage intention. Consequently, understanding motives help accomplish our goal of understanding how to design and implement the metaverse more helpfully. Second, affordances are relatively generalizable and constant across specific implementations. Metaverse is a combined term that refers to the entire digital and virtual world. Because affordances focus on features that align with user goals, they can apply more broadly to various implementations rather than being tied to a specific set of properties.

Past research has investigated how specific affordances of VR and AR enable goal- oriented behavior in particular domains and contexts, i.e., education (Shin 2017) and online shopping (Tawira and Ivanov 2022). Steffen et al. (2019) develop a framework of affordance for VR and AR, proposing four general affordances including diminishing negative aspects of the physical world, enhancing positive aspects of the physical world, recreating existing aspects of the physical world, and create aspects that do not exist in the physical world. Compared with technologies that supporting Metaverse (i.e., VR and AR), we argue that Metaverse is an integrated network of three-dimensional (3D) virtual worlds, the current need to understand the metaverse is far more than what was recently understood as VR/AR technology. Therefore, examinations at a micro-level on VR or AR technologies do not provide a general understanding of what motivates users to adopt the metaverse. It is required to identify the differences between affordances of the metaverse and affordances of VR/AR. As affordances are the relation between features and abilities, we begin by examining the features of the metaverse.

Firstly, the metaverse is ubiquitous. The notion of ubiquity in virtual worlds stems directly from the overarching criterion that a fully realized metaverse must provide an environment for human culture and interaction as psychologically appealing to users as the physical world. A distributed ubiquitous electronic presence was proposed by Gilbert et al. 2011., derived from the tendency people to fragment information for identity consolidation. The real world is ubiquitous to humans. Literally, we inevitably inhabit, move, and interact with it at all times and in all situations (Choi 2018). Virtual worlds need to simulate the real world's ubiquity to serve as a rich alternative site for human activity and interaction. If we cannot access metaverse whenever and wherever we want, we lose a certain level of immersion in it. Thus, we hypothesize:

H2: Ubiquity is positively related to immersion.

Secondly, the metaverse is interoperable. It is the ability of distinct systems or platforms to exchange information or interact with each other seamlessly (Kouroubali and Katehakis 2019). Interoperability within healthcare system can enable capturing, sharing, and understanding of data that leads to taking appropriate actions for better medical care and better patient outcomes, also enables knowledge discovery and research (EIF 2017). In the physical world, human bodies can seamlessly transfer between physical locations without interruption of experience. Considering the metaverse is supposed to provide a milieu for human sociocultural interaction that is psychologically rich and engaging in the same way as the physical world, users of the metaverse should have full access to any environment without being disrupted by changing their login credentials or losing their digital assets. Thus, we hypothesize:

H3: Interoperability is positively related to immersion.

Thirdly, the metaverse is scalable. Scalability is one of common requirements for distributed services, a key requirement for infrastructure as a service providers, and a fundamental requirement of autonomous robot system (Sun et al. 2010). As an attempt to simulate the real world, which is of enormous and potentially infinite scale on many levels and dimensions, scalability is a major concern for the realization of the metaverse. It is the ability to allow efficient concurrent use of the system by massive numbers of users. The limitations of concurrent users, scene complexity and user interaction would undoubtedly reduce users' perceived immersion (Liu et al. 2010). Thus, we hypothesize:

H4: Scalability is positively related to immersion.

Perceived Risk

Eiser et al. (2002) contended that adopters of a new technology are more receptive to it if the information is presented on both the negative and positive implications of using it. Consumer perception of risk is an important hindrance to consumer decision-making in consumer behaviour research (Chang and Tseng 2013). Therefore, understanding perceived risk determinants and implications are particularly useful in the design process. Perceived risk can be defined as an individual's belief to suffer from negative and uncertain results while performing a specific action (Pelaez et al. 2019). A decision is considered a risk when the consequences connected to the decision are negative, undesirable, or uncertain compared to other options. Research in IS field often incorporates broad, general risk factors, for instance, mobile banking (Luo et al. 2010), and VR travel (Sarkady et al. 2021), which have investigated the prominent role of perceived risk as a serious obstacle to consumers' adoption decision. Correspondingly, the direct influence of perceived risk on consumers' usage intention is proposed in the following hypothesis:

H5: Perceived risk is negatively related to usage intention.

Moreover, perceived risk has also been operationalized as a multi-dimensional construct in past studies, especially in the ICT-mediated environment (i.e. Yang et al. 2015). There are differences in the dimensions of perceived risk based on the research phenomenon and contexts. According to Veloutsou and Bian (2008), specific purchasing behaviour, trading environment, and cultural differences determine the perceived risk dimensions. For example, Featherman and Pavlou (2003) find performance, financial, crime, psychological, social, and privacy risks relevant to online services. Luo et al. (2010) employ a comparable approach for mobile banking and find similar relevant dimensions. While prior research has shown that risk factors matter in technology use and risk dimensions vary between different technologies, information on perceptions of risk associated with metaverse remains scarce. More closely related to the context of the present research is a recent study by Christopoulos et al. (2021), who classified risks of AR into four categories related to (i) physical well-being, health, and safety, (ii) psychology, (iii) morality and ethics and (iv) data privacy. In this study, we build on the findings from Christopoulos et al. (2021) and theorize three different risk factors: privacy risk from data collection and sharing with other parties; physical risk from attention distraction from reality while in a physical space; and psychological risk from information overload. These three choices are confirmed in this study to highlight the multi-dimensional nature of perceived risk.

Privacy risk refers to the individual's perception of the risk that one could lose control over his/her personal information due to the use of a technology (Malhotra et al. 2004). There are significant threats to the perceived privacy of users arising from the development of new technologies. In the context of the metaverse, we believe that potential privacy risks relate to app developers who may track user behavior, analogous worries focused on the manufacturer of the devices or their operating systems, and illegal attacks by hackers who may steal personal user information. New types of personal information can be collected through devices for the metaverse, such as facial features, reflexes, eyes, and motor movement. As a result, even anonymized, motion-tracking recorded data can be used to identify personally using AI and ML (Heller 2020). Moreover, geolocation and movement tracking can reveal intimate personal information (Bye et al. 2019). This personally identifiable data is vulnerable to misuse, either by unauthorized perpetrators or irresponsible commercialization.

Physical risk refers to the likelihood that the product may physically harm the consumer and others close to him/her (Schiffman et al. 2013). Mieres et al. (2006) explained it as the consumers' fear that the use of a particular product can damage their health. While immersed in VR/AR-created environment, people are typically focused on these virtual tasks, and are effectively blind to the physical world around them. Alimamy et al. (2017) revealed the influence of physical risk on adopting AR, while Vishwakarma et al. (2020) indicated the effect of perceived physical risk on the intention to adopt VR. Similar to AR/VR, in the context of this study, consumers may perceive the fear of damaging their physical health by joining metaverse.

Psychological risk refers to the risk that technology would have a negative effect on consumers' peace of mind or self-perception (Featherman and Pavlou 2003). Being exposed to virtual worlds may further relate to psychological problems. Research demonstrated that VR can be a useful means of influencing a user's psychological states (Rizzo et al. 2015) and may negatively impact the user's psychological well-being if used "incorrectly". Also, potential psychological consequences have been the subject of controversial discussions regarding the use of the Internet and other technologies. For example, Luo et al. (2010) found that psychological risk as a component of perceived risk may delay the adoption of mobile bank services, while Hong et al. (2020) indicates that psychological risk is the main barriers to the adoption of smart home products and services.

A vast majority of previous studies apply a unidimensional approach to examine risk in consumer decision-making (Ariffin et al. 2018). However, some studies have begun to explore the impact of multi-dimensional risk on consumer adoption using a multi-dimensional approach (Martins et al. 2014). In line with the operationalization of perceived value discussed above, this study also models perceived risk as a formative multi-dimensional second-order construct to gain a comprehensive understanding of its multi-dimensional nature. Thus, combining the conceptualization method of perceived risk with the discussion of risk dimensions, we use the multi-dimensional approach and hypothesize relationships between second-order formative perceived risk and its three particular first-order risk dimensions as follows:

H6: Privacy risk(a), physical risk(b) and psychological risk(c) are formative first-order components of perceived risk.

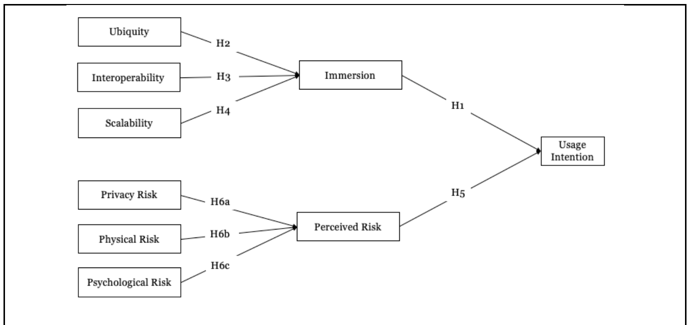

Figure 1. Research Model

Method

Pilot Data Collection

Before collecting data, we asked two PhD candidates to independently translate and back-translate the questionnaire between English and Chinese (Brislin et al. 1970). And a pilot study included 100 respondents was conducted to improve the questionnaire design to test the robustness of validity and reliability measurement items. To control for method bias, we followed the before, during, and after data-collection procedures recommended by: first, we chose high-quality subjects by using the filters available on survey website, to only select respondents with a record of working on at least 100 tasks with a adoption rate of at least 80%. Second, we explained the importance of the study to the subjects and set a minimum response time to make sure that the subjects paid sufficient attention to the survey. Third, we removed responses that failed the quality control, e.g., we dropped the responses of subjects who selected same items for all the questions. We consider that such respondents were most likely performing rote completion of the survey without paying attention to each question. The average response time was 6 minutes, and each respondent was paid ¥2. Thus, our pilot sample included 99 respondents.

In the survey, the subjects watched a video clip of Ready Player One first. The clip depicts a metaverse called the OASIS, which can be accessed with a VR headset and wired gloves. OASIS function as a virtual society where people are able to play multiplayer online role-playing games massively. Then their demographic information was collected, followed by the questions related to affordance, and then the questions on three types of risk. Finally, their attitude and intention on metaverse was collected. We also controlled for demographics.

The socio-demographic profiles, including gender, age, education level, and monthly income, of the sample and general internet users in China. Specifically, the proportion of males (45.5%) and females (54.5%) in

Constructs and Items	Loadings
Ubiquity (Cronbach's α= 0.822; CR= 0.894; AVE= 0.739) *Adapted from Choi (2018)*	
I can access metaverse anytime.	0.820
I can access metaverse on the move.	0.839
I can access metaverse anywhere.	0.917
I expect metaverse to be available when I need it.	-
Interoperability *Adapted from EIF (2017)*	
Technically, metaverse have the requisite software and hardware infrastructure to securely exchange information (technical level).	-
Metaverse enables multiple systems to share, interpret and use the exchanged information (semantic level).	-

Metaverse facilitates the standardization of virtual worlds across various system providers based on a predefined set of agreed rules and processes (organizational level).	
Metaverse can operate under different legal framework, policies, and strategies (legal level).	
Scalability *Adapted from Liu et al. (2010)*	
Metaverse enables enormous concurrent users.	-
Metaverse has no limitation on what users build and behave (scale the scene complexity).	-
Metaverse has no limitation on type, scope and range of interactions, such as “the wave”.	-
Immersion (Cronbach’s α= 0.755; CR= 0.860; AVE= 0.673) *Adapted from Hudson (2019) and Yoo (2018)*	
I could interact with other people or NPC as if I was in the real world.	0.759
I felt detached from the real world.	-
I felt completely involved in metaverse.	0.845
I feel emotionally absorbed in metaverse.	0.853
I experience an altered sense of time in metaverse.	-
Privacy risk (Cronbach’s α= 0.951; CR= 0.965; AVE= 0.872) *Adapted from Jain et al. (2022)*	
I perceive that joining metaverse to socialize may pose a risk to my personal information.	0.927
In metaverse, there would be a high potential for privacy loss associated with giving personal information.	0.949
My personal information may be used illegally by the manufacturer of metaverse.	0.928
Providing personal information to metaverse would involve unexpected problems.	0.932
Physical risk (Cronbach’s α= 0.911; CR= 0.935; AVE= 0.783) *Adapted from Faqih (2022) and Vishwakarma et al. (2020)*	
I fear that I recognize risks in the real world too late while using metaverse.	0.844
Metaverse distract me from immediate danger around me.	0.856
I am concerned that using metaverse may lead to uncomfortable physical side effects.	0.915
I am concerned about the potential health-related risks associated with the use of metaverse.	0.921
Psychological risk (Cronbach’s α=0.907; CR= 0.941; AVE= 0.841) *Adapted from Marriott and Williams (2018)*	
I may perceive unnecessary tension when using metaverse.	0.903
The thought of joining metaverse may make me feel anxious.	0.907
Joining metaverse may make me feel uncomfortable.	0.941
Usage intention (Cronbach’s α=0.726; CR= 0.845; AVE= 0.646) *Adapted from Arfi et al. (2021) and Jain et al. (2022)*	
I would consider joining metaverse.	0.791
I tend to try to socialize in metaverse.	0.745
I will be willing to purchase metaverse-required equipment in the future.	0.871

Table 1. Survey factors and confirmatory factor analysis results

the sample is basically the same, and most respondents (over 90%) were young people between the ages of 20 and 40, which approximate the gender and age characteristics of the general internet users in China. The majority of respondents in our sample has a bachelor degree (83.8%) and almost half of them is in the middle-income level which earn between RMB 3000 and RMB 8000 per month (48.5%).

Measurement Model and Validation

All items were adopted from existing scale (see Table 1). Three constructs of metaverse affordance (i.e., ubiquity, interoperability, and scalability), three constructs of risk (privacy risk, physical risk, and psychological risk), immersion and usage intention were measured. This study used seven-point Likert scales (1 = strongly disagree to 7 = strongly agree) for all items. The interoperability and scalability are considered as formative constructs.

We conducted confirmatory factor analysis (CFA) to validate the measurements. As shown in Table 1, the composite reliability and Cronbach’s alpha of all reflective constructs, are larger than the minimum acceptable level of 0.7 (Hair et al. 1998), strongly supporting the reliability of constructs. As for the convergent validity, the outer loadings of all reflective constructs are higher than the 0.70 cut-off level

(Flynn et al. 2010). In addition, all of their average variance extracted (AVE) are greater than the 0.50 threshold value (Koufteros 1999). The convergent validity is also acceptable. Discriminant validity was assessed through the Fornell-Larcker criterion (Fornell and Larcker 1981). The results show all square root of AVE of each construct are larger than its correlations with all other latent constructs, which provides strong evidence for discriminant validity.

To evaluate the formative measures, including interoperability and scalability, cross-loadings and variance inflation factor (VIF) were calculated. The results show that all formative indicators have higher loadings on the constructs they intended to measure, which supports the discriminant validity. In addition, the VIFs of all the formative indictors are lower than the 5 cut-off level, which indicate there is no collinearity problem.

Contributions and Future Studies

Metaverse, proclaimed to be the future of the Internet, has attracted great interest from many investors. However, it is still in an infant stage, and a minimal amount is known about why and whether users will adopt such fully immersive technology. A theoretical understanding of why people choose to adopt the Metaverse is lacking. Literature that can serve as a starting point for answering this question. To initiate this body of research, we explore the influencing factors of users' willingness to adopt metaverse from the perspective of affordance and risk. We believe that a more integrated understanding of the underlying motivations driving users to utilize Metaverse would help researchers consolidate scattered knowledge across fields and identify paths for future investigation. In addition, practitioners could specify domains where the motivation to use Metaverse is not being satisfied. Our study potentially contributes to literature on IS adoption research, and to practitioners on what need to pay special attention when designing metaverse.

In the future, we will further collect a bigger sample and validate our model by partial least squares structural equation modelling (PLS-SEM). And the repeat indicator approach will be applied to measure formative second-order latent variables of our hierarchical research model. Through this method, a formative second-order latent construct can be directly measured by its observed variables for all of its reflective first-order dimensions (Ringle et al. 2012).

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