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Possibilities for Decision Science in the Metaverse

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As the next generation of the internet, the metaverse will be an immersive, interactive, and persistent three-dimensional world that merges both physical and virtual environments. Its associated advanced technologies (e.g., digital twins, avatar self-representation, virtual reality, augmented reality, extended reality, brain–computer interface, artificial intelligence, machine learning, Internet of Things, blockchain technology) are already functioning, and people are able to experience and make decisions in immersive virtual environments. In this article, we first briefly assess the similarities and differences in the judgment and decision-making (JDM) situations that people may face in the metaverse compared to their physical environments. Next, we discuss how human interaction with metaverse-related advanced technologies may affect the cognitive processes of perception, attention, memory, and reasoning that underlie human JDM, as well as the subsequent effects of these processes on JDM, in both the virtual and physical worlds. Finally, we highlight some opportunities that the metaverse may afford decision scientists, given the availability of integrated digitalized data collected from users (or research participants) as well as some of the challenges that lie therein. We structure these opportunities around the five key metaverse domains: digitalization, virtualization, social networks, virtual worlds, and data integration. As a research platform, the metaverse can help drive a paradigm shift away from traditional approaches to JDM research and enable decision scientists to test and consolidate existing theories as well as advance new ones, while conducting research that has social benefits.

Keywords: Judgment and decision making, metaverse, immersive virtual environment, cognitive processes, advanced technology

The term metaverse means beyond universe (i.e., “meta” = beyond and “verse” = universe). Envisaged as the next generation of the internet, the metaverse will be a ground-breaking immersive, interactive, and persistent three-dimensional (3D) world “merging physical reality with digital virtuality” (Lee et al., 2021; Mystakidis, 2022, p. 486). It will provide a new type of online space where people can work and play, both individually and in interaction with others.

While the metaverse is still in the process of development, with early prototypes being Second Life (2003), Roblox (2006), Minecraft (2011), Decentraland (2017), and Fortnite (2017), its associated advanced technologies (e.g., digital twins, avatar self-representation, virtual reality [VR], augmented reality [AR], extended reality, brain–computer interface, artificial intelligence [AI], machine learning, Internet of Things, blockchain technology) are already functioning

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(e.g., see Dwivedi et al., 2022; Gadekallu et al., 2022; E. Han et al., 2023; Huynh-The et al., 2023; Kovacova et al., 2022; Park & Kim, 2022; G. Wang et al., 2022). This has enabled people to engage in immersive virtual environments. For instance, beyond gaming experiences (Ibrahim, 2023), people have attended virtual concerts held by artists such as Travis Scott, Ariana Grande, and Justin Bieber (Speakman, 2021) and have shopped in Gucci's first virtual store (Moore, 2022). Indeed, in the metaverse, the aforementioned technologies will be combined to enable a multisensory experience when, for instance, people participate in sports and entertainment, as well as engage in education and commerce (Njoku et al., 2023; Setiawan & Anthony, 2022).

The main goals of our article are to explore the potential ways in which human interaction with the metaverse could affect judgment and decision making (JDM) both within the metaverse and beyond in the physical world and to consider the research opportunities that the metaverse may afford decision scientists as well as the challenges posed in taking such opportunities. Our interest in this topic arises from our empirical work on the impact of technology on marketing and consumer behavior (e.g., Annamma et al., 2022; Zhu, 2023; Zhu & Meyer, 2017; Zhu et al., 2020) and our theoretical work on the ethical issues involved in conducting psychological research in the metaverse (Cockerton et al., 2024). The article is divided into three main sections. First, we briefly describe the metaverse and identify the sorts of JDM situations that it will present. Then, we discuss how interacting with the metaverse may affect the cognitive processes that underlie human JDM. Finally, we highlight some of the many opportunities that the metaverse will afford decision scientists, alongside the challenges that lie therein.

Potential Judgment and Decision Situations in the Metaverse

Interacting with the metaverse will present people with a wide variety of JDM situations. Beyond deciding on their virtual identity and capabilities, people must decide whom they want to develop virtual relationships with and what form virtual interactions will take. Additionally, with its own virtual economy, the metaverse will present people with decisions about buying and selling virtual goods and services, as well as owning, designing, and using virtual properties. Relatedly, people will find themselves facing technical and creative decisions (e.g., layout and construction of their virtual spaces) as well as decisions about virtual security and conflict. Finally, people will need to decide if and when to access and engage in the wide range of virtual experiences that are available to them, from education and work, through health care, to sports, entertainment, and social connections (Giang Barerra & Shah, 2023; Kye et al., 2021; Y. Wang et al., 2023; Xi et al., 2023).

In order to illustrate the novel experiences enabled by advanced technologies in the metaverse, we present a *consumer decision-making scenario*. Consider Maya, who enters the metaverse to shop. She is represented by an avatar that has superhuman abilities of teleporting (allowing her to move from store to store instantly) and shape-shifting (allowing her to buy virtual clothes for her sister who is of a different height and body shape). Maya wears VR goggles with a brain–computer interface that monitors her brain waves, while her eye and body movements are tracked through VR goggles and controllers. She wants to buy a dress for her virtual party. Her eyes bypass all sports clothing stores and fixate on a high-end boutique.

Before she enters the store to search for more options, the digital display outside the boutique detects her arrival and promptly exhibits the latest designer dresses in her size (based on the preloaded 3D measurement of her body) and tailored to her preferences (given her previous purchase data). Using Maya's biometric data (e.g., facial recognition, heart rate) and brainwave feedback (e.g., using electroencephalography to detect emotions), the boutique also instantly filters the displayed dresses and only recommends the one that attracts most of her attention and which she finds positively arousing. Maya wears a haptic vest, enabling her to receive sensory feedback and to experience the tactile attributes of a dress she tries on virtually. Appreciating the smoothness of the fabric and the comfort of the fit, she also decides to purchase the same dress in physical form to wear to a party in the real world.

While some situations in the metaverse will resemble those faced in the physical world, such as Maya shopping for a dress, other situations and experiences will be unique to the virtual world (e.g., Maya's decision to have an avatar that possesses superhuman abilities). In Table 1, we provide examples of how select properties of

Table 1
Examples of Judgment and Decision-Making Task Properties in the Physical and Virtual World

Task property	Physical world	Virtual world (metaverse)
Familiarity with task	Based in real-world experiences and education	Broadened through diverse virtual scenarios and experiences allowing familiarity with novel situations
Prior training or knowledge of task	Traditional educational and experiential methods	Enhanced with VR- and AR-based training, offering practical experience in simulated environments, with feedback
Amount of information	Limited by physical or environmental constraints and human sensory capabilities and processing capacity	Vastly increased through VR, AR, and haptic technology; providing immersive multisensory experiences but managed through advanced filtering and sorting technologies enabled by AI and machine learning
Information presentation order	Often sequential, influenced by physical constraints	Highly customizable and algorithm-driven, enabling personalized information flow
Information presentation format	2D or limited 3D, primarily tangible, static or dynamic, restricted by physical environment	Fully immersive, highly interactive and dynamic 3D environments created by VR and AR, offering a multisensory and more holistic and detailed view of information
Information redundancy	Natural occurrences, influenced by real-world dynamics, less controllable	Minimized or amplified in real-time through digital twin simulations and AI algorithms, offering precise control over information exposure
Interpretation of information	Based on real-world logic and human cognition (subjective)	Enriched with virtual-world logic, including alternative realities and scenarios enabled by immersive technologies and AI algorithms (objective)
Number of response options	Limited by physical and practical constraints	Virtually unlimited, only bounded by software capabilities and creative design
Time pressure	Governed by real-world constraints, situational urgency and schedules	Adjustable and extended through virtual time manipulation, with opportunity for scenario replay and analysis
Feedback available	Often delayed and based on observable outcomes	Instant and customizable, with options for real-time adjustments and scenario modifications
Outcome knowledge	Based on real-world outcomes and historical data	Encompasses both real and simulated outcomes, providing a broader perspective for JDM

Note. VR = virtual reality; AR = augmented reality; AI = artificial intelligence; JDM = judgment and decision making.

JDM tasks are likely to differ when these tasks are faced in the physical world as opposed to the virtual world (i.e., the metaverse). Our selection of task properties is taken from work exploring the effect of task properties on human cognition (see Dhami & Thomson, 2012; Doherty & Kurz, 1996).

It is clear that in some cases, when in the metaverse, people will be able to apply their existing JDM skills and strategies (e.g., Zipp & Craig, 2019). When captured digitally over repeated trials, this means that decisions in the metaverse will become quick and easy to make. Individuals will consequently be able to obtain a desired outcome, providing instant gratification, as in Maya's example. However, these experiences are likely to alter expectations of real-world JDM situations.

It is also clear that when in the metaverse, people will additionally need to acquire new JDM skills and strategies. The learning of these can be aided by the ability to simulate outcomes until reaching a desired outcome. Indeed, the dynamic and fast-paced nature of the metaverse will not only require speed of JDM but also greater adaptability and flexibility, given that individuals will encounter unfamiliar circumstances, characters, and experiences (Davis et al., 2009). Some of these will be beyond real-life possibilities, such as Maya exploring the bodily perspective of her sister, potentially modifying her own values and objectives.

As we suggest below, how people respond to JDM situations in the metaverse will be partly affected by their use of metaverse-related advanced technologies and the functions of these technologies. Together, these effects and experiences may also influence people's abilities and skills to make judgments and decisions in the physical world.

Potential Effects of Metaverse-Related Technologies on Human JDM

Human JDM relies on a complex interplay of basic cognitive processes, notably perception, attention, memory, and reasoning (e.g., see Benjamin, 2019; Dougherty et al., 2003; Evans et al., 1993; Krishna, 2012; Mrkva et al., 2020; Orquin & Mueller Loose, 2013; Orquin et al., 2021; Shadlen & Shohamy, 2016; E. U. Weber et al., 1991; Williams & Noyes, 2007; Wittmann & Paulus, 2008). Below, we turn to two sources of literature demonstrating the potential effects that interacting with the metaverse can have on human JDM. One is the emerging research on the effect of immersive virtual environments and related technologies (that will eventually combine to form the metaverse) on specific cognitive processes underlying human JDM. The second source of literature is the extant research in the field of JDM that demonstrates the effects of these cognitive processes on JDM. It is not our intention to provide a comprehensive review of the relevant literature but to simply present some illustrative examples.

In terms of *perceptual processes*, advanced technologies such as the brain–computer interface can be used for neurostimulation, allowing individuals to smell the aroma of bread, for example, (Dwivedi et al., 2023; Golf-Papez et al., 2022). Furthermore, reality-enhancing technologies can induce sensory overload and increase simulated satiation (Pala et al., 2022). It is unclear how such neurostimulation and satiation could affect perceptual processes formed in the real world and subsequent JDM. In fact, immersive virtual environments can alter an individual's perception of reality (e.g., space, depth, motion, color). For instance, in a recent investigation incorporating digital twin technology in VR settings, Kang et al. (2023) observed that participants underestimated distances and exceeded their intended destinations to a greater extent in VR compared to analogous real-world scenarios. These findings suggest significant alterations in spatial cognition and depth perception when interacting with virtual versus real-world spaces and indicate a potential cognitive bias or perceptual adjustment in VR, where the brain recalibrates its perception of space to align with the dissonance between visual input and physical sensation.

VR could also alter the sense of time (e.g., Dwivedi et al., 2023; Mogaji et al., 2023; Read et al., 2021; S. Weber et al., 2020). For instance, Bansal et al. (2019) revealed an effect of continuous movement in VR on people's time perception, particularly in a movement-contingent time flow situation, where participants underestimated time intervals after exposure. In another study, Mioni and Pazzaglia (2023) found that the type of VR environment (i.e., natural vs. urban) can influence how individuals perceive and estimate time, with natural environments leading to more accurate estimations of time. This would have implications for JDM since time perception can affect how people value delayed rewards and influence their intertemporal choices (e.g., Wittmann & Paulus, 2008; Xu et al., 2020).

In addition, as mentioned above, the metaverse provides individuals with a valuable opportunity to learn from repeated exposures and/or feedback (see Harvey, 2011). However, the low (physical) cost of making errors in the metaverse could alter individuals' risk perceptions, making them more inclined to take risks in the virtual setting (e.g., Fischer et al., 2007). This in turn has potential implications for perceptions of risk in real-life situations, especially given the difficulty that some people have in distinguishing virtuality from reality (e.g., Liu et al., 2020).

Finally, the data history and AI algorithms in the metaverse can be used to tailor decision situations to an individual's preferences, as in Maya's example, thus enabling people to "get their way," which may shift reference points for making decisions in the physical world (e.g., Dwivedi et al., 2022, 2023). If individuals, through metaverse experiences involving AI assistance and immediate rewards, learn to adopt a rapid decision-making style, which is biased to short-term gratification, this could adversely affect their ability to make long-term plans in the real world. Consequently, individuals' ability to make decisions with long-term outcomes such as career planning and retirement savings could be negatively impacted.

With regard to *attentional processes*, there is currently mixed evidence on the cognitive load effects of immersive virtual environments (see J. Han et al., 2021). Field research on AR in educational settings, such as physics laboratory courses, has shown that students who use see-through smart glasses to transform traditional displays into virtual representations experienced a significant reduction in extraneous cognitive load compared to those in conventional settings (Thees et al., 2020). Although this finding is encouraging, the fact is that interacting with the metaverse will require simultaneous attentional focus on multiple sensory stimuli from a number of different devices such as VR googles and haptic vest, while navigating through a dynamic, fast-paced, and novel virtual environment. This is likely to result in increased cognitive load, leading to distractions and a reduced ability to filter out irrelevant information, and to individuals potentially ignoring or paying insufficient attention to task-relevant information. For instance, Chen and Yao (2022) found that while VR significantly enhances individuals' sense of telepresence compared to a 360° video experience, it adversely affects recall of specific property details that were viewed. Users engaging with VR exhibited lower memory recall than those using 360° videos, indicating that the immersive attributes of VR may distract and contribute to diminished retention of detailed information. Together, this can result in biased, erroneous, or inconsistent JDM in the metaverse (e.g., Allred et al., 2016; Deck et al., 2021; Dewitte et al., 2005).

On the other hand, paying too much attention to certain information or experiences in the metaverse may lead individuals to develop JDM strategies biased to these stimuli (see Fiedler, 2000), and individuals may unwittingly apply these strategies outside in the physical world, with negative consequences. If people frequently engage in the metaverse, where risk-taking behaviors are rewarded, they may develop a risk-seeking tendency which is applied to situations in the real world. For example, individuals engaging in high-risk sports such as bungee jumping in the metaverse could develop a false sense of confidence in their ability to engage in such sports, which could result in hazardous consequences if they do not believe that they need proper training or safety measures when bungee jumping in the real world. Similarly, individuals who become acclimatized to specific social norms or behaviors, such as noncooperation and aggression, which are likely to be prevalent in the metaverse, might find it challenging to form and maintain healthy interpersonal relationships and/or suffer negative legal consequences in the real world.

Memory processes are also likely to be affected by interacting with the metaverse, as indicated by research involving immersive virtual environments and the traditional internet (e.g., Bailey et al., 2012; Meade et al., 2019; Sparrow et al., 2011). On the one hand, when in the metaverse, an individual's ability to encode and store new memories and retrieve old ones in order to gain useful knowledge to learn and apply JDM strategies could be hampered by the increased cognitive load associated with using metaverse-related technologies (e.g., neurostimulation via brain–computer interface) and the stimuli they provide (e.g., Ricker & Vergauwe, 2022). For instance, Makransky et al. (2019) reported that immersive VR induces a higher cognitive load than traditional computer monitors, as indicated by electroencephalography measurements. This suggests that the VR environment can be overstimulating and so lead to less effective learning.

On the other hand, the ability to rewind events and to have emotionally arousing experiences in the metaverse could help to consolidate memories of both the virtual world and similar physical world experiences, thus aiding recall (see Mancuso et al., 2023). For instance, Schöne et al. (2019) demonstrated that 3D VR experiences better enhance the recall of positive emotions derived from personally meaningful experiences compared to conventional 2D video experiences. It is suggested that this is due to VR's immersive nature that facilitates the integration of experiences into an extensive autobiographical associative network, making them more personally meaningful and impactful than traditional 2D screen experiences. This could, however, also mean that virtual world memories may interfere with physical world memories, which in turn could help or hinder learning and application of strategies to be applied in these different worlds. Indeed, memory biases shaped in interaction with the metaverse could result in selective and biased recall, which could bias JDM (e.g., when using the recognition or availability heuristics; Goldstein & Gigerenzer, 2002; Tversky & Kahneman, 1973). Further research focusing on memory formation in both the metaverse and the real world and their affect on real-life JDM is imperative.

Research in virtual environments has highlighted implications for memory based on how individuals spatially navigate through these environments. Fabroyir and Teng (2018) observed that, whereas females have a tendency for allocentric navigation (characterized by a maplike perspective emphasizing the spatial relationship to external objects and the overall layout), males exhibit an egocentric navigation style (focusing on their immediate surroundings and perspective). These differences can influence male and female memory retention and interaction in virtual settings, with females likely retaining a more comprehensive memory of a store's layout and males demonstrating a greater recollection of products that they interacted with.

Finally, studies have found that *reasoning processes* involved in evaluating information to arrive at an accurate or logical conclusion are affected by interacting with advanced technologies such as a smart wearable and haptic vest (Podgórski et al., 2017). Specifically, smart gloves and haptic vests enable tactile and heat sensation, mechanical vibration, and kinesthetic feedback when individuals use VR and/or AR technologies in the metaverse. This facilitates information acquisition to aid efficient and effective JDM. For instance, haptic cues can enhance mental simulation processes, leading to stronger reward associations and higher intentions to make a purchase decision (see Krishna et al., 2017; Zhu, 2023, for review). Also, as in the example of Maya above, (purchase) decisions may not only be faster and less effortful in the metaverse than in the physical world, since she does not need to search for and compare different options, but they may also be less likely to lead to regret, given that the options made available to her are consistent with her preferences. A recent study revealed that AR alleviates individuals' cognitive dissonance by affecting the perceived similarity between options and reducing confusion caused by excess choices (Barta et al., 2023). Specifically, in consumer shopping scenarios, cognitive dissonance (e.g., second-guessing, doubt, and regret) frequently occurs after choosing between similar products, but AR can help to reduce dissonance by effectively highlighting differences between products and simplifying the decision-making process.

However, the ability to engage in critical thinking, logically weigh up the pros and cons of different options, and solve problems effectively in the metaverse may be hampered by increased exposure to misinformation (Plangger & Campbell, 2022). Similarly, the weighting of rare events in the physical world (see Hertwig et al., 2004) could be affected by overexposure to such events in the virtual world, with virtual-world experiences potentially affecting what is deemed "representative" in the real world (Kahneman & Tversky, 1972; see also Olivola & Sagara, 2009). In addition, the ability to simulate outcomes may allow people, for example, to develop good investment strategies in a volatile market, although this could lead to a false sense of confidence (Dwivedi et al., 2022) when making such decisions in the physical world. As mentioned earlier, individuals' risk perceptions could also be altered by interacting with the metaverse resulting in harmful consequences. For instance, a JDM strategy applied when choosing to engage in "risky" activities in the virtual world (e.g., jumping off a cliff in the metaverse) with one's flying and regenerating avatar would be unsuitable for generalization to the physical world, which is characterized by the laws of physics (e.g., gravity) and biological existence (e.g., physical limits of the human body).

In sum, although there is emerging empirical evidence on the effect of advanced technologies on specific cognitive processes underlying human JDM, research on the direct effects of metaverse-related technologies on human JDM is largely lacking. Therefore, it remains unclear how JDM will "evolve" as human lives are increasingly lived in the virtual world. To that end, decision scientists may wish to take advantage of the research opportunities afforded by the metaverse.

Opportunities and Challenges for Decision Science in the Metaverse

The metaverse provides a useful real-time research environment where researchers can remotely embody an avatar, meaning that they do not need to be in the same physical space as research participants and collaborators (Higgins et al., 2021; Nagendran et al., 2022). This affords the opportunity to conduct research that would be difficult, impossible, or unethical in the physical world (e.g., body changes in VR research, Banakou et al., 2018; Serino et al., 2019; Slater et al., 2020). It also facilitates a more inclusive approach to research participation (Zallio & Clarkson, 2022), with researchers accessing a wider pool of participants worldwide, enabling the study of more diverse samples (e.g., dementia patients, Coelho et al., 2020, and attention-deficit/hyperactivity disorder patients, Seesjärvi et al., 2022). In addition, the research environment and participant pool can both extend beyond physical locations to 3D virtual worlds and cyberspace (Dwivedi et al., 2022) and digital representations of real people (e.g., human digital twins and avatars), respectively.

We suggest that the metaverse will provide decision scientists with (1) digital information on (2) users' or research participants' virtual representations and environments, (3) social networks, and (4) the operation of virtual worlds, which is (5) integrated from all digital devices they use. Each of these five so-called "domains" of the metaverse (i.e., digitalization, virtualization, social networks, virtual world, and data integration; see Cockerton et al., 2024) affords opportunities for research on human JDM but also poses challenges for researchers. Below, we identify several ways in which information collected from users (or research participants) in the metaverse could provide valuable insights into human JDM, and we highlight the challenges that decision scientists may face in doing so. Some of these challenges are ethical in nature, while others are practical. Again, our selection is illustrative and indicative of the concerns we have about the growing field of JDM that is becoming increasingly fragmented in scope, divided in thought, and subject to criticism regarding the quality of its research.

In the metaverse, objects, audio, texts, images, and other aspects of the world around us are digitized (Zallio & Clarkson, 2022). The *digitalization* of data about users (e.g., through brain–computer interface) and their virtual representations (e.g., avatar), as well as their interactions with other people and organizations in virtual worlds, creates rich layers of data that can be accessed for research purposes (Adjerid & Kelley, 2018). This will further allow decision scientists to go beyond commonly used self-report data (for a notable exception, see work on process tracing e.g., Konovalov & Ruff, 2022), enhancing the credibility and (internal and external) validity of research findings. It can also improve researchers' ability to peer inside the "black box" (Ha et al., 2022; Pala et al., 2022) as well as go beyond paramorphic representations of human JDM (Einhorn et al., 1979; Hoffman, 1960). However, there are privacy concerns associated with accessing and analyzing personal and sensitive digital data from the metaverse (see Cockerton et al., 2024). Researchers will also need to be trained to use metaverse-related technologies along with the digital data they generate.

The *virtualization* of humans and other physical animate and inanimate things enables researchers to experimentally manipulate and control variables, standardize stimuli across participants (Loomis et al., 1999), and measure response behavior (e.g., head, body, and hand movements) in a fine-grained, covert, and continuous manner (Yaremych & Persky, 2019). In addition, together VR and AR (i.e., mixed reality or extended reality) provide an enhanced sense of immersive realism with virtual features added to the physical environment (Slater et al., 2020). Thus, decision scientists will be afforded an opportunity to increase the external validity and generalizability of their research with reduced threats to its internal validity (Dhami et al., 2004; for an example, see Hodge et al., 2021). Virtualization also facilitates the measurement of test–retest reliability. Nevertheless, the representativeness of decision situations and tasks will need to be established (see Dhami et al., 2004) in order to ascertain the generalizability of findings to virtual and physical worlds. Researchers will also be faced with the challenge of disambiguating the idiosyncrasies of individual participants from their virtual representations (e.g., avatars and/or digital twins).

Social networks in the metaverse will more closely resemble in-person experiences (e.g., due to 3D-enabled interactions with haptic feedback). This provides a relatively cost-effective and efficient way for decision scientists to examine the effects of both social and cross-cultural interactions and networks on human JDM as well as JDM in various social and cross-cultural contexts. These topics have arguably been relatively underexplored in comparison to research on individual JDM (for notable exceptions, see E. Weber & Hsee, 2000). Indeed, given the potential for the metaverse to be inclusive (Zallio & Clarkson, 2022), decision scientists can broaden their research participant base away from Western, educated, industrialized, rich, and democratic samples (Henrich et al., 2010), as well as potentially access traditionally over-protected groups such as minors and the mentally vulnerable. Increasing the diversity of participant samples will enable decision scientists to test the generalizability of existing effects on new populations and allow them to employ previously proposed approaches to cross-cultural research on risk and decision making (e.g., see McDaniels & Gregory, 1991). Realistically, however, the representativeness of participant samples will depend on the accessibility of metaverse-related technologies. From an ethical standpoint, data from "bystanders" or those who have not consented to participate in research (or refused consent) may be difficult to exclude (see Cockerton et al., 2024). Researchers may also be held accountable for safeguarding participants during social interactions in the metaverse.

The *virtual world* domain of the metaverse refers to an integrated network of persistent online computer-generated simulated environments where multiple users in distant physical locations, represented by avatars, can interact in real time (Dionisio et al., 2013). This provides an immersive experience and tangible sense of presence (Loomis et al., 1999). As previously stated, virtual worlds can expose individuals to new stimuli and experiences that would not otherwise be available to them (Mol et al., 2022) or which are rare or impossible in the real world. For instance, individuals with disabilities could ride a roller coaster in the metaverse, and people can move seamlessly from different locations or situations such as jumping from working in a virtual office space to relaxing on the beach (Dwivedi et al., 2022; Hemp, 2006). Thus, beyond presenting opportunities for decision scientists to test the replicability of existing effects observed in the physical world to virtual worlds, and examining how JDM inside the virtual world spills outside into the physical world, the metaverse presents new avenues for research. For example, researchers could study the application of human JDM in rare situations or for black swan events, as well as situations that would be practically infeasible or unethical to study (e.g., natural disasters, Mol et al., 2022). Researchers could also better examine the learning of JDM skills, the (mal)adaptiveness of JDM strategies, and identify effective interventions for improving JDM (see Dhami et al., 2011). Insights drawn from these areas of research can help to move the field beyond static conceptions of human JDM, divisive "illusionism versus functionalism" debates couched in oppositional "coherence versus correspondence" perspectives (see Hammond, 1990, 2000), and help the field achieve its prescriptive mission (see Fischhoff & Broomell, 2020). However, researchers will be faced with the problem of disentangling the psychological effects of immersion in VR itself, which are not yet fully understood, from the effects of virtualization on JDM. In addition, research in virtual worlds will require extensive pilot testing, making studies resource- and time-intensive.

Finally, *data integration* means that data from a range of sources, including head movement and brain wave data from VR goggles, eye-tracking data from AR glasses, hand movement from a VR controller, sensory data and biometric data (e.g., body temperature) from haptic vests and gloves, and geolocation data from a computer or smartphone, can all be integrated into one database. Data from different sources can be used to triangulate findings, and when pooled for analysis, this "big" data will enable the development and testing of multifaceted and multilevel theories of human JDM. In particular, there is potential for decision scientists to more convincingly test dual systems accounts of JDM, thereby resolving disputes (see Arkes, 2016) and considering alternatives or extensions (see Hammond, 1996). Researchers can also more comprehensively consider the independent and interactional effects of cognitive and noncognitive factors on JDM (see Blanchette & Richards, 2010 and Roberts & Hutcherson, 2019). However, integrating data from different metaverse sources will be challenging because data ownership will be distributed. In addition, the algorithms required for data integration will add a layer of complexity to the analysis of such big data, as well as uncertainty and ambiguity in the interpretation of findings.

In sum, the metaverse will provide decision scientists with layers of rich data that can be used to provide new insights into human JDM as well as examine the generalizability, replicability, and boundary conditions of existing effects. Indeed, research has already been conducted that involves agent-based modeling for hypothesis testing and theory building (Madsen et al., 2019) and identifying cognitive features of creative human JDM as part of a Pi-Mind ("patented intelligence"; Terziyan et al., 2018). Such work is contributing to the advancement of digital cognitive clones that individuals can use as responsible representatives when they themselves are unavailable (Golovianko et al., 2021). Research has also demonstrated how immersive virtual environments can provide people with a valuable opportunity to improve their JDM (see Kerdvibulvech & Ayuttaya, 2023) as well as gain new JDM skills (see Radhakrishnan et al., 2021). However, as we have highlighted, potential research opportunities in the metaverse also come with a variety of practical and ethical challenges.

Final Remarks

For over 2 decades, scholars have highlighted the potential of virtual environments in advancing social science research (e.g., Blascovich et al., 2002; Loomis et al., 1999). In this article, we have provided a "whistle-stop" tour of how the next generation of these virtual environments, namely the metaverse, can be exploited by decision scientists. We have explored how interaction with the metaverse may affect the cognitive processes underlying human JDM. Additionally, we have suggested ways in which decision scientists can use the metaverse as a research laboratory to empirically examine hitherto unresolved or understudied issues. Clearly, other (noncognitive) processes, such as emotion and motivation that underlie human JDM, are also likely to be affected by metaverse-related technologies. In addition, many other JDM-related research avenues can be pursued using data collected from the metaverse.

We encourage readers to delve deeper into the ideas presented herein and expand upon the scope of these ideas when exploring ways to broaden their own research agendas so as to capitalize on the research potential of immersive virtual environments and, eventually, the metaverse. We believe that a focus on how human JDM is shaped by advanced technologies comprising the metaverse has the potential to unite the expanding but increasingly fragmented field of JDM. Finally, as we noted elsewhere (Cockerton et al., 2024), undertaking research in a world where the physical and virtual realms merge, presents novel and distinct ethical challenges that are not currently addressed by existing guidelines. While being mindful of these challenges, we contend that the metaverse will enable decision scientists to gain a deeper and more holistic understanding of human JDM as it currently stands, as well as how it will "evolve" as individuals increasingly live their lives in the virtual world.

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