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Emerging technologies in varied domains: Perspectives and future research directions

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As a result of the continuous advances in the field of digital and virtual technology, robotics, and artificial intelligence domains, we are experiencing profound and extremely rapid changes in almost every aspect of our human experience and are discovering new aspects of it as well. This revolution encompasses a variety of fields, including tourism, communication, entertainment, education, and art.

In this special issue, “Emerging Technologies and Human Behaviour: Challenges in Artificial Intelligence, Social Robotics, and Virtual Reality in Psychology, Complex Experience and Artistic Domains”, to capture the key consequences of this rapid revolution on human behaviour and experience, we focused on the most salient discoveries in a wide variety of domains. Specifically, articles included in this collection focused on how and to what extent emerging technologies are re-shaping human life now and their potential impact in the near future. This collection of articles explores the impact of virtual reality on our emotions as well as artificial intelligence’s role in art creation, looking at how technological advances are reshaping our lives and presenting new opportunities of human experience.

Contributors are from a wide variety of disciplines, as this topic covers different domains. Meta-themes addressed in this collection include the impact of novel robotics, virtual and artificial systems on emotions, attitudes, behaviours and their link with peculiar personality traits.

More narrowed topics revolve around the use of technologies such as Artificial Intelligence (including in education), Augmented, Mixed and Virtual Reality for the study of consumer decision-making process; the addiction attitude towards social media; and pre-diagnostic instrument that leverages Explainable Artificial Intelligence to enhance the diagnostic process of autism, among others.

We privileged empirical articles and systematic theoretical contributions investigating the link between human experience and emerging technology in a specific domain, thus, offering theoretical and methodological guidelines for further research in the field.

In the end we had 19 articles that met these inclusion criteria and that we included in this issue. First, we provide an overview of the most recent discoveries for each domain, and then, we deepened how articles in this issue add to existing literature. Then, we concluded with guidelines for future research in each specific domain and we justify the need for a more interdisciplinary effort across domains.

### 1. Art

In recent times, there has been an intriguing convergence between emerging technologies and the arts, resulting in a synergistic relationship that surpasses conventional limitations of space and time. The

integration of Artificial Intelligence (AI), social robotics, and Virtual Reality (VR) within artistic domains has created novel opportunities for fostering creativity, investigating human behaviour, and facilitating immersive experiences. This section examines the significant influence of these technologies within the realm of art, specifically emphasizing how they affected visitors’ behaviours, artistic interpretation, emotions and aesthetic experience.

Throughout history, art has consistently served as a manifestation of the human condition, a vehicle for expressing emotions, and a platform for communicating concepts. In the context of our dynamic and ever-changing environment, technology has assumed a prominent role within the realm of art, thereby facilitating the emergence of novel avenues for creative expression and intellectual inquiry.

The study conducted by [Trupp et al. \(2023, this issue\)](#) investigates the phenomenon of artistic responsiveness within the digital realm. This study utilizes technology, particularly the Monet interactive art exhibition provided by Google Arts and Culture, for the exploration of the ways in which subjective experiences of pleasure and meaningfulness during engagement with online art contribute to overall well-being. Without using sophisticated technologies but just a simple laptop, [Trupp et al. \(2023; this issue\)](#) showed that even brief exposure to art displayed online was able to decrease negative mood and anxiety, and that this was related to their responsiveness to art itself. Participants were susceptible to art viewing intervention benefits depending upon the pleasure and meaning they felt while viewing the online art. This study highlights the dual role of technology as both a means of delivering well-being and a novel approach for analysing users’ experience of art.

Technology has been used as a medium through which the impact of virtual spaces on artistic involvement can be comprehended also in the study of [Kim and Lee \(2023; this issue\)](#). Following the Construal Theory, they showed that visitors’ perception and behaviour towards metaverse performing arts is dependent on the perceived psychological distance, that is, the more participants perceived an artistic, spatial, social, and economic distance towards metaverse performing art, the more resistance they felt towards this form of art. Within this field, the number of studies investigating the link between real experiences and their “digital and/or virtual twins” is increasing, maybe due to an enhanced awareness of the potential of VR not just as a mere replication of reality but as a novel form of reality ([Gaggioli & Chirico, 2023](#)).

In the following study, [Demmer et al. \(2023, this issue\)](#) explore the perception of emotion and intention in art created by humans versus art generated by computers.

They explore the captivating domain of emotion and intention perception in art produced by both humans and computers. The study

presented in this research challenges the prevailing belief that art produced by humans inherently elicits more intense emotional responses. Additionally, it provides insights into the intricate interactions between viewers and art, regardless of its source. Specifically, they tested for the first time, whether priming information regarding the provenance of an artwork (e.g., stating explicitly that the artworks were produced by either a computer or a human) influenced the outcome of evaluations of intentionality, liking, and emotions showing that only one out of five AI artworks could be attributed to a computer. Technology functions as a medium through which one can analyse the complexities of art engagement and explore the prospective advancements of computer-generated digital interactions.

Technologies have been used also to enhance the process of art interpretation (Lucifora et al., 2023; this issue). The researchers aim to enable users to embrace different viewpoints and perspectives through the immersive experience provided by VR. A virtual museum is established wherein avatars engage with various subjects, thereby promoting a contemplative process that facilitates the development of empathy and perspective-taking abilities. The VR experience has been found to be effective also in promoting social cohesion: through a change of perspective in the interpretation of cultural heritage, virtual art proved to be able to support empathy in users experiencing embodiment with an avatar in a virtual museum (Lucifora et al., 2023; this issue). However, despite repeatedly claiming the persuasive power of VR and the metaverse, they still remain instruments used in some sectors and by specific types of users. In the present context, technology serves to augment the ability to embody and empathize, presenting a new method for engaging with and interpreting art.

The aforementioned four studies collectively underscore the significant impact of technology within the realm of art. The utilization of technology has become an essential instrument in comprehending, augmenting, and redefining the human encounter with art, ranging from the examination of aesthetic responsiveness and online art engagement to the investigation of metaverse performing arts, emotion perception, and VR-driven art interpretation. As society increasingly adopts emerging technologies, the distinction between art and technology will become increasingly indistinct, presenting boundless opportunities for artistic expression and deeper insights into the human psyche within the domain of art.

## 2. Robot and conversational artificial agent

The study of the interaction between humans and AI-based entities has become a central focus in the rapidly evolving field of AI. This discourse examines three notable research studies that investigate the influence of personality traits on interactions with artificial conversational agents (ACA) and the acceptance of robots within the hotel sector.

In this regard, Pal and colleagues (Pal et al., 2023; this issue) discussed the role that personality features play in specific AI-based tools such as ACA. One particular form of love, namely consummate love, was investigated in shaping human-machine interaction and user experience. The triangular theory of love posited by Sternberg first established this form of love as the most difficult to maintain and nurture (Sternberg, 1986).

In the study conducted by Priya et al. (2023), the authors examined the personality traits exhibited by intelligent virtual assistants within the context of financial services. Priya and their team investigate the utilization of Intelligent Virtual Assistants within the financial services sector, with a specific emphasis on prominent characteristic attributes including Perceived Intelligence, Perceived Anthropomorphism, and Perceived Animacy. The findings of their study highlight the importance of these characteristics in augmenting user acceptance of Intelligent Virtual Assistants.

From a contrasting standpoint, the research conducted by Binesh et al. (2023) delves into the examination of human characteristics that exhibit greater favorability in the context of human-robot interaction. In

this regard, the European Union outlined guidelines and ethics to ensure that humans and artificial intelligent systems have a mutually beneficial interaction. In this way, people can feel comfortable and trust this technology, for example, in leisure or touristic settings. For instance, in their study, they examined the impact of individual personality traits on the propensity to embrace service robots within hotel environments. The study conducted a survey among a sample of 525 individuals who had recently stayed in high-end hotels rated 4 or 5 stars. The findings of the research indicate that age plays a significant role in influencing individuals' behavioral intentions towards the adoption of service robots. There is a greater propensity among younger and higher-income individuals to adopt service robots within the hotel setting.

## 3. Artificial intelligence

The integration of AI within our continuously advancing technological environment has initiated a novel era characterized by innovation and the ability to address complex problems. This section introduces two significant studies that utilize AI for practical applications, with each study focusing on different facets of human behaviour and development (including education).

In the current era, where technology is assuming a progressively significant role in education and the development of skills, the interaction between individuals and AI is still to be fully understood and ethically situated. As explained by Activity Theory, elucidating this aspect has become more crucial since emerging technologies mediate the relationship between actors and knowledge construction (Boer et al., 2002). Benvenuti et al. (2023; this issue) proposed a novel framework where computational thinking as “the thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer - human or machine - can effectively carry out” (Wing, 2017, p. 8) plays a crucial role. Developing this ability in compulsory education enables students to move beyond operable skills and become problem solvers rather than just technology beneficiaries. To achieve a strong computational mindset, critical thinking and creativity were suggested as key skills to be developed (Benvenuti et al., 2023; this issue). A core further application of AI-based tools with young children in the clinical domain is the one developed and tested by Paolucci et al. (2023; this issue) for the early detection of Autism Spectrum Disorders. This AI pre-screening tool is easily administrable by both caregivers and teachers: starting from the analysis of pre-verbal interactions observed in videos of children doing everyday activities it allows to identify potentially alarming signs of non-typical behaviour.

## 4. Virtual reality

Virtual Reality has emerged as one of the most used technologies in present day experience. The convergence of art and technology has led to the emergence of VR as a potent tool for enhancing the educational and emotional resonance of artistic encounters. A recent work from Karnchanapayap (2023; this issue) showed the effectiveness of VR scenarios for educational experience in exhibition settings: through physical activities (i.e., looking, walking, performing a specific physical action, locating an object) audience engagement can be significantly improved. In this regard, Scorolli et al. (2023; this issue) investigated the aesthetic emotions and the social presence during a music concert experienced in four environments, characterized by different levels of immersivity: at one extreme is the live concert, at the other the traditional music video on a computer screen, in between two experiences in VR, provided by more or less affordable devices. The level of enchantment and joy conveyed by the live concert was higher than that experienced with video and *Google cardboard*, but similar to that experienced with the *HTC vive*. Moreover, the *HTC vive* was able to lead to a significant increase of interest in the sample of students, who initially did not appreciate the chosen music genre (i.e., tango).

## 5. Virtual reality and emotions

The application of VR to elicit and examine human emotions has received considerable attention in recent years. In the present context, scholars have been investigating the impact of emotions evoked within VR environments on diverse facets of human cognition and memory. In this regard, the systematic review conducted by [Mancuso et al. \(2023; this issue\)](#) has shown that VR has been used to study the link between emotions and memory in two ways, either inducing emotional states in participants before the VR experience or using the VR experience itself as a means of inducing emotions. In any case, VR emerged as an ‘affective medium’ capable of shaping complex emotional reactions and creating a plausible context for testing memory retrieval, and recall.

In a similar vein, [Xia et al. \(2023\)](#) have conducted a study that explores the impact of emotions induced in VR on cognitive functions. Notably, the study introduces an additional variable of investigation, namely colors. The authors conducted two experimental studies utilizing immersive VR equipment to investigate the potential impact of colour stimuli on individuals’ cognitive performance within VR environments. This novel methodology emphasizes the intricate relationship between emotions, colors, and cognitive processes, revealing fresh perspectives on the ways in which immersive technologies can influence and augment human experiences.

Another contribution comes from the study of [Pizzolante et al. \(2023; this issue\)](#), who demonstrated not only the feasibility, but also the effectiveness of a VR-based training program for eliciting awe, which had a positive impact on a specific dimension of creativity, namely creative thinking. As such, VR has become increasingly significant for studying even complex emotional phenomena in a controlled manner as well as peculiar cognitive processes, such as memory.

Similarly, [Huang and colleagues \(2023; this issue\)](#) showed that VR-based training for creativity significantly increased the elaboration, vividness, and novelty of creative outcomes compared to the same content conveyed via normal lectures.

Finally, [Mauri et al. \(2023\)](#). Examines the effects induced by a real estate website that offers the opportunity to evaluate the potential purchase of a property in two ways: by viewing photos of the house (nonimmersive conditions) and by taking a virtual tour of the same house using a VR headmounted display (immersive conditions). Forty participants interested in evaluating the purchase of a new house, randomly assigned to one of the experimental conditions, participated in the experiment. Results show that immersive navigation is associated with more positive emotions (EEG), more intense physiological arousal (SC), higher scores on the presence questionnaire, and higher scores on the UX questionnaire compared to the non-immersive one. The psychological scales measuring emotions did not yield significant results. No significant difference in the three-item ad-hoc self-questionnaire was found, except for the item examining willingness to visit the real house building. Implications are also discussed.

## 6. Social media

This is the topic of the work by [Arora and Mehta \(2023; this issue\)](#) who systematize literature on social media addiction use for practitioners and policy makers, immediately highlighting the need for a synergic endeavour between science and politics to contrast this increasing issue. In this regard, more and more scientists are working to improve the quality of data extracted from social media, in order to better and more precisely outline human behavioural tendencies and attitudes, as in the work of [Srivastava et al. \(2023; this issue\)](#) which proposed and tested a novel spam influence minimization model for identifying spam-influential users and limiting spam tweet flow within the Twitter network.

## 7. Technology’s duality: Benefits and challenges

The proliferation of technology has brought forth a plethora of favourable facets, as evidenced by prior research endeavours that have delved into its advantageous influence on human affect and interpersonal connections. Nevertheless, the swift advancement of technology presents various challenges and adverse consequences. In the present context, it is imperative to acknowledge that although technology enriches our lives through diverse means, it also introduces vulnerabilities and potential drawbacks.

[Du et al. \(2023\)](#) examines financial literacy and resident fraud victimization. They examine the complex relationship between financial literacy and fraud victimization among residents. According to the researchers, endogeneity between variables means they can influence each other. Moreover, technology can heavily drive consumers’ decision-making process for purchasing goods. This is what [Sharma et al. \(2023; this issue\)](#) demonstrated in the AISAS (Awareness, Interest, Search, Action, and Sharing) model. They confirmed prior research showing that digital technologies affect how consumers search for products and services, evaluate, and choose them, consume, and build relationships with them ([Sharma et al., 2023](#)).

[Ciroku et al. \(2023\)](#). Present a deep ontological analysis of the implicit data model of the Visual Genome image dataset, and its formalization in the novel Visual Sense Ontology (VSO). To enhance the multimodal data from this dataset, we introduce a framal knowledge expansion pipeline that extracts and connects linguistic frames—including values and emotions—to images, using multiple linguistic resources for disambiguation. It then introduces the Visual Sense Knowledge Graph (VSKG), a novel resource. VSKG is a queryable knowledge graph that enhances the accessibility and comprehensibility of Visual Genome’s multimodal data, based on SPARQL queries. VSKG includes frame visual evocation data, enabling more advanced forms of explicit reasoning, analysis and sensemaking. This work represents a significant advancement in the automation of frame evocation and multimodal sense-making, performed in a fully interpretable and transparent way, with potential applications in various fields, including the fields of knowledge representation, computer vision, and natural language processing.

In summary, technology is a constantly evolving canvas upon which human experiences and interactions are redefined. For instance, AI-driven tools such as adaptive learning algorithms and intelligent tutoring systems are used to personalize learning experiences and provide tailored instruction to individual learners. The topics presented here encapsulate the intricate interplay between innovation and human experience and behaviour, offering a glimpse into the profound changes underway across various spheres. As we navigate this transformative journey, a deeper understanding of these intersections paves the way for harnessing technology’s potential to cautiously enrich, empower, and elevate our lives.

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The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## References

- Arora, S., & Mehta, M. (2023). Love it or hate it, but can you ignore social media?-A bibliometric analysis of social media addiction. *Computers in Human Behavior*, Article 107831.
- Benvenuti, M., Cangelosi, A., Weinberger, A., Mazzoni, E., Benassi, M., Barbaresi, M., & Orsoni, M. (2023). Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context. *Computers in Human Behavior*, 148, Article 107903.
- Boer, N. L., van Baalen, P. J., & Kumar, K. (2002). An activity theory approach for studying the situatedness of knowledge sharing. In *Proceedings of the 35th Annual Hawaii International Conference on system sciences* (pp. 1483-1492). IEEE.
- Chirico, A., & Gaggioli, A. (2023). How real are virtual emotions? *Cyberpsychology, Behavior, and Social Networking*, 26(4), 227-228.
- Cirotu, F., De Giorgis, S., Gangei, A., Martinez Pandiani, D. F., & Presutti, V. (2023). Automated multimodal Sensemaking: Ontology-based integration of linguistic frames and visual data. *Computers in Human Behavior*.
- Demmer, T. R., Kühnapfel, C., Fingerhut, J., & Pelowski, M. (2023). Does an emotional connection to art really require a human artist? Emotion and intentionality responses to AI-versus human-created art and impact on aesthetic experience. *Computers in Human Behavior*, 148, Article 107875.
- Huang, H. T., & Chang, Y. S. (2023). Effects of virtual reality on creative performance and emotions: A study of brainwaves. *Computers in Human Behavior*, 146, Article 107815.
- Karnchanapayap, G. (2023). Activities-based virtual reality experience for better audience engagement. *Computers in Human Behavior*, 146, Article 107796.
- Kim, H., & Lee, H. (2023). Performing arts metaverse: The effect of perceived distance and subjective experience. *Computers in Human Behavior*, Article 107827.
- Lucifora, C., Schembri, M., Poggi, F., Grasso, G. M., & Gangemi, A. (2023). Virtual reality supports perspective taking in cultural heritage interpretation. *Computers in Human Behavior*, 148, Article 107911.
- Mancuso, V., Bruni, F., Stramba-Badiale, C., Riva, G., Cipresso, P., & Pedrolì, E. (2023). How do emotions elicited in virtual reality affect our memory? A systematic review. *Computers in Human Behavior*, Article 107812.
- Mauri, m., Rancati, G., Riva, G., & Gaggioli, A. (2023). Comparing the effects of immersive and non-immersive real estate experience on behavioral intentions. *Computers in Human Behavior*.
- Pal, D., Vanijja, V., Thapliyal, H., & Zhang, X. (2023). What affects the usage of artificial conversational agents? An agent personality and love theory perspective. *Computers in Human Behavior*, 145, Article 107788.
- Paolucci, C., Giorgini, F., Scheda, R., Alessi, F. V., & Diciotti, S. (2023). Early prediction of Autism Spectrum Disorders through interaction analysis in home videos and explainable artificial intelligence. *Computers in Human Behavior*, 148, Article 107877.
- Pizzolante, M., Borghesi, F., Sarcinella, E., Bartolotta, S., Salvi, C., Cipresso, P., ... Chirico, A. (2023). Awe in the metaverse: Designing and validating a novel online virtual-reality awe-inspiring training. *Computers in Human Behavior*, 148, Article 107876.
- Priya, B., & Sharma, V. (2023). Exploring users' adoption intentions of intelligent virtual assistants in financial services: An anthropomorphic perspectives and socio-psychological perspectives. *Computers in Human Behavior*, 148, Article 107912.
- Scorrolli, C., Grasso, E. N., Stacchio, L., Armandi, V., Matteucci, G., & Marfia, G. (2023). Would you rather come to a tango concert in theater or in VR? Aesthetic emotions and social presence in musical experiences, either live, 2D or 3D. *Computers in Human Behavior*, 149, Article 107910.
- Sharma, P., Ueno, A., Dennis, C., & Turan, C. P. (2023). Emerging digital technologies and consumer decision-making in retail sector: Towards an integrative conceptual framework. *Computers in Human Behavior*, 148, Article 107913.
- Srivastava, S., Agharari, S., & Singh, A. K. (2023). Spam community detection & influence minimization using NRM algorithm. *Computers in Human Behavior*, Article 107832.
- Sternberg, R. J. (1986). A triangular theory of love. *Psychological Review*, 93(2), 119.
- Trupp, M. D., Bignardi, G., Specker, E., Vessel, E. A., & Pelowski, M. (2023). Who benefits from online art viewing, and how: The role of pleasure, meaningfulness, and trait aesthetic responsiveness in computer-based art interventions for well-being. *Computers in Human Behavior*, 145, Article 107764.
- Wing, J. (2017). Computational thinking's influence on research and education for all. *Italian Journal of Educational Technology*, 25(2), 7-14.
- Xia, G., Henry, P., Chen, Y., Queiroz, F., Westland, S., & Cheng, Q. (2023). The effects of colour attributes on cognitive performance and intellectual abilities in immersive virtual environments. *Computers in Human Behavior*, 148, Article 107853.

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