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Article

Digital Art and the Metaverse: Benefits and Challenges

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Abstract: As a concept that is somewhat under emergence, the notion of the Metaverse varies across different academic articles. Yet there is a shared view on the benefits to its ongoing implementation, particularly for digital art, where the technology can provide a new metric for artists to showcase and sell their artwork to a global audience with minimal barriers, and for consumers to have an unbounded experience not limited by physical space or museum entry fees. In this article, a contribution is provided to a broader conversation about the future of the digital art and the Metaverse and its role in shaping our online culture. We discuss the concept of the Metaverse, its structure, the role of artificial intelligence and the benefits (and limitations) the technology holds for digital art. For a case study, we develop a 3D art gallery housing an art collection generated using artificial-intelligence-based techniques such as diffusion models. A total of 67 individuals are surveyed from three pools (two in-person and one online-based), with questions relating to the future of digital art, the Metaverse and artificial intelligence. Findings include that the majority of participants were familiar with the concept of the Metaverse and overall, they had a predominately optimistic view of both the use artificial intelligence for art, and the use of the Metaverse to support digital art, with 85.3% of the participants having already seen artificial-intelligence-based artwork. The identification of consumer segments further highlights the importance of finding customised solutions, considering consumers' heterogenous preferences for AI-generated art. Research presented in this article will be beneficial for those looking to explore the Metaverse for artwork and develop virtual galleries, and the findings further highlight the Metaverse as a potential democratising force in the art world.

Keywords: digital art; metaverse; artificial intelligence; non-fungible tokens

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1. Introduction

The Web first created a connection with everyone in the world at any time. Later, the Internet of Things (IoT) revolution led to a remote connection with devices as well as people. Next, the notion of the semantic Web emerged by means of technologies, such as the Resource Description Framework and Web Ontology Language that make Web data more understandable by machines. This caters to multifarious intelligent applications, including media management and optimised Web search [1], all driven by artificial intelligence (AI) subfields (e.g., machine learning and machine vision). At present, the concept of the Metaverse is a vision for the next evolution of the Web, focusing primarily on the type of communication, interaction (namely, 2D to VR/3D) and immersion, brought about at a key moment in time where there is both a visible growing hunger for a VR-driven Web transformation and the technology in place to cater to machine reading of Web content.

Yet, the idea of a 3D Web or Metaverse is not a new one. The technological capabilities to create interactive 3D virtual environments have been available for the last 30 years. For example, since 1994, the Virtual Reality Modelling Language (VRML) has enabled the use of vector graphics to be deployed on the Web, supporting the creation of sharable 3D environments. VRML as a browser plug-in is a technology that is still actively used in a

broad range of research applications, as demonstrated by Li et al. (marine simulation [2]) and Yan et al. (VR-based education systems [3]) and, within the art and cultures domain, Xiaobing et al. employ the technology for ceramic painting and a fusion with virtual reality [4]. Hitherto, with 3D content being graphically heavy, scalability has been a longstanding limitation for widescale updates due to computational boundaries. This has led to many using existing infrastructure for their 3D worlds, for example the online social game Second Life, which gained prominence in the early 2000s and is still actively used in research [5], as well as Roblox [6] and Minecraft [7]. All three are popular choices, because the cloud infrastructure is already in place to cater to shareability, and users are able to create 3D environments without needing to learn how to code or create their own 3D assets and game world.

Hence, there is an organic push towards a 3D Web [8] and this growing interest in the notion of the Metaverse [9] is driving the creation of varied 3D-based platforms and siloed environments for commercial, entertainment, social and educational purposes. With this notion, Giannini et al. discuss that the digital identity of the museum is evolving alongside human interactions on the Internet [10]. It must also be noted that the COVID-19 pandemic and its accompanying lockdown experiences have acted as a catalyst for this evolution as many galleries and museums began to offer alternative virtual visitor experiences [11]. Still, beforehand, the technology was already particularly beneficial for virtual art galleries and cultural heritage applications. It offers the opportunity to preserve aspects of our physical historical sites (in event of climate change, war, etc.) in a format that is sharable and future-proof, as well as allowing artists to share their creations in a manner that is not just constrained to local visitors, but rather freely accessible to others around the globe. The 3D Web holds, therefore, high potential for cultural heritage, as discussed by Kantaros et al. [12].

The Metaverse concept follows what Kalpokas et al. refer to as a '*shift to turn online as much of daily life as possible, ultimately leading to the dominance of digital media logistics across the whole society*' [13]. Thus, referring to the growing intertwining of humans with digital medium where our life, work, sociality and entertainment are becoming increasingly inseparable from the digital realm. With the rigorous pace of technology evolvement, we can expect to see new ways of combining fine art embedded with Web3D services. Further, extended reality services (e.g., virtual reality and augmented reality) and AI provide to modern artists new technics, tools for showcasing their creations to their audiences in 3D digital platforms. As the development of the Metaverse continues, more possibilities for fine art artists are available. The utilisation of non-fungible tokens (NFTs) is, thereby, empowering (digital) artists, including those working in visual and audio media, to establish their creatorship of digital content [14]. This revolutionary technology enables artists to prove ownership and safeguard their intellectual property rights, which is of paramount importance in the world of art. Additionally, NFTs allow artists to sell their designs as unique, one-of-a-kind digital assets, thereby providing publicly recognisable ownership [15]. Hence, the ability to authenticate authorship and to sell digital art as distinctive assets are of immense significance in the art industry, and NFTs have opened up new possibilities for artists to monetize their talent and creativity.

Though the expected benefits for artists and the cultural society as a whole appear to be evident, less is known about the actual consumer preferences and opinions regarding AI-generated artwork exhibited in digital galleries. Hence, in this article, a novel focus is provided through reflection on the nexus between technologies related to the Metaverse, digital art, AI and NFTs. This nexus can be considered as emerging, with relatively untapped potential. Thus, the following research questions are put forward, from which the aggregated findings can be used to investigate what benefits and challenges may emerge as the technology develops: (1) To what extent are consumers currently aware of digital art and the Metaverse? (2) To what extent will the Metaverse be beneficial for artists? (3) How will consumers perceive AI-generated art? and (4) What role does AI play for digital art and the Metaverse? Answering these questions will prime an understanding

of how artists could potentially use digital platforms to create and share digital art and explore the role of digital art in the context of society (and its potential social and cultural implications for consumers). The method used to answer the research questions relies on a synthesis of works in the existing literature and a mixed-method questionnaire surveying a community of consumers by developing an AI-based virtual art gallery. This narrative will contribute towards what is an unexplored topic through both a systematic view and methodological primary data collation process (for one specific use case) that can serve as a platform for subsequent research.

The remainder of this article is as follows. Section 2 provides a background on the Metaverse concept and current state of the art within this domain. Section 3 discusses the methodology used for the experimentation and survey process. Section 4 provides the findings and answers the research questions, with a discussion of the key benefits and challenges outlined in Section 5. The article is concluded in Section 6.

2. Background

Metaverse applications have been defined by some as anything on the Internet that is three-dimensional, immersive and virtual [15]. Others refer to the Metaverse as an all-encompassing universe populated by Metagalaxies (i.e., nodes), where each galaxy is a node created by an individual or corporation [16]. For example, a virtual art gallery could be such a node (or Metagalaxy) within the wider Metaverse universe. In this section, a reflection is provided on the Metaverse structure (with the aim of providing clarity on the concept from a technology perspective), as well as a discussion on art and the Metaverse.

2.1. Metaverse Structure

Currently there is not one single defined set of standards relating to the Metaverse structure [17], which may impact practical application (yet there are some developments towards using a set of open standards for interoperability, such as by the Metaverse Standards Forum [18]). As Weinberger discusses '*the Metaverse is rather a vision under evolution*' [19] with clear differing descriptions within academic articles [13]. However, it is widely accepted that six foundational technological components are required for its realisation, as discussed by Dolata et al. [20]. Still, authors often document them in a varied layering formats depending on their application domain. For example, Venugopal et al. present an aggregation of these six technologies into a four-layer technology stack [21]. Namely, these six technologies include (*i*) a computational infrastructure, (*ii*) virtualisation software, (*iii*) a viable economy substructure and economic interoperability, (*iv*) the human interface hardware, (*v*) virtual worlds (centralised and decentralised) and (*vi*) AI. These six layers lead to three major new outputs, including experiences, datasets and economies, outlined as follows.

2.1.1. Experiences

Large technology companies (e.g., Mozilla, Oculus, Microsoft, Magic Leap and Google) have all produced their own VR-capable browsers. The Unity game engine even has several plug-ins to allow others to create their own VR applications that contain a Web browser within them. As mentioned, VRML has allowed researchers this capability for over 30 years. Thus, these technologies allow the creator to develop immersive and interactive experiences that go beyond what is possible in the physical world or cater to a blending of the digital and physical world. Such experiences remain engaging and memorable for end users (without the users needing to be physically present) and offer advantages over viewing a static screen. There are well-documented uses of such experiences for education, entertainment and healthcare. Examples include the work by Samarnggoon et al. who discuss a Metaverse-based approach in education for use by university-level students, with a focus on showcasing the Chiang Mai University campus to prospective students [22]. Findings indicate that information about the university's curricula and career paths were well-received by participants. Furthermore, Moztarzadeh et al. discuss the use of the

Metaverse for healthcare implications, whereby the authors focus on digital twins of cancer and outline how a Metaverse-based approach '*allows users to fully experience the high levels of interaction and immersion*' [23], which is beneficial for applications such as simulating the diagnosis and development of cancer over time. Further, Suh et al. discuss the state of the technology in the wider medical field, surmising that a Metaverse-based application has the potential to support educators and implement interactions with patients in a bespoke manner [24]. What all these research findings have in common is that Metaverse-based experiences show clear benefits above and beyond solely entertainment purposes.

From a technology perspective, the future of the Metaverse experience lies in decentralisation. As Aria et al. indicate, Metaverse projects should be built as decentralised platforms [17] as this would allow for appropriate content access through the Web3D ecosystem. There are both technological and ethical benefits for this notion. In terms of a technological consideration, a centralised process has the potential to create an environment in which the exploitation of both creators and participators become possible, for example, being locked into a single currency or development pipeline for content creation and management; thus, this creates an argument for the use of a decentralised approach. Regarding the ethics, ownership of personal data has been a well-debated issue for social media companies, and a 3D-created social environment has the potential to generate vastly richer datasets relating to user interaction, movement and gaze tracking (as further discussed in Section 2.1.2) and user data which goes beyond the level currently available to existing social media platforms. Further, one can consider that new experiences could also lead to the creation of new haptic devices to allow for 3D exploration and bi-directional interaction (digital to physical world and vice versa), thus extending our digital experience even further [17].

2.1.2. Datasets

New interactions provided in new 3D online experiences inevitably lead to innovative and richer datasets. The richness of information is increased through, for example, the integration of haptics such as motion tracking, gaze tracking, biometric readings and coordinate movements, which can all be collated using haptics to generate a deeper understanding of user behaviour. This leads to novel datasets that were previously unexplored on a large scale, resulting in additional possibilities to study human behaviour. However, this can also lead to commercial opportunities, for example, many social media companies use their members as data sources, gaining money from targeted advertising. As Kalpokas et al. discuss, what we may see in the future is that '*the increasing penetration of and reliance on digital media and other technologies involve a deepening of connectedness and interdependence among not only individuals but also multiple entities involved in the process*'. This means that, with the data analysis process becoming more automated (by means of AI), the richness of the datasets collected from the Metaverse may shape daily life experiences and produce an understanding of customer/user behaviour on an unprecedented scale, which has benefits, such as improved services for customers, but also drawbacks, such as increasing possibilities for disinformation or cross-reality illusion.

With this new richness of data, we can surmise that the collection can still be classified into one of the three standard groupings: structured, semi-structured or unstructured [13], as outlined in Table 1.

2.1.3. Economies

New data lead to new economic opportunities. With richer datasets, AI-driven data mining can lead to an understanding of consumers in a manner that was never previously possible, thus creating new marketing opportunities. In his forward-thinking article on the Metaverse, Ball highlights the potential for the emergence of the Metaverse to revolutionise payments, products and hourly labour [16]. However, to fully realise its potential, the Metaverse must provide value to its users. Generating value for its users is, therefore, essential for the Metaverse to serve its purpose effectively [25,26]. In addition, the Metaverse will

only function if it contains commercial opportunities within itself for the avatar within the 3D virtual world [13]. For example, for artists and wider creative content developers, the role of NFT technologies allows creators to safeguard their contents, meaning that digital ownership is possible both for the creator and the consumer. This means that avatars can own unique items and thus creates value through rarity. Digital artists and collectors are already employing NFTs to purchase and sell one-of-a-kind pieces of digital and physical art in virtual marketplaces. NFTs also enable artists to digitally track and verify their work's ownership, as blockchain makes ownership of a digital asset possible.

Table 1. Potential Metaverse data types.

Type	Description	Example
Structured	A fixed human boundary-based environment.	Directed interaction or passive observation takes place, meaning data recordings are structured in nature—an example would be an education environment.
Semi-structured	A game-based environment for entertainment purposes.	The environment is semi-controlled, as the play space is constrained and may include storylines and non-player character interactions and fixed hotspots, but the user actions may be uncontrolled. An example would be a virtual museum or art gallery.
Unstructured	A purely social environment.	As there is no fixed 'story', the data produced are directed entirely by the users and are unstructured. An example would be a virtual 3D chatroom.

Thus, digital art can now provide long-term conservation and accessibility since it can be more readily preserved and archived than previously possible. The future of digital art is closely related to the development of NFTs. As more artists and collectors become familiarised with NFTs, there is potential for the digital art market to expand [27]. Based on current trends, NFTs have the potential to transform the art world, as well as other domains that rely on digital services.

2.2. Art and the Metaverse

As discussed, emerging Metaverse technologies offer exciting new opportunities for the digitisation of fine art. As Lee et al. state, the Metaverse will create '*unprecedented opportunities for artists to blend every corner of our physical surroundings with digital creativity*' [28]. However, there are still several features and obstacles that need to be addressed to fully analyse the potential of digital fine art in Web3D environments. Regarding research on the state-of-the-art for art-based Metaverse applications, a survey of the wider landscape identifies four causal barriers, including (*i*) scalability of real-time, (*ii*) lack of 3D content, (*iii*) implementation and (*iv*) exclusion of existing 2D content recognised by studies such as by Xiuquan et al. [29] and Liang et al. [30]. Due to the infrastructure requirements, many 3D Web studies involve siloed approaches lacking scalability or adopt the use of third-party software with an existing infrastructure. Aside from the technological constraints, legislation, such as copyright laws, may vary from country to country, making the digitalisation and distribution processes without the copyright holders' permission a challenge. Additionally, verification mechanisms are needed to ensure the digital artwork authenticity and prevent art fraud.

Further, the growing use of AI for art generation has led to widespread debate relating to the role the technology plays within the art community. As Epstein et al. discuss, it is not clear who should get the credit for AI-generated art [31]. For demonstration purposes, in Figure 1 we provide examples of AI-generated artwork created by the authors of this article using skybox blockadelabs (https://skybox.blockadelabs.com/ accessed on 1 February 2023) and pollinations ai (https://pollinations.ai/ accessed on 1 February 2023) by means of a selection of words which are used to generate an image.

(**A**) (**B**)

Figure 1. AI-generated art: (**A**) 'Bird rain sad smile machine fantasy' and (**B**) 'Universal birds fly from the hyper-universe to bring peace and love to humanity and restore climate change'.

As demonstrated in Figure 1B, an AI-based approach can generate new art that mimics existing features of original human-created paintings (e.g., style, colours, composition). Figure 1B was created using a training set of original hand-painted artefacts. One of the most commonly used AI approaches for this is the generative AI (GAN) [32]. New era artists can use GANs to generate unique pieces of art that are then incorporated into Metaverse-based experiences. For example, an artist could use such a model to generate a new piece of art based on their personal style or the style of a different artist, and then display that artwork in a Metaverse-based virtual gallery. Another application of these models can be the personalisation of experiences for end users based on an analysis of preferences and interests. With these analytics models, artists may reach a wider audience by catering to individual needs.

One potential application of stable diffusion models in creating immersive Metaverse experiences is in the development of complete AI-generated virtual galleries and museums. By combining diffusion in digital art, artists could develop virtual spaces based on their text prompt inputs that showcase their most influential artworks during their life cycle and personal style. These virtual spaces could be designed to provide a more engaging and immersive experience embedded with various digital services. AI-based models and, more specifically, stable diffusion combined with immersive Metaverse experiences have the potential to play a catalytic role on the domain of fine art and beyond. They could be an important feature in the creation of a well-informed, engaged and responsible global community. Thus, in the following section we discuss our methodology for the development of a virtual gallery for AI-based art and the subsequent consumer-based evaluations.

3. Methodology

To investigate the benefits and challenges for digital art and as exhibited in the Metaverse, we build on the background section by exploring consumers' perception of AI-based art presented in a Web3D digital gallery. By using a mixed-method study approach, we are able to provide a synthesis composed of findings from related articles, but also by means of primary data collated directly from a diverse audience.

The actual development process for this study follows the stages of analysis, design and implementation and testing. These stages align to other extended reality-based workflows, such as the approach adopted by Majid et al. [33], however in comparison to their research, we combine the design and implementation into one section for clarity. We refer to the virtual environment as a Metagalaxy and would consider it one node in a wider Metaverse-based network, to align with the description provided by Ball et al. [25], discussed in Section 2.

3.1. Analysis and Challenge

The exploration conducted during the related-works analysis in Section 2 identifies that creating a 3D Web with a scalable and affordable cloud-based backend remains a challenge due to the financial costs involved. Further, centrally hosted prebuilt 3D applications are typically known to be prone to packet delay, which negatively affects the sense of reality and interaction. Therefore, our approach involves the use of third-party software for scalability/accessibility, namely Virtual Art Gallery (https://app.virtualartgallery.com/ accessed on 1 February 2023), which is an approach widely adopted in many other works where a 3D-based set up for experimentation is used, for example, the aforementioned works by Lozano-Durán et al. for medical imaging communication using Second Life [5] and de Bruno et al.'s use of Minecraft for educational purposes within the urban planning domain [7]. The artwork presented within the Web3D gallery will be AI-generated and the environment should be suitable for exploration on (mobile) devices such as laptops, PCs or smart phones. The application should cater to an analysis of user opinions on AI-generated art, the Metaverse, virtual art galleries and NFTs.

3.2. Design and Implementation

As mentioned, the Metagalaxy application was developed using the *Virtual Art Gallery* tool, from which a gallery template was selected. The artwork was developed using pollinations ai (https://pollinations.ai/ accessed on 1 February 2023) and skybox blockadelabs (https://skybox.blockadelabs.com/ accessed on 1 February 2023). Each artwork is generated by specifying a style and a collection of words that create a theme in the digital creation. The artwork was divided into two parts within the virtual gallery, namely, a fine-art-style section and a modern-style display. The text prompts, tools and format used for the AI art generation are outlined in Table 2.

In some instances, the same words or phrased were repeated in order to experiment with different style generation types, and also to demonstrate how the AI-based tool creates a different image each time. Figure 2 displays multiple views of the virtual gallery containing the artworks outlined in Table 2. It should be noted that the AI-image creation tools employed are just two of a large (and growing) collection of possible options. Further, it should be emphasised that our study is exploratory in nature and one of the first to investigate the use of AI-generated and AR-presented art in exhibitions. As such, our work provides initial insights into the advantages and challenges of this new form of art (exhibition), aiming to inspire future research—thus, the work should be perceived as a case study and not as a universal finding for AI-generated art or virtual galleries.

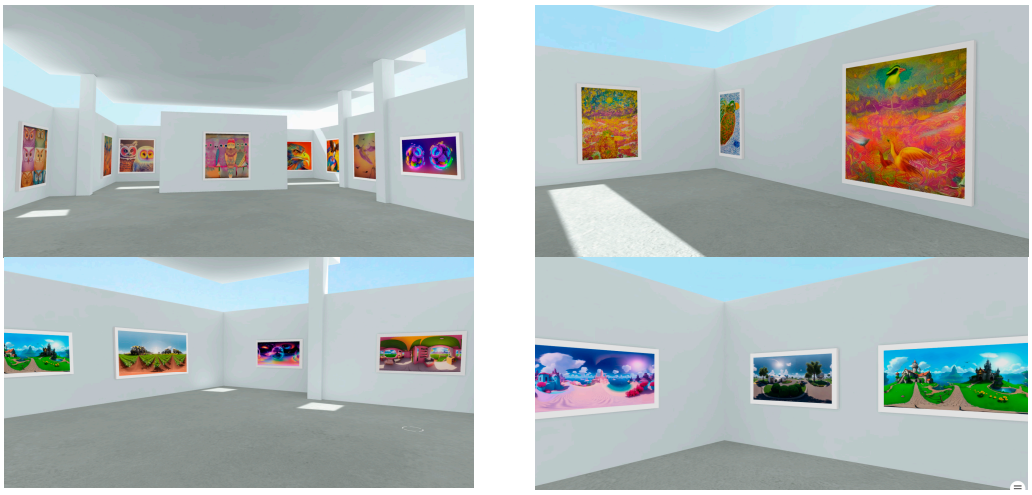

Figure 2. Multiple views of the Metagalaxy AI-based art gallery.

Table 2. AI art parameters.

Word Selection	Format	Artefact N°	Tool
Owls of Wisdom	Modern fine art acrylic style	1	pollinations ai
Universal birds fly from the hyper-universe to bring peace and love to humanity and restore climate change	Modern fine art acrylic style	2	pollinations ai
Eagle of the universe restores universal ataraxia	Modern fine art acrylic style	3	pollinations ai
Eagle of the universe restores universal ataraxia	Modern fine art acrylic style	4	pollinations ai
Flying colourful birds guided by spiritual wisdom deliver the message of peace and kindness	Modern fine art acrylic style	5	pollinations ai
Augmented reality	Digital painting	6	skybox blockadelabs
Human computer interaction digital twin	Surreal style	7	skybox blockadelabs
Rainy	Modern computer animation	8	skybox blockadelabs
Bird rain sad smile machine	Fantasy lands	9	skybox blockadelabs
Extended reality for agriculture	Realistic	10	skybox blockadelabs
Extended realities for agriculture	Dreamlike painting	11	skybox blockadelabs
Virtual reality crop agriculture	Digital painting	12	skybox blockadelabs
Owls of Wisdom	Modern fine art acrylic style	13	pollinations ai
Flying colourful birds guided by spiritual wisdom deliver the message of peace and kindness	Modern fine art acrylic style	14	pollinations ai
Owls of Wisdom	Modern fine art acrylic style	15	pollinations ai
Flying colourful birds guided by spiritual wisdom deliver the message of peace and kindness	Modern fine art acrylic style	16	pollinations ai

3.3. Exploring Consumers' Perceptions

A 14-item questionnaire was developed to address the research questions. To select a demographically diverse sample aligned with recent studies on the visitor characteristics of art exhibitions [34,35], data collection was carried out using a sampling method in three stages. The first stage involved distributing the survey at the Thinking Within (TW) symposium held at Wageningen University on 13 April 2023. This event was attended by 70 immersive technology experts from academia and industry who shared an interest in the Metaverse. Survey participants were therefore familiar with the Metaverse and expected to represent the ultimate target group; these participants were provided with a tablet device containing the survey form and access to the virtual art gallery. They were given no time constraints but were provided with a tutorial on navigating the 3D environment. The second stage involved randomly approached individuals at the Wageningen University Leeuwenborch (WUL) campus on 20 April 2023. Participants recruited on the WU campus were expected be younger and, as Olson et al. discuss, tend to use a greater breadth of technologies [36], while also having a higher level of education, being important drivers to visit an art exhibition [34,35]. Finally, in the third stage, the survey was posted on social media (SM) from the authors' accounts to receive wider feedback during the week of the 17–21 April 2023. This online data collection method was particularly favourable for this study, as the Metaverse and future Web applications can only be used online. The online data collection process was also aligned to match the timing of the TW event. Therefore, distributing the questionnaire via social media was an active choice made by the authors as participants are expected to have at least a general interest in AI-generated art exhibitions [37]. In all three stages a consent request was included in the questionnaire, informing participants about the process, and notifying them that they could stop at any point or skip questions if they would like to do so. The data of the survey were treated anonymously, and no personal data were collected or stored.

By collating data as described, we aimed to establish a balance between expert feedback and data collation from a wider (potential target) audience. Survey questions included a combination of quantitative and qualitative questions [38] as outlined in Table 3. As Braun et al. outline, the inclusion of qualitative data (particular for surveys deployed online) can provide '*nuanced, in-depth and sometimes new understandings of social issues*' [38]; thus, we included open-ended questions centred on the Metaverse, art and AI and future possibilities, as these questions have the potential to produce rich information, such as subjective experience and the general opportunity to express positive and negative opinion beyond the Likert-based options.

Table 3. Questionnaire overview.

Number	Question	Response Format
1	What is your age?	Open, quantitative
2	What is your profession?	Open, qualitative
3	Are you familiar with the term 'Metaverse'?	5-point Likert scale, quantitative
4	Are you familiar with the term 'Metagalaxy'?	5-point Likert scale, quantitative
5	How often do you interact with 3D content on the Web?	5-point Likert scale, quantitative
6	Are you familiar with the term 'Non-Fungible Token (NFT)'?	5-point Likert scale, quantitative
7	Have you ever visited a virtual art gallery (e.g., an art gallery on the web)?	3-point selection (yes, no, not sure), quantitative
8	Have you previously seen artwork generated by Artificial Intelligence?	Yes, no, not sure
9	What does digital art mean to you?	Open, qualitative
10	How much would you grade the future market potential for virtual art galleries in the Metaverse?	5-point Likert scale, quantitative
11	Which was your favourite artwork(s)?	Checkboxes
12	If you could buy one of these paintings would you like to be the sole owner?	3-point selection (yes, no, not sure), quantitative
13	What role do you think Artificial Intelligence can play for digital art and the Metaverse?	Open, qualitative
14	To what extent do you think the Metaverse will be beneficial (or not beneficial) for artists?	Open, qualitative

4. Results

In this section, the questionnaire findings are presented and discussed, in which consumer responses are used to support a reflection on the research questions outlined in Section 1.

4.1. Sample

In total, $n = 67$ participants completed the questionnaire. It should be noted that our study was exploratory in nature, seeking to investigate potential consumer perceptions of AI-generated and AR-exhibited artwork. Although we took guidance from the works of Green et al. [39] and Van Voorhuis and Morgan, who suggested that a sample size of 50 participants is sufficient to conduct relationship analyses, we did not intend to run any statistical relationship analyses [40]. Instead, we adopted a mixed-method approach, combining descriptive statistics with qualitative insights to shed light on art in the Metaverse.

Nonetheless, we did carry out a cluster analysis to examine homogeneous clusters in our diverse consumer sample. Although no established guidelines exist for sample size in cluster analysis, a sample size of 100 is generally considered to be at the higher end to achieve sufficient statistical power [41]. Therefore, our sample size of $n = 67$ participants can be considered as adequate to support our research findings.

Participants ranged in age from 20–62 years, with an average (mean) age of 30.5. The balance of the survey completions included n = 9 TW participants (12% of the total event attendees), n = 17 WUL and a further n = 41 SM. Table 4 provides an overview of the participants' professional statuses. The employment demographic distributed at 58.2% (n = 39) classed as in an employed status, 38.8% (n = 26) as a student and 2.9% (n = 2) with no current employment. The survey covered n = 22 different occupations and academic positions, providing a broad range of feedback from distinctive professions and user groups, offering valuable insight from both domain experts and the general population, as to align with the works in [34,35].

Table 4. Overview of survey participants.

Profession	Frequency
Student	26
Entrepreneur	4
Lecturer	2
PhD student/researcher	8
Professor	1
Technologist	1
Farmer	1
None *	2
Intern	1
Tour guide	1
Architect	2
Digital content developer	4
Programmer/SE engineer	3
Computer vision expert	1
Social creative artist	1
Ecologist	2
Electronic/mechanical engineer	1
Admin/office assistant	1
Business coach/development	2
Language teacher	1
Barista **	1
Course writer **	1
Total	67

* None was provided twice as an answer, but it is not clear if the participant refers to having no profession, or is not willing to provide a response. ** This profession title included a minor typo in the original response.

4.2. To What Extent Are Consumers Currently Aware of Digital Art and the Metaverse?

The research findings reveal that the use of terms such as 'Metaverse', 'Metagalaxy', and 'NFT' present some significant challenges for the participants, as the familiarity is not yet established (Figure 3). While the term 'Metaverse' was the most recognised concept, with 51% of participants claiming to be familiar with it to some degree, the term 'Metagalaxy' was relatively unfamiliar, as only 3% of respondents stated they have heard of it. With regard to 'NFT', the familiarity trend was comparable to the 'Metaverse' trend, with 51% being somewhat or very much familiar with the concept, while 22% had no opinion, and 27% were unfamiliar with the notion. Hence, these survey results indicate that there is a need for further education on and awareness of these concepts to improve consumers' understanding and integration into consumers' nomological networks in the context of digital art.

An additional and interesting finding was the high percentage of individuals who have previously experienced artwork generated by AI, with 85.3% (n = 58) answering yes, 11.8% (n = 8) saying no and 2.9% (n = 2) not sure if they have or not. Yet, as an obstacle, a lower percentage of individuals have visited a virtual art gallery (e.g., an art gallery on the Web), as evidenced by only 28.4% of the participants (n = 19) stating that they had, 64.2% (n = 44) stating they had not and 7.5% (n = 5) being unsure if they had (question 7). This obstacle is closely linked to the responses provided to question 5, where the number

of participants who do not consistently engage with 3D Web is 67%, with only a low percentage (15%) stating that they actively do so.

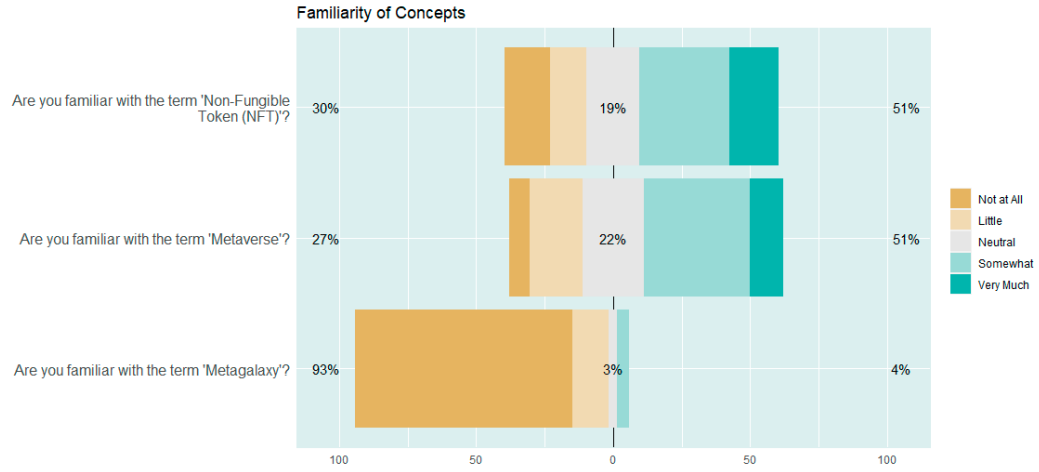

Figure 3. Likert scores for questions 3, 4 and 6 previously outlined in Table 3.

4.3. To What Extent Will the Metaverse Be Beneficial for Artists?

At a consumer level, Figure 4 demonstrates that 51% of the participants would grade the future market potential for virtual art galleries in the Metaverse positively, with 30% neutral towards the notion. As discussed, the use of NFTs is expected to have the potential to create value through scarcity [13]. Interestingly, however, in this study only 28.4% of the participants indicated that they want to be the sole owner of the AI-generated paintings, while 77.6% indicated to be not interested in owning the artwork. This finding contradicts previous research findings, displaying that NFTs are important for consumers in the context of digital art ownership, showing an 8% annual increase in value of artworks [13,35]. Thus, in a digital context, the significance of owning AI-generated digital art appears to be lower compared to in the physical world.

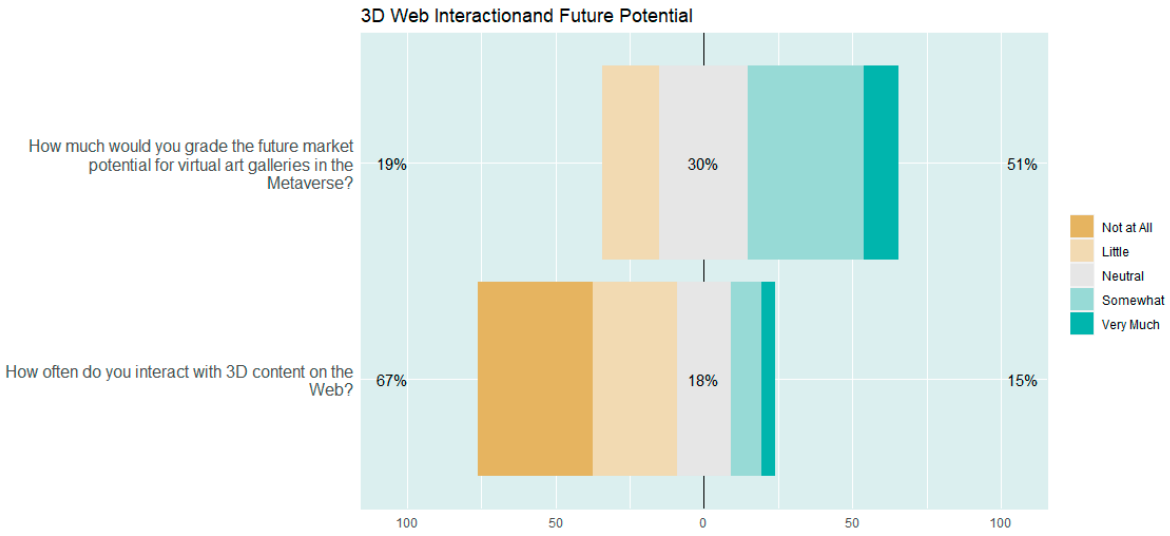

Figure 4. Likert scores for questions 5 and 10 previously outlined in Table 3.

To further explore consumers' perceptions on the benefits of the Metaverse for artists, we include the qualitative responses from question 14, '*To what extent do you think the Metaverse will be beneficial (or not beneficial) for artists?*'. In Table 5, we reflect on a sample of the positive and negative comments provided by the participants. Overall, qualitative responses were provided by $n = 51$ of the participants, with $n = 7$ providing no response and $n = 9$ saying that they did not know.

Table 5. Sample of qualitative responses provided to question 14.

Tone	Response *
Positive	'More outreach?'
	'Very beneficial, as they can reach more potential customers'
	'I think it would give artists an opportunity to show their uniqueness at a larger scale'
	'I think only very young artists will benefit from it'
Negative	'You feel everything is artificial and miss the real I think'
	'Some artists who will find ways to innovate in the Metaverse (new mediums, new interactive ideas) will prevail but most of the existing "traditional artists" will not benefit at all.'
	'I am afraid it will not benefit artists, since people now can look at free digital art instead of paid art in a museum'
	'It won't be. Digital art and physical art are very different artforms'

* Typos were corrected in the responses provided.

Overall, n = 25 written responses were positive regarding the notion, with n = 7 negative and a further n = 17 offering a balanced or mixed response. However, in viewing the answers it must be noted that n = 43 of the participants had previously not visited a virtual art gallery before completing the survey (yet this question was given after experiencing the gallery outlined in Section 3), with n = 19 saying that they had previously done so and n = 5 not sure if they had or not. Consumers evidently link advantages, such as ease of use, wider customer access, sources of inspiration, sharing prospects and accessibility for non-professionals to the utilisation of AI-generated art in the Metaverse.

Another remarkable benefit identified is that the technology nexus is recognised as having the potential to produce benefits beyond storytelling and entertainment. This is in line with previous research, as Cotter et al. discussed the '*impacts of visiting art museums on well-being outcomes, such as stress, emotional well-being, and feelings of connection. Within psychology, meanwhile, scholars have examined the role cultural engagement plays in depression, anxiety, and global well-being . . . '* [11]. Further, other physical benefits were also identified by the survey participants when responding to question 14, with one participant stating that the technology '*will help people who do not have the physical ability to do a painting or a 3d object create art. And for people that are already artists, it may help them generating different ideas*'. Thus, within this domain, we can also consider the integration of more advanced haptic devices for interaction and disability support for the design and creation of digital artefacts. For instance, combining this technology with haptic gloves may be of use in the future to enhance the experience of people with vision impairment in the Metaverse, an approach that is already being investigated for use with immersive video by Villamarín et al. [42].

4.4. How Will Consumers Perceive AI-Generated Art?

Despite, or perhaps because of, the controversial nature of art, consumers have differing opinions on AI-generated artwork in a digital 3D environment. To further explore the diverse sample and to identify homogeneous consumer preferences related to AI-generated art, a k-means cluster analysis was conducted, relying on the standardised z-values of the constructs 'expected market potential' and the 'request for ownership' of AI-generated and in-the-Metaverse-exhibited art. Based on the results of the dendrogram to identify the number of expected consumer clusters, and the subsequent performed k-means cluster analysis, consumers can be divided into the following three consumer clusters: Consumers assigned to Cluster 1 (C1) believe that AI-generated artworks have a bright future and that owning digital art is not crucial but rather that the art should be considered as a public good that is available and accessible everywhere. In contrast, consumers assigned to Cluster 2 (C2) are pessimistic about the future of AI-generated art and, in addition, are not interested in owning AI-generated art. Consumers assigned to Cluster 3 (C3) show lower expectations of the potential of AI-generated art as exhibited in Web3D galleries but place a high value on ownership.

Taking the demographic characteristics into account, it can further be concluded that the age distribution in the respective clusters is not a distinguishing factor, as the average

age is almost identical for all three clusters: 29.8 (SD7.6) for C1, 30.4 (SD9.5) for C2 and 31.9 (SD9.7) for C3 (Table 6). This result suggests that demographic factors do not play a major role in the perception of AI-generated artworks, while other intrapersonal factors, such as the expected market potential and willingness to own the artwork, do.

Table 6. Cluster analysis results, based on individual consumers utility values.

Tone	Consumer Cluster 1	Consumer Cluster 2	Consumer Cluster 3
Market potential	0.89	−0.83	−0.54
Ownership	−0.34	−0.46	1.48

4.5. What Role Does AI Play for Digital Art and the Metaverse?

In general, it can be said that when surveying the participants on the role AI can play for digital art and the Metaverse, the vast majority have a clear idea about the concept, evidenced by the response to question 13, '*What role does AI play for digital art and the metaverse?*' (Table 7); of the 67 individuals, n = 7 provided no reply and a further n = 8 stated that they did not know. Compared to question 14, the responses were predominately optimistic, with n = 43 providing a positive response, and only n = 2 negative and n = 6 mixed. Given the widespread debate on the use of AI for art generation [43], these findings can be considered unanticipated.

Table 7. Sample of qualitative responses provided to question 13.

Tone	Response *
Positive	'An important one, as it allows to access art from everywhere and for everyone'
	'I think a lot. I have seen a lot of pictures online created by AI and I think it can play a huge role in it'
	'I think it can adds new dimensions and can be a boost for creativity, I think it might make it easier to create a more interesting environment'
Negative	'It could make art accessible to more people but also maybe lower the value of human generated art'
	'I will not consider a project as art when it's not done by humans. For me, art needs to have a hidden or not meaning'
Future Directions	'A huge role. I think it will change the way we think about art'
	'It could take a role of hybrid creation tool between the AI and the artist, or it could replace human artists completely, given enough data'.
	'It will replace a lot of artists for financial reasons since the art created by artificial intelligence could at some point be indistinguishable from human-created art'

* Typos were corrected in the responses provided.

5. Discussion

Whilst these findings do not contribute towards core aspects of the debate, such as how AI-generated art can be associated with human-centred creativity [43], or what Grba et al. calls '*technologically entangled creativity*' [44], what the findings do demonstrate is that there is potential for AI art to be perceived positively. In terms of the societal impact of AI art and 3D virtual galleries, there are many potential benefits. For example, such experiences could be used for storytelling purposes, and may have strong benefits for raising awareness about important social and environmental issues (such as climate change and food crises), or for cultural heritage, for example, as currently used by Nikolakopoulou et al. [45] and Paulauskas et al. [46], yet with a focus of Metaverse-related technologies such as virtual reality. By creating engaging and interactive digital art experiences that allow users to explore these issues in a more meaningful way, it might motivate people to take drastic actions to address these challenges. In Table 8, a synthesis is provided of the key benefits and challenges identified in this article, both relying on secondary and primary data investigations, with quotes directly from the questionnaire included.

Table 8. Synthesis of the key identified benefits and challenges.

Classification	Description	Source
Benefit	Creation of novel datasets that were previously unexplored on a large scale. This results in additional possibilities to study human behaviour [13].	Background
Benefit	The integration of higher levels of interaction and immersion than traditionally possible [23].	Background
Benefit(s)	'I think AI will have a large effect on the (digital) art world, probably not all for the better'; 'I think it can play a big role, since it can create different things which do not exist yet. It opens up a whole new creative world'; 'It could help creating NFTs and other forms of art that do not currently exist, helping to combine human imagination and inspiration with the precision of computer graphic design'; 'Will provide new jobs for creating content';	Questionnaire, question 13
Benefit(s)	'It could act as an inspiration, but it might replace the artwork of artists'; 'It will be another platform to show their art. And the good news is that it will let different kind of experiences to be created with AR';	Questionnaire, question 14
Benefit(s)	'It can allows artists to share their art to a larger population like people who are not generally attracted to go to the museum, or people who can't or don't have the time to move to an art gallery'; Producing outputs beyond storytelling and entertainment [11], such as education and disability support as the technology ' . . . *will help people who do not have the physical ability to do a painting or a 3d object create art*';	Questionnaire, question 14 and background
Challenge	Technological challenges exist, including technological blockades and four underlying barriers, namely, (1) the scalability constraints of implementation; (2) the lack of widespread/accessible 3D content; (3) the costs of VR implementation; and (4) the resulting exclusion of existing 2D Web content. Fibre Optics and 5G technologies have vastly improved the speed with which content can be accessed, and growing cloud infrastructures are able support the high demands of 3D.	Background
Challenge	Establishing an appropriate decentralisation or centralisation process has both technological and ethical considerations and may result in users being locked into a single currency or development pipeline [17].	Background
Challenge	Ownership of personal data is a challenge when creating potentially richer datasets [17].	Background
Challenge	The Metaverse must provide value to its users, whereby generating value is, therefore, essential to serve its purpose effectively [25,26].	Background
Challenge	The number of participants who do not consistently engage with Web3D is 67%, with only a low percentage (15%) stating that they actively do so.	Questionnaire, question 5
Challenge	The low percentage of individuals have actually visited a virtual art gallery (64.2%).	Questionnaire, question 7
Challenge	'Nice space to showcase art. Devalues the physical painting'; 'Some artists who will find ways to innovate in the Metaverse (new mediums, new interactive ideas) will prevail but most of the existing "traditional artists" will not benefit at all'; 'Everybody can be an artist, which is a good thing! But if you are an artist it's not a direct advantage I think'	Questionnaire, question 14

Overall, the future of fine art embedded with Web3D services and the Metaverse is a promising domain that is ripe for innovation and creativity. As technology continues to evolve, artists and storytellers will have even more tools at their disposal to create unique and immersive groundbreaking experiences that captivate audiences globally. Within these findings, accessibility of digital artwork was highlighted numerous times in the survey responses as a clear feature and benefit of the technology, meaning the aforementioned storytelling activities can take place on a large and unbounded scaled. As two participants express, the technology can be used '*to help artists share their views, ideas, and others more easily and visual, help audiences more enjoy it*' and that '*artists would be more visible across the world and their art would be more accessible*'. It is of note that the participants under discussion were predominantly individuals who had not previously experienced an art gallery. Thus, it can be inferred that an exhibition based on AR has the potential to diminish the transactional costs incurred by consumers, thereby granting artists an avenue to access a wider audience than previously possible, possibly even one that is considered mainstream.

Regarding AI-generated artworks, the respondents were in general positive, with comments such as '*I think it can adds new dimensions and can be a boost for creativity I think it might make it easier to create a more interesting environment*', and that AI can '*be an inspiration*

for artists who have a temporarily block in creating artwork'. Yet, there was some hesitation, with one participant stating that an AI-driven approach '*could be beneficial for artists if they want to explore digital art and showcase it in a digital format. However, there would need to be a mechanism to filter through good art if anyone could showcase their art as it would dilute the quality*'. The results also show the need to account for individual differences in the perception of AI-generated and digital-exhibited art in future research, practice and art.

6. Conclusions and Future Directions

What is clear is that AI-generated art and Metaverse-based galleries can offer new ways for artists, consumers and collectors to expose, discover and purchase new art as well as engage and interact with fine art globally. It is also clear that an immersive Web is very much still in its infancy [29] and there are several technical limitations (resolution, rendering, etc.) to capabilities that do not allow the creation of high-quality digital art experiences. Yet, existing research demonstrates that as a digital communication medium, the technology has the potential to increase interaction and bring higher levels of human awareness.

As our findings of the consumer questionnaire suggest, Metaverse-art-related experiences can and must be customised to the end users' preferences and needs. Thus, if AI is integrated, innovative personalised approaches are to serve individual preferences that finally shape the consumers' digital art perceptions, as displayed in the heterogenous consumer preference clusters identified in this study. Hence, personalised narratives can be developed leading to a more engaging and immersive experience for the user. Such experiences, if combined with other forms of media, music or narrative digital storytelling, can create fully immersive experiences for individual user engagement on multiple levels, building on the personalised data collected with AI.

Limitations of this research work include the earliness of the study. As discussed, the Metaverse is a somewhat evolving and emerging concept, as one participant indicated in the response, '*I believe it is too early to say anything in this field*'. So, the research findings might be seen as a first step towards a flourishing digital art experience. Furthermore, in this study we did not measure a change in knowledge for those who had no prior knowledge/experience of Web3D and had no prior knowledge of the Metaverse. Thus, future work could include adding to our preliminary findings on consumer perceptions by assessing the change in knowledge and awareness of the core concepts related to digital art and the Metaverse technologies after experiencing the virtual art gallery. Despite the significant effort made to ensure that a diverse sample was selected to represent the potential target audience of AR/AI artwork, it is possible that the chosen sample was impacted by sampling bias. To address this issue, future research should consider accounting for self-selection biases by recruiting a larger and even more heterogeneous sample. A further limitation of this study is the use of two AI-image generation tools. As a final note, it should be emphasised that there is an increasing volume of tools available, and to build on this article, future directions of the work could include an expansion of the gallery with a larger number of AI tools and a comparison of the different techniques used for AI-based image generation.

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