Digital Art Gallery in Metaverse: Eye Tracking Digital Visitors' Visual Attention, Engagement and User Journey when Interacting with Digital Artworks on Smartphones

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Abstract

With the exponential adoption of smartphones among young people, the rapid adoption of digital environments, namely Metaverse, for cultural engagement is increasing in creative industries. There is a limited understanding of how digital artwork, exhibited in digital art galleries, influences visitors' visual attention and engagement with artworks in Metaverse's Art Gallery. This study used a multi-method approach, triangulation of eye tracking experiments on smartphones, mapping AOIs, and developing user journeys based on visual attention patterns. The user journey map framework helped to evaluate behavior patterns in the Metaverse Digital Art Gallery with implications for industry and academia. This is one of the few studies that utilized the user journey approach and mapped gaze data to understand the behavior of digital visitors within the Metaverse Art Gallery. The findings provide useful guidance for further application in art gallery design and research and inform better ways to engage a wider audience of digital visitors in valuable cultural experiences.

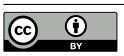
CCS Concepts

• **Human-centered computing** → **Empirical studies in interaction design**; **Smartphones**; **Empirical studies in ubiquitous and mobile computing**; **Heat maps**; **Empirical studies in HCI**; • **Applied computing** → **Media arts**; **Multi-criterion optimization and decision-making**.

Keywords

Metaverse, Smartphones, Mobile Eye Tracking, Digital Art Gallery, Artworks, Mobile App, User Journey, User Experience, UX, Mobile Consumer

ACM Reference Format:
Zofija Tupikovskaja-Omovie. 2025. Digital Art Gallery in Metaverse: Eye Tracking Digital Visitors' Visual Attention, Engagement and User Journey when Interacting with Digital Artworks on Smartphones. In *2025 Symposium on Eye Tracking Research and Applications (ETRA '25), May 26–29, 2025, Tokyo, Japan.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3715669.3725874



ETRA '25, Tokyo, Japan

ACM ISBN 979-8-4007-1487-0/25/05
https://doi.org/10.1145/3715669.3725874

1 Introduction

Art has been a focus of many past studies, especially those interested in understanding how visitors interact with artworks in art galleries and museums. Within these physical environments, namely art museums, previous research used eye tracking technology [Garbutt et al. 2020] to understand how movement in front of art can influence emotion and evaluation in a gallery-like setting [Kühnapfel et al. 2023]. With the increasing trend of using digital devices for many everyday activities, especially entertainment, smartphones have become an inseparable part of young people's lives. This study explores the behavior, visual attention, and engagement with the digital and virtual art gallery, the influence that the Art Gallery can have on visitors in Metaverse environments, and how these users interact with digital art and artworks in the purely digital spaces.

2 BACKGROUND LITERATURE

2.1 Artworks in Physical Environments

The evaluation of studies utilizing eye tracking in art galleries helps to assess the types of eye tracking technology used to capture data in 3D environments such as art galleries and art museums. Studies using mobile eye tracking technology are the most common approach, as the stimuli are presented in a physical 3D space [Reitstätter et al. 2020]. The metaverse world is also a 3D space, but in the digital environment, where users can move in any direction and can interact with design elements in this digital environment.

Past studies focused on art research and the impacts of the digital revolution on cultural heritage research [Sober et al. 2022]. To evaluate what visitors do in the art museum, some studies focused on examining how exactly exhibit labels are used in gallery settings [Reitstätter et al. 2022], and what interests visitors in the gallery [Pierdicca et al. 2020]. Due to the challenges in setting up eye tracking studies, past studies utilized a simplified version of the art galleries' and art museums' settings by reducing the complexity of the real space and environment's configurations. This approach allows for ease of data collection and analysis processes, but leads to manipulated and non-natural settings during eye tracking studies. A similar approach was applied in the eye tracking experiments with adults and children who observed just five paintings with similar characteristics to simplify the data collection and analysis process [Pierdicca et al. 2020].

With advances in mobile eye tracking technology, past studies investigated visitors' embodied visual behaviors as they move

through exhibition spaces [Garbutt et al. 2020] and accompanying information elements noticed by visitors while looking at artworks [Yi et al. 2021]. The museum's visitor experiences, attitudes, and information processing patterns were tested with mobile (portable) eye tracking devices [Raffi 2017]. Past studies evaluated eye movement scan paths in paintings [Chen et al. 2022], the direction of scanning artworks [Tymkiw and Foulsham 2020], viewers' attention to both installed artworks and/or to the contemporary art museum environment [Pelowski et al. 2018]. The eye tracking study was conducted to compare the viewing of artworks in the museum and in the laboratory; these experiments were recorded with a mobile eye tracking system [Brieber et al. 2014].

2.2 Artworks in Digital Environments

The research into artworks in digital environments focused on games and Metaverse. The existing literature has investigated the impact of digital gamified environments and how game-based approaches, which incorporate rewards [Whittaker et al. 2021] and points, have a propensity to increase interest among young people [Mulcahy et al. 2021]. Thus, utilizing the Metaverse world can yield better engagement and interest towards the artworks within digital art galleries or digital art museums of the future.

More recent studies explored the effect of metaverse experiences and their broader use for education due to gamified characteristics [Park and Kim 2022], but research on interactive art experiences within the metaverse environment is limited. The recent study proposed measuring user behavior through novel technologies in the Metaverse [Dwivedi et al. 2022] due to the shifts from static interactions to more immersive digital environments [Dwivedi et al. 2023]. Further recent advances in eye tracking technology [Ruppenthal 2023] have led to the increased use of novel methods of data collection and processing, namely data visualization [Burch 2021]. With Metaverse consisting of unique characteristics and gamified features, which are distinct from physical environments [Hadi et al. 2024], it has been adopted on a wider scale due to easier access, its digital immersion, shared, and interactive experiences. Although Metaverse is often envisioned with VR headsets, many Metaverse platforms and environments do not require VR equipment; users can simply access Metaverse environments via computers, tablets, and even smartphones [Barwitz and Maas 2018]. Therefore, this study is timely in exploring the digital visitors' experiences with artworks in the Metaverse world's Art Gallery accessible via mobile devices.

2.3 Understanding Digital Visitor Behavior in Digital Art Gallery

The literature review of previous research has shown that research on digital art galleries and art museums in digital environments is scarce. This study evaluates the use of artworks in a digital dynamic environment such as Metaverse, and how these new technological developments can enhance the reach of digital art, with a potential to offer access to wider audiences. Current physical art galleries or art museums cannot offer the same wide reach because of attachment to a certain location, a limited number of visitors allowed in the physical space, and a distance to the gallery. The Metaverse digital art gallery, on the other hand, can offer a wider access to digital visitors who can be anywhere in the world but otherwise might not be able to access the exhibition in real physical environment or would be required to travel to the actual location, like city or even country, to see the exhibition.

This research study explores how digital visitors within the Metaverse environment engage with an art gallery when visiting one of the Metaverse worlds. The purpose of this study is to examine what visitors do when visiting the digital art gallery within the Metaverse environment. This paper focuses on the following research questions: what visitors look at in the art gallery within the Metaverse environment; what extra information do they seek about the artwork; do they click to read the descriptors of the artwork; what order or pattern of examining the artworks in the digital space, namely the digital art gallery in the Metaverse, is the most commonly used.

3 METHODOLOGY

The multidisciplinary approach was used to design this multimethod study utilizing eye tracking technology, data visualization, and user journey mapping. Eye tracking technology allowed us to document real live interaction with Metaverse environment on smartphones which are more accessible to a wider audience than VR based Metaverse platforms. This study used a Metaverse app that is accessible via smartphones, offering a way to explore a virtual world and interact with a digital realm directly from a mobile device. The Metaverse world chosen for this study has an Art Gallery within it, with artworks accompanied by artworks' descriptors accessible by clicking on the interactive buttons next to it.

3.1 Sample Description

The sample for data collection consisted of 10 participants, who were young adults, aged 18 to 25 years. Study participants interacted with the Metaverse platform through a mobile app on a smartphone. All study participants used the same smartphone, iPhone 11, provided by the researcher, to ensure equal conditions for all participants in terms of hardware, software, and Internet connection. The data collection instrument was pilot tested before the main data collection to streamline the account settings required to access the world, tasks to be completed, and ensure eye tracking data collection and other tools used for screen and voice recording were set accordingly.

The sample of 10 participants had an equally distributed number of female and male participants, accounting for 5 of each gender. The average age of the sample is 20.9 years. Most of the participants had no prior experience with Metaverse in general or with the mobile app used in this study. Only 3 out of 10 participants were somewhat familiar with other metaverse environments, and only 1 out of 10 had prior experience with the mobile app the metaverse world was from but not the actual metaverse world itself.

The data collection procedure involved all participants exploring the Metaverse environment. The task was to imagine that they had heard from someone or had seen it somewhere and wanted to explore a new metaverse world as they would normally do. This Metaverse world has a wide range of interactive activities, with one of those being the Art Gallery, which is the focus of this study.

3.2 Settings for Eye Tracking Experiments

The data collection involved several steps: Participants created a new account (no personal data was needed to create a new account), customized their avatar, and explored the new Metaverse environment as usual. The Metaverse world, which has a range of interactive activities, and the Art Gallery, was explored by the participants without restrictions; they were free to engage with any content within the Metaverse environment and in any order.

Participants interacted with this gamified Metaverse environment via a smartphone, while the iPhone 11 was connected to the Tobii Pro Mobile Testing Accessory and the Tobii Pro Nano eye tracker (Fig. 1) to capture their eye movements and visual attention. This type of eye tracking set-up is designed for usage with mobile devices and allows for recording of the screen of the smartphone as well as the gaze data of the users. Each session lasted around one hour; this included reading the participant's information sheet, signing the consent form, asking any further questions about the project, and collecting eye tracking data. The project was approved by the Ethics Committee of the Manchester Metropolitan University through the EthOS system.

Eye tracking technology was used during this study to document user behavior within the Metaverse environment, where they were instructed to visit and explore the Metaverse world. The researchers wanted to target approximately 10 minutes of interaction, but participants were not informed about the time restrictions; the researcher used it as a guide to evaluate the completeness of their user journey. Only if the participant spent more than 5 min exploring the Metaverse world without interacting with any gamified elements, they were asked to look for some interactive content. The participants had the possibility of participating in various interactive activities available within this metaverse world, but there was no request to complete any specific number of them. Furthermore, this study focuses on a more natural behavior in the Metaverse environment which is the closest to their actual behavior in real life when using digital Metaverse platforms for leisure.

3.3 The use of Eye Tracking Data for User Journey Mapping

The understanding of visitor interaction within metaverse environments is a complex matter, due to constantly changing surroundings and the dynamic nature of the stimuli. Past studies that looked at a deeper understanding of consumer interaction within digital environments [Barwitz and Maas 2018] used the customer journey as an effective technique to break down these complex behaviors [Kuehnl et al. 2019] and decision-making processes [Dasgupta and Grover 2019], [Halvorsrud et al. 2016]. The types of data used to inform the development and mapping of customer journeys varied; some utilized reconstruction by participants themselves, survey [Herhausen et al. 2019], focus groups [Vakulenko et al. 2019] or previous literature [Lemon and Verhoef 2016], [Voorhees et al. 2017]. However, these studies, using the customer journey approach, often use generic touch points or simulated websites [Cortinas et al. 2019], which limits opportunities for the development of new knowledge.

There is a need to document the actual user journey, experienced by the actual users, as they interact with digital environments, especially with the Art Gallery in the Metaverse world. This study follows the user journey framework to evaluate what elements and features visitors interact with, and their visual attention towards the artworks displayed. The initial stage involved using eye tracking data to map user experience journeys [Tupikovskaja-Omovie and Tyler 2021a], such as digital visitor journeys within the Metaverse environment, developed individually to allow comparison between and across the sample of participants. Then, the areas of the metaverse environment were evaluated based on the level of engagement and returning behavior of the art gallery visitors. This was followed by a comprehensive evaluation of all interactive elements of the metaverse world.

Figure 1: Tobii Pro Nano Eye Tracking Set Up with Tobii Pro Mobile Testing Accessory).

4 Analysis and Findings

The analysis incorporated several stages, including initial analysis of the user experience journeys of the entire experience within the Metaverse environment. The findings of this stage highlighted that digital visitors behaved differently in the Art Gallery, showing some variations within the sample. Therefore, the next stage evaluated each participant's individual user journey and experience, followed by their visual attention behavior within the Art Gallery, which is the main focus of this study.

This research used Tobii Pro eye tracking hardware and software for data collection, analysis, and processing. The data documented using eye tracking comprises multiple different data files generated to complement the aim of this study. The following datasets were used to compare how digital visitors interacted with the artworks exhibited in the Art Gallery on smartphones: the shopping journeys, the total number of artworks and artwork descriptors within the user journey, the elements viewed within the artworks' descriptors, fixation count, revisits, and the total fixation. Therefore, three main stages of data analysis are presented as follows: development and

Table 1: Duration of the 1st and 2nd visits to the Art Gallery.

Participant ID	1st visit duration	2nd visit duration
P1	00:00:11.101	00:02:39.238
P2	00:01:55.425	00:00:02.740
P3	00:00:35.849	00:02:19.231
P4	00:02:15.102	00:01:15.757
P5	00:01:12.058	00:07:06.984
P6	00:00:12.649	00:04:04.459
P7	00:00:08.519	00:00:26.07
P8	00:02:52.856	–
P9	00:02:39.990	–
P10	00:01:56.247	00:00:01.608

analysis of the data obtained through the analysis of the behavior user journeys, analysis of the data obtained through manual gaze data mapping onto AOIs, and visual attention user journey evaluation based on data from AOIs. Concluding by presenting the digital visitors' visual attention user journeys for the whole sample of participants who visited the Art Gallery's space in the Metaverse to identify patterns in behavior and visual information processing.

4.1 Evaluation of Digital Visitors' User Journey in the Digital Art Gallery in Metaverse

Firstly, the eye tracking data was analyzed using an approach [Tupikovskaja-Omovie and Tyler 2021a] in which the eye tracking video files for each individual participant were used to map the digital user journeys. This mapping method was modified to serve the complexity of context within the Metaverse experience by replacing the four levels as used in previous research [Tupikovskaja-Omovie and Tyler 2018], [Tupikovskaja-Omovie and Tyler 2020] and reflecting the interactive elements available within this dynamic environment by capturing the diverse spaces and various gamified content, features, and functions used. Furthermore, this study incorporated the user journey mapping as one of the most valuable sources of data that capture digital visitors' behavior and visual attention while interacting with Metaverse environment and visiting the Art Gallery.

Table 1 shows the total duration each participant has spent within the Art Gallery in the Metaverse world on two first visits, as the majority of the study participants visited the Art Gallery twice. The findings show that only two out of 10 participants have visited the Art Gallery just once, but eight users returned to the Art Gallery again and explored it further. On average, the participants visited the Art Gallery 3 times, and 3 out of 10 participants came back to the Art Gallery 4 and 5 times. Some of them spent longer during their second visit to the Art Gallery than during their first visit. The participants spent on average about 12 min within the Metaverse environment, with the shortest session accounting for 7 min 16 s, and the longest – 18 min 6 s. The evaluation of this sample has shown that the duration visiting the Art Gallery varied depending on individual participant and their interest in the artworks displayed. On average, some participants spent longer during their second visit, suggesting that they returned to the Art

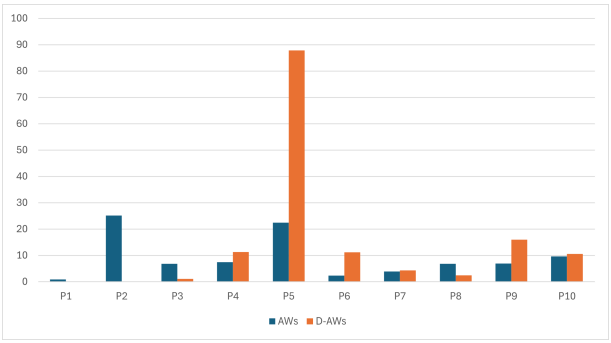


Figure 2: Comparison of Total Fixation Duration on the Artworks (AWs) versus Descriptors (D-AWs) (Participants P1-10).

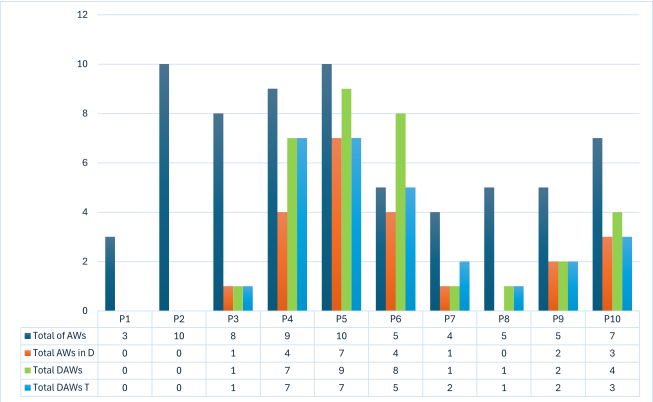


Figure 3: Comparison of Numbers of Artworks and Descriptors viewed (Participants P1-P10).

Gallery as their interest increased while exploring the Metaverse environment.

4.2 Engagement with Artworks and Descriptors of the Artworks

Eye tracking gaze data mapped in AOIs and user journeys were used to calculate how digital visitors engaged with individual artwork (AW) and the descriptors of these artworks (D-AW) in the Metaverse Art Gallery (Fig. 3). The findings show that the engagement varied depending on the particular participant and the artwork in question. The differences among the digital visitors were obvious within the Art Gallery setting, with 7 out of 10 participants who have viewed all elements of the Art Gallery, including the artworks and the elements of the descriptors of these artworks. The descriptors of the artworks were displayed as a pop-up window and comprised the following elements: a repeatedly shown artwork in the descriptor window (AWs in D), the title of the artwork (DAWs T) and the description of the artwork (DAWs). These elements were numbered according to the display order in the Art Gallery, starting with AW1, D-AW1, AW1 in D, DAW1 T, and DAW1 for all elements associated with the artwork the closest to the entrance, and the rest were numbered following the clockwise direction in the Art

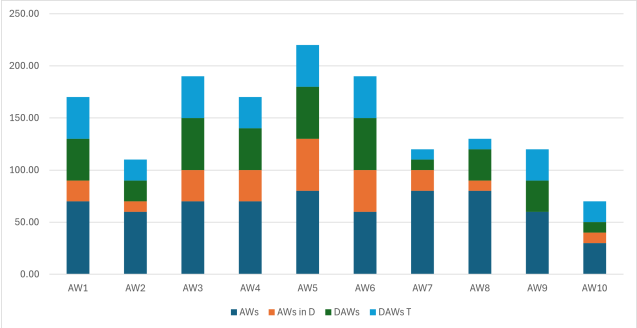


Figure 4: Comparison of AOI Visits Count per artwork in the Metaverse Art Gallery (Participants P1-P10).

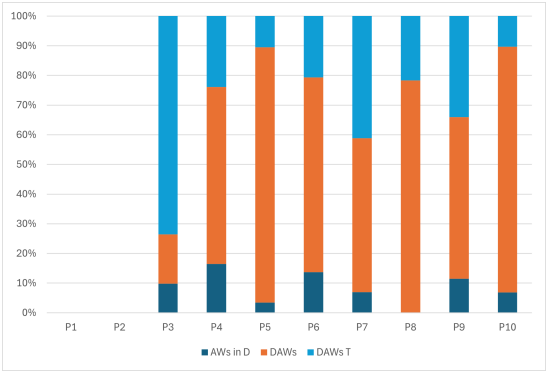


Figure 5: Comparison of Fixation Durations on AOIs within the Artworks' Descriptors (Participants P1-P10).

Gallery. AW1 -AW5 were on the left wall in the Art Gallery, and AW6-AW10 were on the right wall.

The majority of the participants explored various elements in the Art Gallery, but 2 out of 10 have only viewed the artworks within the Art Gallery without clicking on the descriptors of any artwork. Surprisingly, of the eight who viewed the artwork descriptors, one participant did not even glance at the artwork displayed within the descriptor (AW in D) and only engaged with just one DAW and DAW T. 4 out of 10 participants have shown really high engagement within the Art Gallery by exploring both the artworks and the descriptors of these artworks. However, only two participants have viewed every single artwork within the main Art Gallery, but one of them did not engage with the descriptors at all.

Evaluation of total fixation duration on the artworks and the descriptors showed that half of the participants fixated longer on the descriptors compared to the main artwork itself (Fig. 2). The rest of the sample has fixated longer on the main artwork, with one fixating more or less equally on both the artworks and the descriptors, and two who only fixated on the artworks because they did not click on any of the descriptors. Regarding AOIs that are directly related to the elements being evaluated within this study, it is obvious that the artworks and the descriptors received a variety of visits from the sample of participants (Fig. 4).

Certain artworks gained deeper levels of attention, as evidenced by the visits count to the AOIs. There was a need to analyze and compare the fixation durations on AOIs within the artworks' descriptors, that is, how participants engaged with individual elements of the artworks' descriptors (Fig. 5). The most surprising findings were around the proportion of fixation duration on descriptions of the artworks, which were text-heavy sections describing the poster. Whereby, the artworks in the descriptors received the least fixations with one participant not even glancing at it at all. Somehow, the titles of the artworks outperformed the artworks within the descriptors too. Perhaps, these findings align with the higher cognitive load and information processing required due to the textual nature of those elements of the descriptors. The findings from this subsection show that there are certain emerging patterns of digital visitors' attention across the sample in the space of the Art Gallery. This will be further evaluated in the next subsection.

4.3 Patterns of Visual Attention and Viewing Behavior in the Art Gallery in Metaverse

This study examined how visitors interact with the artworks in the Art Gallery and if they follow a specific pattern when examining the artworks exhibited in the Art Gallery with a focus on space. In some settings, users are used to a specific way of following the information or environment, such as a specific way of swimming in the swimming pool or running around the track. Often these behaviors are conducted in the anticlockwise direction. The analysis of the patterns of visual attention will utilize the user journey framework by manually mapping the flow and direction of digital visitors' attention within the space of the Art Gallery.

There were 10 artworks within the Art Gallery, five on one wall and five on the opposite wall. The comparison of the total duration of the fixations on the artworks in the main Art Gallery and the descriptors of those artworks showed unexpected results that half of the participants fixated more on the descriptors than the artworks (Fig. 2). This could be linked to the small screen that digital visitors used on the smartphones to visit the Art Gallery, and perhaps harder to consume the visual content of the artworks. However, a future study could investigate more deeply the reasons behind this behavior. The fixation count shows the users' visual attention, it was needed to compare these users' revisits to all Artworks. Data about the revisits might reveal which AOIs were inspected more regularly (Fig. 6).

The finings in Section 4.2 showed that the number of artworks and descriptors viewed varied across the sample of participants. Therefore, a more granular analysis of behavior and visual attention patterns was needed at the individual level. The AOIs visit count was utilized to analyze how many times and how often the participants' attention shifted between individual artworks (Fig. 6). The findings suggest that there are possibly two diverse groups within the sample of participants used in this study. With half of the participants being more engaged, the following participants revisited more artwork and more frequently: P2, P3, P4, P5 and P10. However, the remaining five participants were much less engaged in the digital Art Gallery experience. These behavior patterns might be useful for understanding how to engage a wider audience with

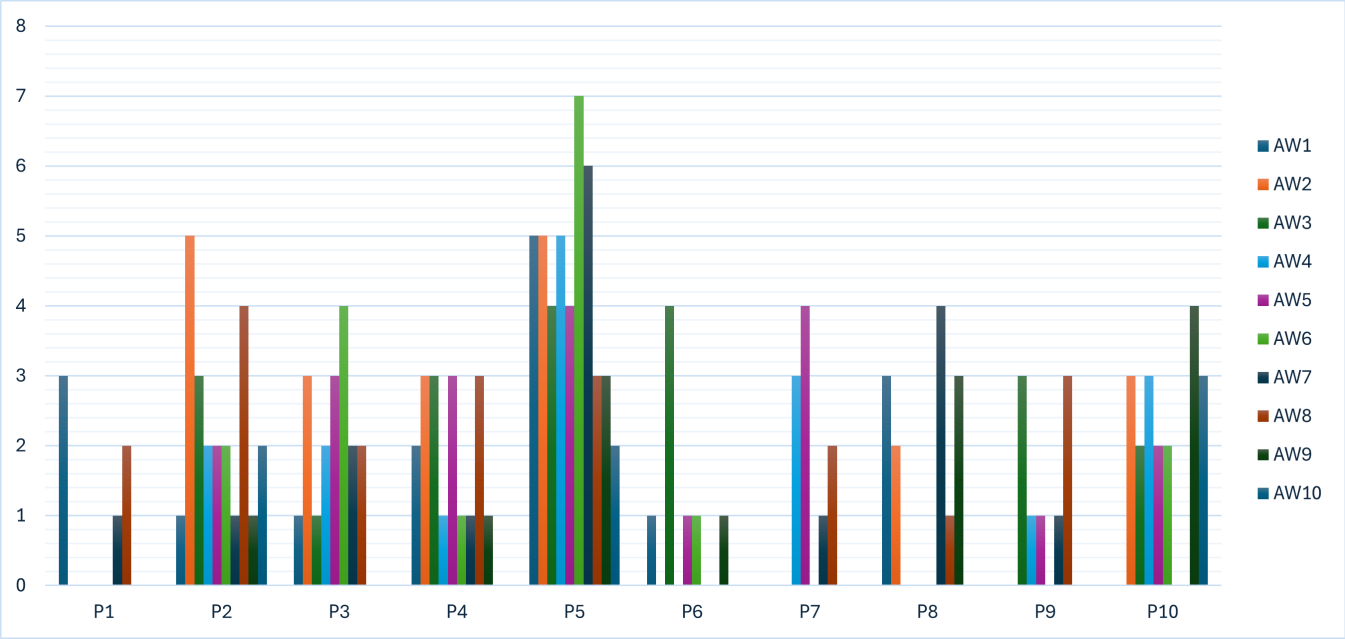


Figure 6: AOIs Visits Count per individual artwork (AW) (Participants P1-10).

Art Galleries in the Metaverse. The further study could explore qualitative feedback on the experience with Digital Art Gallery in order to understand how to improve user engagement and retention.

When analyzing the results of the comparison of the elements of the Art Gallery used during the user journey, there were certain differences and similarities within the sample of participants. Some participants appeared to be more involved in the Art Gallery than others and exhibited significant differences (Fig. 3). The eye gaze data captured within the AOIs and scan paths were used to map digital visitors' behavior and visual attention journey within the Art Gallery's space. A schematic layout was used to link the visual attention flow to individual artworks and their descriptors. The level of detail on three elements of the artwork descriptors was ignored at this stage, as the visual attention journeys are complex enough when incorporating just two concepts for each artwork in the Art Gallery (Fig. 7).

The most significant findings were around the first artworks viewed when entering the Art Gallery. As seen in the combined visualization of eye tracking data representing the visual user journey in the Art Gallery, visitors engaged with different artworks at the start of their experience (Fig. 7). There were two routes of entry observed, with 3 out of 10 participants viewing AW1 in the first instance when entering the Art Gallery, namely P4, P5, and P6 followed this approach. The other three participants then started their experience with viewing AW6 firstly, with P1, P7, and P9 following this route. The visual user journey was useful for identifying further patterns of behavior, with the accumulation of joining lines around certain artworks suggesting that the locations of those artworks in the space might receive higher levels of visual attention when exploring the exhibition in the Art Gallery in the Metaverse. The central part of the space received the highest visual attention and visits, namely the following artworks: AW3, AW4, AW5, AW6, AW7, and AW8. Somehow, there are observable blind spots even in the digital Art Gallery, with artworks AW1, AW9 and AW10 receiving the least of the visual attention. Surprisingly, the AW1, which is the closest to the entrance, often got ignored when entering the Art Gallery, as often the visitors' attention would dive further into the space.

In summary, analysis of the visual attention user journey can reveal clearer scanning and browsing differences when comparing groups of users [Tupikovskaja-Omovie and Tyler 2020]. One of the most informative eye tracking data visualization approaches was based on the visual attention journey that captures two main elements of the Art Gallery (Fig. 7).

5 Conclusions and Future Work

The findings of this eye tracking study reveal unexpected results, considering the visual attention of visitors to the digital Art Gallery in the Metaverse environment. The visualizations of the eye tracking data allowed us to evaluate the degree of visitor engagement with the Metaverse environment, when the users actively explored the Art Gallery without any specific task, and showed how their natural behavior would evolve in the Metaverse. This study addressed the following research questions: what visitors look at in the art gallery within the Metaverse environment; what extra information do they seek about the artwork; do they click to read the descriptors of the artwork; what order or pattern of examining the artworks in the digital space, namely the digital art gallery in the Metaverse, is the most commonly followed. The approach used in this study was based on mapping user behavior and visual attention within the user experience journey for further analysis of patterns observable

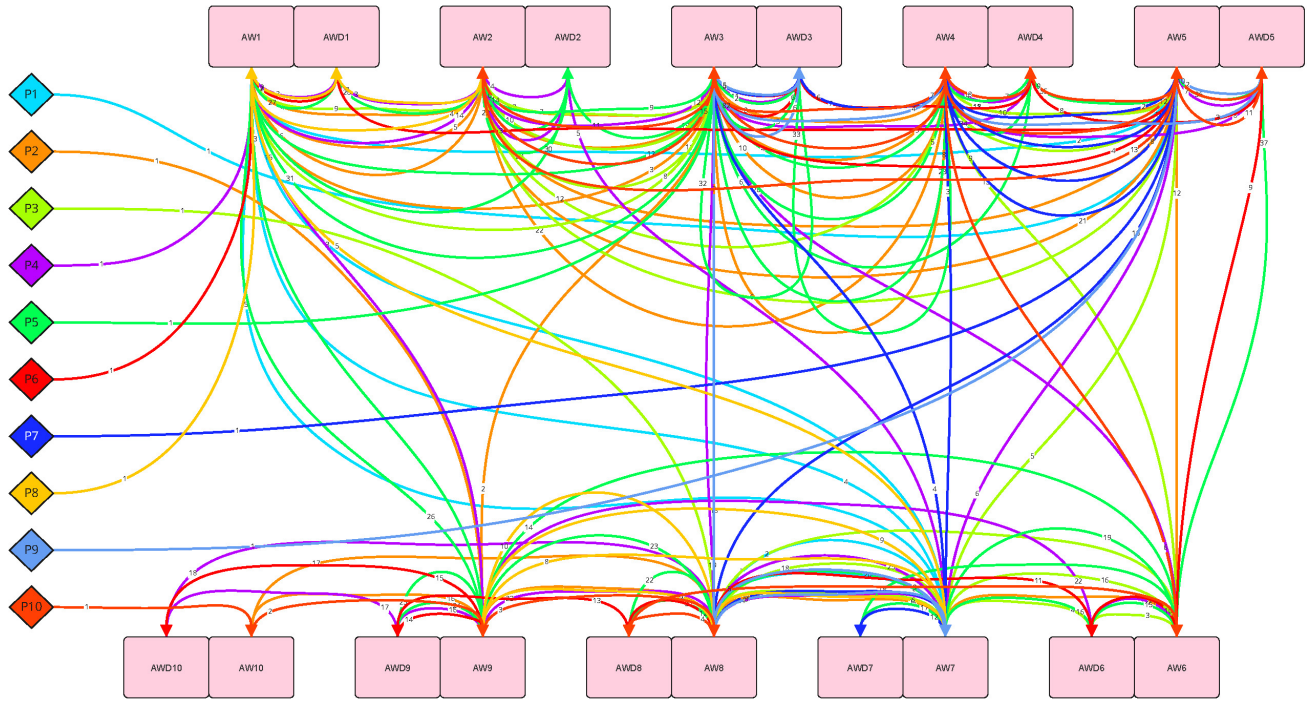


Figure 7: Visual User Journeys of the whole sample in the Art Gallery in the Metaverse (Participants P1-P10).

across the sample of participants which can be used for clustering of digital visitors [Tupikovskaja-Omovie and Tyler 2020].

The study applied manual eye gaze data mapping for AOIs and user journeys due to dynamic stimuli used in this eye tracking project. This approach produced a visualization of informative eye tracking data, but it was time consuming. Therefore, further ways of visualizing eye tracking data, including scan paths and AOIs could be explored to develop a semi-automated pattern generation of user journeys for in-depth analysis.

Future research could explore the differences within the data mapping system in Tobii Pro software to evaluate and compare the results of gaze data per individual artwork when the gaze filter is set to fixation against the filter set on attention. Furthermore, the actual data visualization tools and their usefulness in research to understand user, consumer, or visitor behavior would ensure the wider applicability of these techniques for meaning and reasoning creation rather than hypothesis testing. Past studies using eye tracking in extremely constrained laboratory settings cannot broaden an understanding about human behavior in the 'wild' where this behavior happens. Therefore, new methodological approaches are needed to expand the application and use of eye tracking technology in dynamic, natural, and unobtrusive environments to ensure the state of flow.

Although higher fixation durations on AOIs within the artworks' descriptors were observed across many participants, some artworks' descriptors received significantly higher proportion of visitors' attention, linking to past work examining what interests visitors [Pierdicca et al. 2020]. The findings suggest that even in digital spaces, users seem to interact more with artworks placed near the middle of the space and on repeated occasions, compared to artworks placed in the corners, which are often unattended and missed [Kühnapfel et al. 2023]. Comparison of fixation count showed that the amount of information a digital visitor extracts from visual stimuli is different from the textual content [Wedel and Pieters 2000]. This allowed us to test how easy and usable the descriptors of the artwork were if all participants were able to engage with them and how much of their attention was consumed reading the textual description of the artwork, similar to the research in physical museums for exhibit labels used in gallery settings [Reitstätter et al. 2022]. Future studies could analyze the patterns of visual attention, examining the elements within the artworks themselves and the artworks' descriptors, to understand how digital visitors evaluate and process the information about the artworks.

The future study could expand the focus to desktop screen devices to evaluate whether the artworks viewed in the Art Gallery in the Metaverse would be perceived differently compared to the small smartphone screen. Further comparison of behavior between large and small screens could confirm if more artworks would be viewed and engaged with if users had a different device at hand. Perhaps, a more design-led approach could be used in experimenting with screen sizes, but also with the sizes of artworks, their positioning, and supporting information such as description utilized in various ways to find the most appropriate solution that would inform future design of Metaverse environments and digital or virtual art galleries.

The findings align with previous studies on the level of complexity, suggesting that low-complexity Web pages [Liu et al. 2019] and with concise designs [Hsu et al. 2018] attract the attention of viewers more. Furthermore, digital users shift their attention between various elements of the information and visual stimuli they are interacting with, with images information being the most important [Mónica et al. 2019]. Past research found that women inspect images faster than men [Bahman et al. 2019], the future study could explore the differences in behavior between men and women and how they attend to viewing the artworks in the Metaverse Digital Art Gallery. The current study identified and highlighted some significant findings that could be used by digital art curators when planning and designing digital art exhibitions in Metaverse.

The findings showed that digital visitors within the sample of participants with similar demographic characteristics did not behave the same way when visiting the Metaverse Digital Art Gallery, further study could explore why these differences occur by conducting a qualitative eye tracking study focusing on user experience in the Metaverse Art Gallery. This study was conducted with 10 participants, and the unique behavior patterns observed showed some differences within the sample, suggesting that a future study could explore whether gender differences play a role in Metaverse. With all these suggestions in mind, considering that accessing it in the Metaverse might be somewhat challenging by itself due to a small smartphone's screen size, it would be useful to conduct future research focusing on improving the user experience (UX) for digital visitors in the Metaverse Art Galleries to enhance digital visitors' engagement and offer satisfactory experiences. This research provides new insights into the research on mobile user behavior in Metavers digital art galleries with potential for further development using other Metaverse platforms, mobile apps, and games. There is a possibility to group digital visitors based on their viewing behavior by applying user journey patterns for user segmentation [Tupikovskaja-Omovie and Tyler 2019, 2020].

The findings from eye tracking data analysis and user journeys showed that a combination of approaches produces more detailed and in-depth results to understand digital visitors' behavior in Art Gallery in Metaverse. This study focused on the Metaverse accessible on smartphones, which is one of the early studies in this area. Although all stages of the analysis, even the user journeys, were developed from eye tracking experiment recordings, the data types have impact on the types of the findings possible. This paper attempted to evaluate how digital visitors interact with artworks exhibited in the Art Gallery in the Metaverse environment on smartphones, and all the data types used helped to identify and understand the differences in behavior and visual attention between the sample of participants. This study provides useful implications for industry and academia, firstly, by providing an overview of design and layout within the digital art gallery and how to increase digital visitor engagement among young audiences accustomed to smartphones. The findings of this study have practical implications for the creative industry, user experience, and developers of digital mobile apps and games. Through understanding what digital visitors do and how they behave in the Metaverse, and more specifically, in the digital Art Gallery, curators and designers can better design future new Metaverse platforms to accommodate the diverse needs of mobile visitors.

Acknowledgments

The authors thank anonymous referees for their valuable comments and helpful suggestions.

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