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“24 Jiyue ”MR Experience: Multidimensional Analysis Based on IoT Game Visitor Experience Evaluation Model

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Abstract
The aim of this study is to explore the impact of IoT games on visitor experience in the MR experience of "24 Jiyue". By conducting exploratory research and collecting quantitative and qualitative data, evaluate the impact of games on visitor emotions, overall experience, and workload. The research results provide reference for cultural venues to enhance visitor experience through the use of IoT and MR technologies, which will help promote the application and development of related technologies in the cultural field.

Keywords
Exploratory research; User experience; Emotion; Workload; MR experience; IoT game

1.INTRODUCTION AND BACKGROUND

Cultural heritage, as a precious treasure passed down by humanity from the past, carries the memories of history, culture, and art, and needs to be shared with contemporary and future generations. This plays a crucial role in building cultural identity. Numerous studies have shown that advanced information and communication technologies play a significant role in enhancing people's awareness and appreciation of cultural heritage content. Mixed reality (MR) technology, as an emerging technology, cleverly integrates reality and virtual world to create an immersive experience environment for users; The Internet of Things (IoT) technology enables seamless connection between physical devices and the digital world, providing functionality and data access through distributed software services that leverage physical devices. These devices, namely smart objects, are typically equipped with sensors to detect events in the environment, or equipped with actuators to change the state of the environment or IoT system.

In the context of cultural venues, the combination of MR and IoT technologies brings unprecedented opportunities for innovative visitor experiences. Taking the theme experience of "24 Jiyue" as an example, introducing IoT based MR games is expected to create a unique and attractive cultural experience for visitors. '24 jiyue' originates from ancient cultural traditions and contains rich historical and cultural connotations(Chen & Yang, 2019). By presenting it to visitors through modern technological means, it can bring new vitality to ancient culture. Despite the strong interest in IoT and MR based solutions in cultural venues, research on the actual impact of such technologies on visitor experience is currently relatively scarce(Smith & Johnson, 2021). In the field of human-computer interaction, user experience (UX) is used to describe people's overall feelings during the interaction with information technology. The ISO 9241-210 standard defines UX as "the perception and response of an individual when using and/or expecting to use a product, system, or service. In fact, UX is a complex concept that encompasses multiple subjective attributes such as aesthetics, emotions, and social participation. Traditional information technology applications mainly focus on usability, and the primary goal of product and service design is to provide practical and easy-to-use features to support people in completing tasks. However, in today's era of extremely abundant goods and services, pleasure has also become an important consideration factor. The scope of UX is broad, including meeting non instrumental needs such as aesthetics, pleasure, creativity, and social needs, as well as obtaining positive emotions and happiness, with the emotions evoked by users being particularly critical(Hassenzahl, 2004).

Given the enormous potential of IoT and MR technologies in enhancing engagement and creating personalized experiences, it is of great significance to explore the impact of IoT games on visitor UX in the "24 Jiyue" MR experience. This not only helps to reveal the advantages and disadvantages of the application of this technology, but also clarifies the positive and negative factors that affect the visitor experience, providing strong basis for subsequent optimization, and designing experience plans that are more in line with visitor needs, preferences, and prior knowledge, thereby improving the service quality and attractiveness of cultural venues.

In the MR experience of "24 Jiyue", the aim is to provide visitors with a deeper and more comprehensive understanding of cultural knowledge related to "24 Jiyue" after participating in the experience. During the game, visitors participate in groups, using MR devices and IoT intelligent props to immerse themselves in a fusion of virtual and real scenes. They need to complete a series of tasks in this unique environment, gradually exploring and discovering the cultural mysteries hidden behind it by solving puzzles related to "24 Jiyue". In order to gain a deeper understanding of the impact on visitor experience, this study conducted an exploratory research. During the research process, we measured and analyzed the emotional changes, overall experience, and workload of visitors before and after the experience. By collecting and analyzing this data, a comprehensive analysis of various factors that affect visitor experience can be conducted, providing valuable references for cultural venues to better utilize new technologies to improve service quality.

2.RELATED WORK

Modern cultural venues, such as museums and theaters, are actively utilizing digital technology to transform from traditional display modes to interactive and experiential modes, in order to enhance visitor experience, attract a wider audience, and promote active participation of visitors. In this transformation process, the role and structure of cultural venues have undergone significant changes, no longer just storage places for cultural relics or content, but gradually evolving into active educational and entertainment venues supported by digital innovation(Li, Zhao, & Liu, 2022).

However, the application of information technology in the cultural field has not been smooth sailing and faces many obstacles. Researchers categorize these obstacles into three main types: firstly, organizational barriers(Smith & Johnson, 2021), such as cultural institutions' low enthusiasm for digital innovation, and traditional management models and ways of thinking that may limit the introduction and application of new technologies; Secondly, technological barriers, manifested as inadequate infrastructure that cannot meet the requirements of digital technology operation, such as unstable networks and aging equipment; Thirdly, there are financial obstacles. Due to limited funds, cultural institutions lack the time and resources to manage digital innovation, making it difficult to afford the costs of purchasing, maintaining, and training advanced technology equipment and related personnel. Taking Italy as an example, the country has over 4000 public museums, but most museums face difficulties in using advanced and expensive technologies such as interactive screens or holographic projections to enrich exhibition content due to a lack of economic resources. At the same time, there are also challenges in maintaining these complex technological facilities.

In order to attract more visitors and increase their participation in cultural venues, many cultural venues have begun to adopt gamification strategies. Gamification refers to the use of game elements in various scenarios and computer applications, by introducing game logic and mechanisms, to better attract user participation and solve practical problems(Brown & Green, 2020). The application of this strategy in the cultural field can increase interactivity and fun, allowing visitors to actively participate in activities during the visit, thereby enhancing the overall experience. For example, some cultural venues have launched treasure hunting games that require visitors to explore specific areas within the venue, searching for clues or items related to cultural knowledge. In this process, visitors can not only learn rich cultural knowledge, but also experience the joy of exploration. The design of IoT games in the "24 jiyue" experience draws inspiration from the idea of combining games with cultural experiences, aiming to provide visitors with a deeper understanding of the cultural connotations of "24 Jiyue" through gamification.

The application of IoT technology in cultural venues is becoming increasingly widespread, and the use of smart devices can significantly enhance visitor engagement(Bonsignore et al., 2015),. For example, the famous meSch project aims to support professionals in the cultural heritage field in creating and deploying personalized interactive experiences, allowing visitors to gain a deeper understanding of cultural content by operating intelligent physical objects. In the Loupe case under this project, museum visitors can use an intelligent object called a "magnifying glass" to point at specific exhibits and obtain rich cultural details in augmented reality. There is also a case of using interactive belts. When visitors are hiking in the Italian Alps to visit the site of the Italian trenches of World War I, the interactive belt can detect nearby cultural relics of interest and emit sound to guide visitors to approach. When visitors approach the cultural relics, the belt will play related stories, bringing them a unique experience. These cases demonstrate the innovative application and significant effects of IoT technology in cultural venues. The AR and VR games in "24 Jiyue" also draw on these successful experiences, using IoT technology to enable visitors to interact naturally and smoothly with the "24 Jiyue" elements in virtual scenes, enhancing the immersion and fun of the experience.

Although many studies have focused on evaluating the effectiveness of technology applications in cultural venues, there is relatively little analysis of visitor emotions in many studies. Most research focuses mainly on the functionality and usability of technology, neglecting the emotional experience of visitors. Emo-

tional experience has a significant impact on visitors' evaluation of cultural venues and their willingness to revisit (Desmet & Hekkert, 2007). This study aims to address this deficiency by using mature and validated evaluation tools to comprehensively measure the emotional changes, overall experience, and workload of visitors in the "24 Jiyue" MR experience, and deeply analyze various factors that affect visitor experience, providing more comprehensive and targeted recommendations for optimizing technology applications and improving service quality in cultural venues(Bradley & Lang, 1994; Laugwitz, Held, & Schrepp, 2008; Hart & Staveland, 1988).

3."JIYUE EXPLORATION": IOT GAMES IN EXHIBITIONS

In the theme experience of "24 Jiyue",the IoT based game "Ji Le Exploration" emerged, bringing visitors a unique cultural experience. This section will elaborate on the design and development of the game, including gameplay, meta design, and technical implementation.

3.1 Gameplay

The "Jiyue Exploration" game in the "24 Jiyue" MR Experience Zone. It is a deep interactive session that starts after visitors complete their regular "24 Jile" exhibition visit, aiming to deepen visitors' understanding of relevant cultural knowledge and bring them a fun and engaging gaming experience.

When visitors finish their regular exhibition visit, the staff will divide them into groups and each group will be equipped with a complete set of gaming devices, with customized MR glasses as the core equipment, and IoT smart props such as sensing bracelets and smart cards. The game starts, and visitors put on MR glasses and instantly step into the highly realistic virtual "24 Jiyue" performance scene. In this virtual world, 24 geisha performers are lifelike, dressed in gorgeous costumes, holding exquisite instruments, and performing smoothly and naturally. The performance scene is full of details, from stage arrangement to light and shadow effects, giving people a sense of immersion.

The smart card is carefully designed with various puzzles closely related to "24 Jiyue", covering rich cultural knowledge such as instrument types, performer identities, and music titles. Visitors need to explore in collaboration between virtual scenes and real experience areas, and solve puzzles through close interaction with IoT intelligent props. For example, visitors can touch specific signs within the experience area by sensing the wristband. The wristband's built-in sensors interact with surrounding IoT devices, triggering sound clues in the virtual scene. Visitors can infer the corresponding instrument based on the unique instrument tone they hear and their knowledge; Or scan the smart card with MR glasses, and the RFID tag information inside the card will be read, presenting detailed text prompts to visitors and helping them gradually overcome puzzles.

When the group successfully solves all the puzzles, the virtual scene will trigger a reward mechanism full of surprises. It may be a rare performance segment of the "24 Jiyue" collection, which showcases unique performance techniques and lost dance movements, allowing visitors to appreciate the unique charm of ancient Ji Yue art; It is also possible to unlock exclusive virtual souvenirs, such as exquisite virtual instrument models, personalized performer images, etc. Visitors can keep these souvenirs after the game ends as a unique witness to this unforgettable experience, deepening their memory and love for the "24 Jiyue" culture.

3.2 Meta-Design

To break down technological barriers and allow non-technical professionals to participate in game design and adjustment, "Jiyue Exploration" adopts a meta design concept for development. Meta design is mainly promoted in two stages. The first stage is the construction of the design environment and tools, which is the responsibility of a professional technical team. In terms of hardware, deeply customize MR glasses to optimize their display resolution and color reproduction, ensuring clear and realistic virtual scenes; Upgrade the

accuracy of tracking sensors to enable precise feedback of visitor movements in the virtual world; Improve the quality of the audio system, achieve 3D surround sound effects, and enhance immersion. At the same time, the reasonable layout of IoT sensors and actuators ensures that they can accurately capture visitor behavior and environmental information, triggering rich interactive effects. At the software level, create a dedicated programming environment and intelligent object behavior definition tool to provide a convenient and efficient development platform for subsequent game design.

The second stage focuses on the final game design, which requires cultural experts (such as senior cultural scholars, professional performing artists, etc.) to work together with the technical team. Experts in the cultural field, with their profound professional knowledge, carefully conceptualize puzzles, cleverly design clues, and reasonably plan interactive activities based on the historical and cultural background and artistic expression forms of "24 Jiyue". For example, cultural scholars design puzzles that are both consistent with historical facts and full of challenges based on ancient book records and research results; Performing artists add artistic appeal to virtual interaction from the perspective of stage performance. During the design process, both parties exchanged ideas and sparks of creativity through multiple discussions and meetings. At the same time, the design content is repeatedly tested, feedback is collected from all parties, and continuous optimization and improvement are carried out to ensure that the game accurately conveys cultural connotations while being full of fun and challenge, meeting the diverse needs of different visitors.

3.3 Implementation

The smooth operation of the game "Jiyue Exploration" relies heavily on a series of carefully configured technical equipment and systems. Its core equipment - customized MR glasses, integrates multiple advanced technologies. The high-resolution OLED display screen can present extremely delicate and realistic virtual images, whether it is the texture of the costumes of the performers or the changes in light and shadow on the stage, they are all clearly visible; High precision six degree of freedom tracking sensors capture visitors' head movements in real time, enabling real-time switching of perspectives and allowing visitors to move naturally and smoothly in the virtual world; High quality stereo headphones provide an immersive audio experience, with instrument playing sounds and live ambient sound effects coming from all directions, creating a strong sense of immersion. MR glasses are stably connected to IoT smart props through low-power Bluetooth technology, ensuring fast and accurate data exchange, allowing visitors to interact with smart props in a timely manner in virtual scenes.

IoT smart props play a key role in games, with sensing wristbands and smart cards being the main interaction carriers. The induction wristband is equipped with an accelerometer, gyroscope, and proximity sensor. The accelerometer and gyroscope accurately monitor the visitor's movement and posture, while the proximity sensor keenly perceives the distance between the visitor and specific virtual or real objects. When visitors approach game related objects, the wristband provides prompts through vibration and triggers rich interactions, such as activating virtual character conversations, unlocking hidden clues, etc. Smart cards embedded with ultra-high frequency RFID tags store a large amount of puzzle and clue data. The built-in RFID reader in MR glasses can quickly and accurately read card information, providing clear game guidance for visitors and promoting smooth game progress.

The game backend system is built on advanced cloud computing platforms and serves as the "smart hub" of the entire game. The backend system comprehensively manages game data, user information, and interactive logic to ensure stable game operation and personalized experience. Through RESTful API interfaces, efficient communication between MR glasses, IoT smart props, and backend systems is achieved, with real-time synchronized data updates. For example, when visitors use smart cards to obtain clues and complete puzzles, the backend system quickly records the data and dynamically adjusts the subsequent game content and difficulty based on the game logic, tailoring a unique game experience for each visitor to ensure the smoothness and fun of the game (Wang & Xu, 2017).

4.EXPLORATORY STUDY

As mentioned in the introduction and related work, there is limited research on the impact of IoT technology on museum visitors. Specifically, there is almost no research in the literature on how the Internet of Things affects visitors in terms of emotions, overall experience, and workload. To investigate the impact of introducing IoT games during museum visits, we conducted the exploratory study reported in this section.

4.1 Research Design and Participants

In the context of the integration of cultural experience and technology, it is particularly important to have a deep understanding of the application effects of new technologies in cultural venues. This study focuses on the "Jiyue Exploration" game in the "24 Jiyue" MR experience, aiming to comprehensively explore the advantages and disadvantages of the game, as well as identify key factors that affect visitor experience. Based on this, the following three core research questions are proposed:

RQ1: Will playing the IoT game “Jiyue Exploration” have an emotional impact on visitors during the “24 Jiyue” MR experience ?

RQ2： How does playing the game “Exploration of Jile” affect visitors’ overall experience of “24 Jiyue” MR?

RQ3： How will playing the game “Jiyue Exploration” affect the workload of visitors?

To further explore these issues, this study adopted a repeated measurement design. This design aims to evaluate the same group of participants at different stages in order to clearly observe and analyze changes in variables. In this study, the participants’ experience of the “24 Jiyue” exhibition was set as the pre-test stage, during which various data of participants in the regular visiting mode could be obtained as a baseline reference; Playing the game “Jiyue Exploration” as a post testing stage is seen as a process of applying processing, and by comparing the data from the two stages, the impact of the game on visitor experience can be accurately explored. The research will be conducted at the exhibition at [specific time].

Considering the characteristics of the “24 Jiyue” theme experience and related games, this study will recruit visitors aged between 18-35. This age group has a higher acceptance of new technologies and a strong desire to explore cultural experiences, which enables them to better adapt and participate in this study. The recruitment work is carried out through a combination of online and offline methods. Recruitment information is released online through the official exhibition website and social media platforms, while offline promotion is carried out within and around the exhibition hall. A total of 50 eligible visitors were invited to participate, and after a complete research process, 40 visitors successfully completed the entire study (including 18 females; average age=23.5 years, standard deviation=2.1). Before the start of the study, each participant signed a detailed informed consent form, fully understanding the research purpose, process, and potential risks involved. As a token of gratitude for the time and effort invested by the participants, carefully prepared souvenirs will be provided as a reward after the study is completed(Creswell, 2014).

4.2 Measurement Tools

To comprehensively and accurately answer the above research questions, this study mainly collects quantitative data for analysis. For RQ1, which explores the impact of games on visitor emotions, considering the large range of visitor activities during the game process, traditional emotion measurement methods may be limited. After comprehensive evaluation, the Self Assessment Manikin (SAM) questionnaire was chosen to measure the emotional state of visitors. The SAM questionnaire is a widely validated and cost-effective self-report questionnaire that evaluates an individual’s emotions from three dimensions: pleasure, arousal, and dominance. Participants conducted intuitive self-assessment of their emotional states at different times using a 9-point visual scale. During the exhibition visit phase, in order to comprehensively capture the emotional changes of visitors during the visit, participants are invited to fill out a questionnaire every 15 minutes; In the game stage, considering that the completion of puzzles is a key node in the game and may

trigger emotional fluctuations, participants are invited to fill out a questionnaire for each completed puzzle(Bradley & Lang, 1994).

Regarding RQ2, which studies the impact of games on the overall experience of “24 Jiyue” MR, a brief version of User Experience Questionnaire (UEQ-S) is used to measure visitor experience. UEQ-S is widely recognized in related research fields and has high reliability. It can effectively measure people’s subjective impressions of experiences and deeply explore the advantages and disadvantages of experiences. This questionnaire measures practical quality and hedonic quality from two dimensions, using an 8-item semantic difference scale. The score range is set from -3 (representing extremely poor experience) to+3 (representing excellent experience). Invite participants to fill out questionnaires at the two key points of exhibition visit and game completion, in order to compare their experience scores at different stages(Laugwitz, Held, & Schrepp, 2008).

For RQ3, which analyzes the impact of games on visitor workload, we chose to use the NASA-TLX questionnaire for evaluation. The NASA-TLX questionnaire is a widely used tool, initially developed by NASA to assess pilot workload, and now applied in multiple fields. The questionnaire evaluates from six dimensions: psychological needs, physical needs, time needs, performance, effort, and setbacks. Participants rate each dimension on a scale of 0-100 based on their own feelings, and finally calculate the overall workload index through a specific algorithm. Measurements will also be taken during the two stages of exhibition visit and game completion to obtain workload data for different stages (Hart & Staveland, 1988). In addition, in order to further analyze the emotions and experiences of visitors, in addition to quantitative data collection, audio and video recordings of participants’ performance during the game were also conducted. And using thematic analysis method to systematically analyze these qualitative data, this method can uncover the behavioral patterns, emotional expressions, and deep understanding of participants’ gaming experience during the game process, providing richer and more comprehensive information for research(Braun & Clarke, 2006).

4.3 Procedure

The research process is rigorous and orderly, ensuring the accuracy and reliability of the data. Participants will first embark on a tour of the "24 Jiyue Music" exhibition, which will be fully explained by professional guides. The tour guide, with rich knowledge reserves and vivid presentation methods, provides participants with a detailed introduction to the historical origins, cultural connotations, artistic features, and other aspects of “24 Jiyue”. The tour lasts about 30 minutes. During the visit, participants are strictly invited to fill out the SAM questionnaire every 15 minutes according to the predetermined time interval, in order to record their emotional changes during the visit. After the visit, in order to avoid the fatigue of the previous stage interfering with the subsequent gaming experience, participants are arranged to take a 5-minute break so that they can immerse themselves in the gaming process in a better state.

After the break, participants enter the game area. The staff provided them with a clear and easy to understand explanation of the rules and gameplay of the “Jiyue Exploration” game, ensuring that each participant fully understood the game process and objectives. Subsequently, participants were grouped according to the on-site arrangement for the game. During the game, participants are encouraged to fully exert their subjective initiative, freely explore the integration of virtual and real scenes, and actively interact with IoT intelligent props. After completing each puzzle, participants need to immediately fill out the SAM questionnaire and record their emotional state in a timely manner. After the game, participants filled out UEQ-S and NASA-TLX questionnaires to evaluate their gaming experience in terms of overall experience and workload (Yin, 2018).

Throughout the entire research process, three professionally trained observers were arranged to carefully observe and record the behavior of the participants. Observers focus on participants’ actions, expressions, and language communication, recording their various performances in the game and providing rich materials for subsequent qualitative analysis.

4.4 Quantitative Results

After collecting the data, use professional statistical methods to conduct in-depth analysis of quantitative data. Using Welch's t-test to analyze SAM questionnaire data, this method is suitable for testing whether there is a significant difference in the mean of two independent samples. In this study, it was used to test the difference in emotional dimensions of visitors before and after the game; The paired sample t-test was used to analyze the results of UEQ-S and NASA-TLX questionnaires. This method can effectively evaluate the changes in the same group of subjects at different time points or under different conditions. In this study, it was used to evaluate the impact of games on overall experience and workload. Set the significance level α=0.05 to determine whether the results have statistical significance. In terms of emotions, the analysis results showed that the scores of pleasure, arousal, and dominance during the game stage were significantly higher than those during the exhibition visit stage (pleasure: χ (39)=35.621, p=0.000; Wake up: χ (39)=42.583, p=0.000; Dominance: χ (39)=38.742, p=0.000) (Russell, 1980). This result indicates that the game "Jiyue Exploration" has a positive impact on visitors' emotions, making them feel more pleasure, higher levels of physiological and psychological activation, and stronger sense of control during the game process.

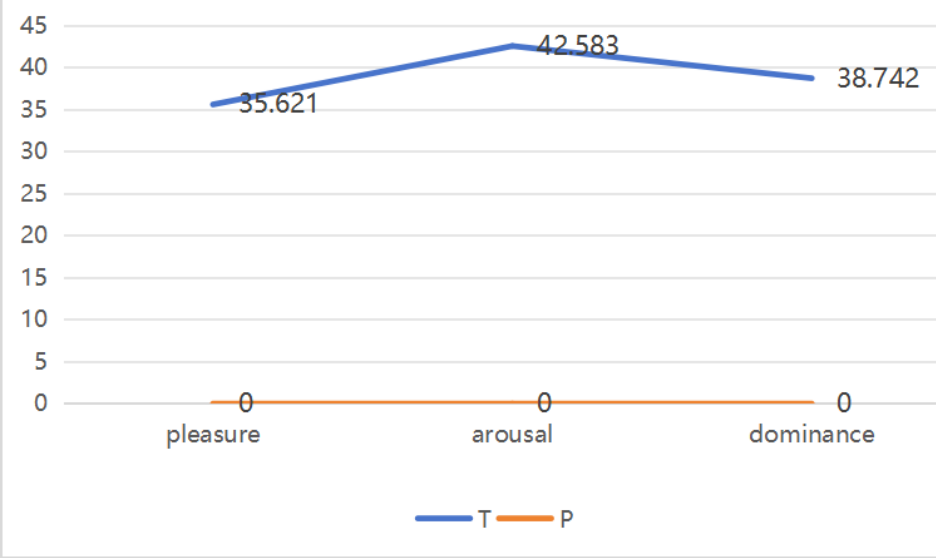

Figure 1: Comparison of Emotional Dimensions (SAM Questionnaire)

The results of the UEQ-S questionnaire indicate that the overall score during the exhibition visit stage is $\bar{x}$=1.2, SD=0.85, The practical quality score $\bar{x}$=1.4, SD=0.78, Enjoyment quality score $\bar{x}$=1.0, SD=0.92; The overall score of the game stage is $\bar{x}$=2.2, SD=0.45, The practical quality score $\bar{x}$=2.0, SD=0.55, Enjoyment quality score $\bar{x}$=2.4, SD=0.42。 Through paired sample t-test analysis, it was found that the gaming stage significantly outperformed the exhibition visiting stage in terms of overall score, practical quality, and enjoyment quality (overall score: t =4.852, p<0.000; Enjoyment quality: t (39)=6.213, p<0.000; Practical quality: t (39)=3.124, p=0.003) 。 This indicates that the "Jiyue Exploration" game has a significant effect on improving visitors' overall satisfaction with the "24 Ji Le" MR experience, both in terms of practical quality that meets functional needs and in terms of the enjoyment quality that brings emotional pleasure (Hassenzahl & Tractinsky, 2006).

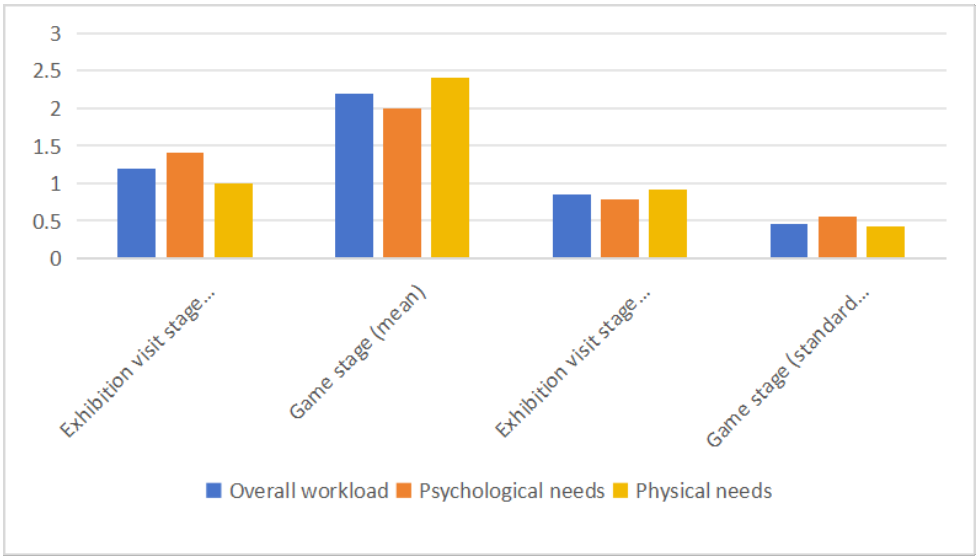

Figure 2: User Experience Comparison (UEQ-S Questionnaire)

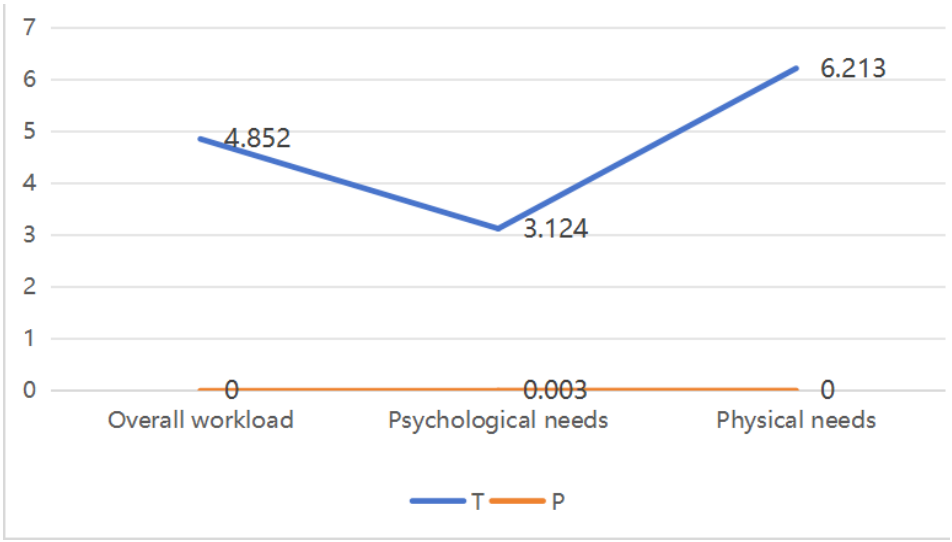

Figure 3: User Experience Comparison (UEQ-S Questionnaire)

The analysis of the NASA-TLX questionnaire showed that the workload during the gaming phase was significantly higher than that during the exhibition visit phase ($t(39)=3.526$, $p<0.001$). Further analysis of each dimension revealed that psychological needs ($t(39)=3.215$, $p<0.002$) and physical needs ($t(39)=2.874$, $p<0.006$）、 There is a significant difference in the dimensions of time demand ($t(39)=3.018$, $p<0.004$) and performance ($t(39)=-2.563$, $p<0.014$), while there is no significant difference in the dimensions of effort ($t(39)=1.357$, $p=0.182$) and frustration ($t(39)=1.125$, $p=0.266$). This indicates that visitors need to invest more energy in cognition, physical strength, and time when playing the game “Jiyue Exploration”, but at the same time, it also improves their performance to a certain extent.

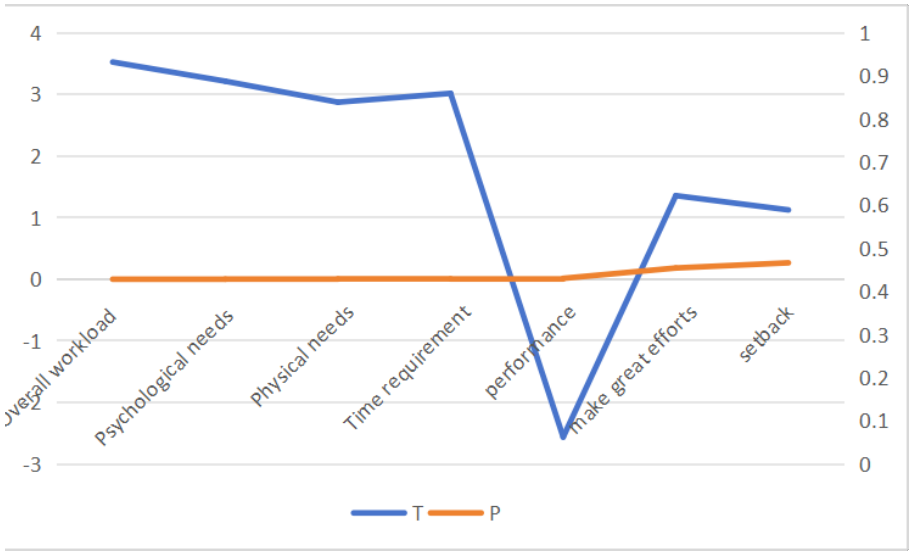

Figure 4: Workload Comparison (NASA-TLX Questionnaire)

4.5 Qualitative Results

Through thematic analysis of the audio and video recordings during the game, a series of interesting and valuable behavioral patterns were discovered.

On a personal level, some participants exhibit unique innovative thinking. For example, some participants cleverly utilize the special functions of MR devices, such as switching perspectives, zooming in on details, etc., to observe virtual scenes from different angles, break conventional thinking patterns, and search for puzzle clues. Cultural knowledge and background also play an important role in the process of solving puzzles. Participants who have a certain understanding of ancient music culture can quickly identify the cultural elements involved in solving puzzles and quickly find solutions based on their own knowledge reserves. In addition, participants also demonstrated good adaptability and flexibility. When encountering difficulties or discovering that their original puzzle solving strategies were ineffective, they were able to adjust their strategies in a timely manner according to the progress of the game, demonstrating strong adaptability(Liu & Huang, 2018).

In the collaborative dimension, knowledge sharing behavior is very evident within the group. The group members actively share various information obtained during exhibition visits and games, including their understanding of the cultural knowledge of "24 Jiyue" and clues discovered in the scene. Through communication and integration, they work together to promote the puzzle solving process. The scene of mutual support and encouragement frequently occurs. When a member encounters difficulties or makes mistakes, other members will give positive feedback and encouragement. This team cohesion effectively enhances the confidence and motivation of the entire group. When faced with differences, participants are able to maintain rationality and resolve conflicts through active communication. They respect each other's perspectives, jointly explore solutions, and ensure the harmony and efficiency of the team in solving puzzles. The communication between team members is positive and effective, whether in sharing clues, discussing strategies, or coordinating actions, they can achieve timely and clear communication, which provides strong guarantees for the smooth progress of the game.

By observing the expressions, actions, and language of the participants, it was found that they exhibited a high level of participation during the game. Most participants show a strong interest in the game, with focused eyes, actively exploring virtual scenes, and frequently operating IoT intelligent props. They show excitement and joy when solving puzzles, and can also maintain focus and perseverance when facing difficulties, fully demonstrating their dedication and enthusiasm for the game.

5.DISCUSSION

This exploratory study focuses on the impact of the IoT game "Jiyue Exploration" on visitor experience in the "24 Jiyue" MR experience, aiming to provide valuable references for cultural venues to optimize services using new technologies. The research results present multiple findings, clearly demonstrating the advantages of the game in enhancing visitor experience, while also revealing some issues worth further exploration.

Playing the game "Jiyue Exploration" has significantly increased visitor engagement and positive emotions (RQ1). Through a detailed analysis of the game process video, it can be found that visitors showed a high level of engagement throughout the entire game process, maintaining an active participation state from start to finish, with a warm and focused attitude. From the quantitative data analysis results of the emotional dimension, it can be seen that the scores of pleasure, arousal, and dominance in the gaming stage are significantly improved compared to the exhibition visiting stage. A higher sense of pleasure score fully indicates that visitors have truly enjoyed the fun during the game, immersing themselves in the atmosphere created by the game and giving positive feedback on the gaming experience. The improvement in awakening level indicates that the game has successfully stimulated visitors' interest and vitality, making them more excited and focused during the experience, demonstrating a strong desire for exploration. The enhanced sense of dominance means that visitors feel more autonomy and control during the experience, which is largely due to the personalized interactive experience constructed by MR and IoT technologies. In the game, visitors can interact with virtual scenes and intelligent props at their own pace and in their own way, freely exploring the cultural world of "24 Jiyue". This autonomy gives them a stronger sense of control over the entire experience process. However, it should be noted that the emotional data in this study mainly came from self-report questionnaires, which may have certain subjectivity and limitations in the data collection method. Therefore, further diversified research is needed in the future, using multiple measurement methods to complement each other, in order to more comprehensively and accurately verify these findings, and to explore other potential factors that may affect visitors' emotional experiences in depth.

The IoT game "Jile Exploration" has achieved significant results in improving the hedonic and practical quality of the "24 Jiyue" MR experience (RQ2). On the level of hedonic quality, the game successfully stimulated positive emotional responses from visitors, bringing them a rich and enjoyable emotional experience. The innovative thinking patterns discovered from qualitative analysis indicate that the game encourages visitors to break through conventional thinking and explore the "24 Jiyue" culture from different perspectives. For example, some visitors utilize the special features of MR devices to observe details in virtual scenes from a unique perspective, thereby discovering hidden clues. This exploration method not only increases the fun of the game, but also allows visitors to have a deeper and more unique understanding of the "24 Jiyue" culture, greatly enhancing the freshness of the experience. In addition, the behavior patterns of support, encouragement, and knowledge sharing that arise during the collaboration process further enrich the emotional experience of visitors. The mutual encouragement and support among team members create a positive and harmonious atmosphere, allowing visitors to experience the joy of teamwork in the game; And knowledge sharing allows them to learn from each other, jointly explore the connotation of the "24 Jiyue" culture, and improve the overall experience quality. In terms of practical quality, the results of the UEQ-S questionnaire show that visitors generally believe that games are more efficient and effective in helping them achieve their experiential goals. The carefully designed clues and rich interactive elements in the game provide strong support for visitors to understand the culture of "24 Jiyue". By interacting with IoT smart props and exploring puzzles, visitors can gain a deeper understanding of the cultural knowledge and artistic features contained in "24 Jiyue". This makes the entire experience not only enjoyable but also highly practical, effectively enhancing visitors' awareness and understanding of the "24 Jiyue" culture.

The phenomenon of increased workload brought by games deserves special attention (RQ3). Research data shows that the workload during the gaming phase significantly increases in terms of psychological,

physical, and time requirements compared to the exhibition visiting phase. This is mainly because games require visitors to actively participate in interactions, constantly thinking, exploring, and solving puzzles, which puts higher demands on their cognitive abilities. At the same time, operating MR devices and IoT smart props also increases the burden on the body, such as frequent use of sensor bracelets, operating MR glasses, etc. Although the performance score has also improved, indicating that visitors may be more efficient in certain aspects during the gaming process, further in-depth research is needed to determine whether this increase in workload will have different impacts on the experience of different types of visitors. Visitors of different ages, genders, cultural backgrounds, and levels of technical familiarity may have varying levels of workload tolerance and perception. However, based on current data, although the workload during the gaming phase has significantly increased, the positive emotions and overall experience of visitors have not been negatively affected(Steuer, 1992). This indicates that under the current game design, visitors are able to accept changes in workload to a certain extent and still obtain high satisfaction from the gaming experience. But in order to ensure that the game can meet the needs of a wider range of visitors, in the future, in the process of game design and optimization, more attention needs to be paid to the balance between workload and visitor experience. By adjusting game difficulty reasonably, optimizing interaction methods and other means, the overall experience quality of the game can be further improved.

6.LIMITATIONS

While deeply analyzing the results of this study, we also clearly recognize that there are some key factors that may affect the internal and external validity during the research process, which to some extent limit the universality and accuracy of the research conclusions and require further exploration.

Internal validity concerns our confidence in causal relationships in research, ensuring that the tested causal relationships are not disrupted by other factors or variables. In this study, although we conducted preliminary experiments and comprehensively optimized the game process and props before the formal research, striving to make the game rules clear and easy to understand, and the prop operation simple and smooth, we still cannot completely rule out the possibility that some participants may not have a clear understanding of the game rules. The game process involves various complex interactive elements and puzzles, and there are differences in the understanding ability and cognitive style of different participants. This may lead to some people's deviation in grasping the rules during the game process, which in turn affects their gaming experience and the accuracy of research results. In addition, the order in which games are played in the study may also pose potential issues. During the research process, participants played the game in sequence, and the groups that later participated in the game inevitably experienced waiting time. Although the waiting time is relatively short in actual operation, it may still have a certain impact on their gaming performance and experience. For example, anxiety during the waiting process may interfere with their memory of the exhibition content, making it difficult for them to fully utilize the knowledge gained from visiting the exhibition in the game segment, affecting puzzle solving efficiency and experiential experience. However, given the limited waiting time, this impact may be relatively small in this study, but it is still a potential factor that cannot be ignored.

External validity mainly involves whether research results can be extended to other different contexts. In this study, there are several prominent issues in this regard. Firstly, the age group of participants is concentrated between 18-35 years old, which has a higher acceptance of new technologies and a certain similarity in their needs and expectations for cultural experiences. However, the visitor population of cultural venues covers various age groups, and there are significant differences in cognitive abilities, interest preferences, and technological usage habits among different age groups. Therefore, the results of this study cannot directly represent the experiences and reactions of visitors of all age groups. Subsequent research needs to further expand the age range and cover a wider audience to obtain more universal research conclusions. Secondly, this study only focuses on the specific IoT game of "Jiyue Exploration", which has a unique theme, gameplay, and technological application. There are various forms of IoT games in cultural venues,

and different games have different design concepts, interactive mechanisms, and cultural connotations. Therefore, the results of this study may not be applicable to other types of cultural venue IoT games, and caution should be exercised when extending the conclusions of this study to other games. Finally, the relatively small sample size (40 participants) is also an important factor affecting external validity(Zhou & Sun, 2016). A smaller sample size may not fully cover various types of visitors, resulting in biased research results that cannot accurately reflect the true situation of the overall visitor population, thereby limiting the generalizability of the research findings.

7.CONCLUSION AND FUTURE WORK

This study systematically evaluated the impact of the "Jiyue Exploration" IoT game on visitor experience in the "24 Jiyue" MR experience through a carefully designed exploratory study. The research results indicate that the game “Jiyue Exploration” has shown a positive effect in enhancing visitors’ emotional experience and improving overall experience quality. During the game, visitors’ sense of pleasure, arousal level, and dominance significantly improve, and their positive emotional experience is greatly enriched; At the same time, from the perspectives of hedonic quality and practical quality, the game effectively enhances visitors’ satisfaction with the “24 Jiyue” MR experience. Although the game may increase visitors’ workload in terms of psychological, physical, and time requirements, it is gratifying that this has not had a negative impact on visitors’ positive emotions and overall experience, indicating that the game has achieved a balance between fun and challenge to some extent.

Looking ahead to the future, there are still many valuable research directions waiting to be explored in the field of integrating cultural venues with new technologies. On the one hand, it is possible to conduct in-depth research on the practical effects of different forms of IoT and MR applications in cultural venues. For example, developing games with different cultural themes, starting from multiple perspectives such as historical stories, art genres, and folk customs, to meet the diverse cultural needs of visitors; Or change the existing interaction mode, introduce more advanced sensing technology and more creative interaction design, to bring visitors a brand new immersive experience. By comparing the effects of different application forms, a more scientific basis can be provided for the selection and optimization of technology applications in cultural venues. On the other hand, it is crucial to pay attention to the reactions of visitors of different ages and cultural backgrounds to such experiences. People of different age groups grow up in different cultural environments and technological eras, and their expectations and acceptance of cultural experiences vary greatly; And visitors from different cultural backgrounds, due to their different cultural values and aesthetic concepts, will have different feelings and needs for the experience in cultural venues. Thoroughly studying these differences can help cultural venues provide more personalized services and meet the needs of various visitors. In addition, exploring the impact of such experiences on cultural knowledge dissemination and learning outcomes from an educational perspective is also a highly meaningful research direction. With the increasingly prominent educational function of cultural venues, understanding the role of IoT and MR technology in cultural knowledge transmission, comprehension, and memory can better leverage the educational value of cultural venues and promote cultural inheritance and innovation. By continuously conducting these studies, it is expected to provide more solid theoretical support and practical guidance for the deep application of IoT and MR technologies in the cultural field, promote the continuous optimization of services in cultural venues, and bring visitors a better and richer cultural experience.

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