Do curators' decisions about visual elements have an impact on knowledge acquisition in digital art exhibitions? It is analyzed from the perspective of human cognitive processing

Mengdie Zhao
Beijing Institute Of Graphic Communication CHN,13402238305@163.com
Yi Tong Zhan
Northwestern University US,1432566869@163.com

Abstracts

In the field of art, exhibitions are used to draw the audience into a state of active appreciation and knowledge acquisition through immersive and interesting interactions that include rich visual situations. There is evidence that there are individual differences in the way people inherently search, process, analyze, understand, store, and retrieve visual information from their surroundings, and that these differences are ireflected in their performance, experience, effectiveness, and efficiency in these environments. Although curators tend to provide learning experiences in such contexts, current art exhibition design and evaluation practices take little account of the viewer's individual differences in visual information processing. This can be attributed to deficiencies in understanding and predicting the impact of the audience's visual behavior, interactive behavior, and cognitive style on knowledge acquisition in art exhibitions, resulting in inadequate approaches to creating cognitive-centered audience models, and insufficient ability to actually consider these human cognitive factors in current state-of-the-art design and evaluation methods. To bridge this gap, we have selected three known art exhibition projects.The Digital Art exhibition adopted a credible cognitive style theory and conducted three independent evaluative user studies (N = 149) over a 6-month period, following an inter-subject, eye-tracking based experimental design.The results of the evaluation study show that curators' visual search decisions inadvertently favor users with specific cognitive characteristics, influencing their visual behavior and thus game behavior, leading to differences in knowledge acquisition.Conclusion:The results of the evaluation study also revealed the correlated effects of individual differences in visual information processing, user visual behavior strategies, and interactive behavior during the exhibition. These findings require that cognitive features be considered as assessment and design factors when providing art exhibition activities based on visual search tasks. This consideration will help us to better understand and interpret different approaches to information processing in the context of digital art, and drive the design of adaptive mechanisms to provide personalized exhibition activities that meet the unique cognitive needs of the audience.

CCS Concepts: Human-centered Computing → Human-Computer Interaction (HCI; Social and professional topics → User characteristics;

keywords : individual cognitive differences, digital art exhibitions, visual behavior

1.INTRODUCTION

A large amount of research is devoted to digital art, with the main aim of building digital art learning activities and improving user experience through immersive digital art exhibitions. The main goal of the curator is to engage the audience in interesting art exhibition activities in which the audience is actively exploring the educational content rather than passively receiving .

In this context, knowledge acquisition and learning is expected to be achieved by stimulating audience interest, teamwork, collaboration and competition, thereby encouraging the construction of knowledge and meaning through exhibitions and immersive activities .However, there are differences in the way people perceive and process visual information [and some researchers have tried to understand and explain these differences from the perspective of cognitive styles. One fundamental cognitive style is the field-dependent-independence (FD-I) style, which is a credible and validated framework and a cornerstone of other cognitive styles.

According to FD-I theory, people are classified as field-dependent (FD) or field-independent (FI) based on their ability to extract information from visually complex scenes. Field-dependent types tend to process and organize visual information in a holistic way, and they have difficulty recognizing details in complex visual scenes. However, financial institutions tend to adopt an analytical information processing approach, pay attention to detail, and are able to easily distinguish simple structures from the surrounding visual environment.

Thus, FD-I theory supports cognitive differences in visual perception and processing of contextual information, both holistic and analytical. Despite several studies highlighting the impact of FD-I on visual processing activities, interactive behavior, knowledge acquisition/learning and taking into account differences in the way FDS and FIs search, process, and understand information, current digital art exhibition design and evaluation methods do not consider users' FD-I style as a design or evaluation factor.

The reason is that the mechanisms behind these effects have not been thoroughly studied, resulting in a lack of understanding of how to actually take this cognitive factor into account in current state-of-the-art digital art exhibition design and evaluation methods. Therefore, our research question is to explore whether the decisions of which curators regarding visual information processing benefit or hinder the acquisition of knowledge by people with specific cognitive characteristics.

Inspired by the reasoning above, and considering that activities involving information processing tasks are preferred, especially in the field of digital art exhibitions, we investigated whether users with different cognitive styles follow different strategies when interacting with these activities, whether these strategies are reflected in the audience's behavior, and whether this behavior can be correlated with the knowledge gained.

The interaction between the above factors (i.e., human cognition, interactive behavior, and knowledge acquisition) has not been thoroughly studied in the context of digital art exhibitions, and therefore the basic mechanisms of the effects between these factors are poorly understood.

Therefore, answering the above research objectives will provide a new perspective for the evaluator to consider the cognitive characteristics of the individual as an important assessment parameter. Treating human cognition as an assessment parameter will help evaluators uncover and explain user behaviors that cannot be explained when cognitive factors are ignored, and better understand how specific activity factors can be customized for individuals. Understand cognitive preferences and needs, and make questions and recommendations that support design principles for all, with the aim of achieving diversity and inclusion for a wider audience.

Do curators' decisions about visual activities affect knowledge acquisition in the digital art media display space?

In order to study the above research objectives, we selected three aesthetic art exhibitions designed by professional curators and deployed by professional art and cultural institutions and industries, aiming to capture representative exhibition types and forms of expression in the field of digital art exhibitions. For the six-month study, we recruited 150 participants who participated in the intersubject eye tracking Evaluation Study. Our

goal is to explore the potential mechanism of audience behavior (including interactive form and visual behavior) and FD-I cognitive style in the process of knowledge acquisition and their interdepen

dence; Therefore, we aim to emphasize the importance of using human cognition as an evaluation factor, which can drive the design of personalized games to suit the cognitive characteristics of users.The rest of the article is structured as follows. First, we analyze the work involved. Then, the purpose of this study is expounded. Subsequently, the background and methodology of the audience research is described, and then the resuklts are analyzed and the main findings are discussed. Finally, the significance of the reported research is summarized and the full text is summarized.

2.RELATED WORK

Digital art exhibition, as an emerging art form, combines digital technology with artistic creation, bringing a new visual experience and knowledge transfer mode to the audience. Curators play a key role in this process, and their decisions not only affect the visual presentation of the exhibition, but also directly affect the audience's cognitive experience and knowledge acquisition. In recent years, the practice of digital art exhibition continues to emerge, from data visualization to multi-sensory interaction, curators through a variety of means to explore how to better convey artistic information, stimulate the audience's sense of participation and emotional resonance. Through the analysis of relevant literature, this paper discusses how the curatorial practice of digital art exhibition affects the audience's cognitive experience and knowledge acquisition. In recent years, the form of digital art exhibition has become increasingly diversified, from traditional offline exhibition to online virtual exhibition, from static display to dynamic interaction, curators continue to explore new ways of display. For example, the 2020 Global Art School Online Graduation Exhibition breaks through the limitations of time and space through the form of virtual exhibition halls, panoramic Tours and dynamic folders, providing the audience with a new exhibition experience（ZHANG Hao，2008）. This diversified form of exhibition not only enriches the audience's visual experience, but also provides a broader space for art communication. The development of digital technology has brought new possibilities for art exhibitions. Through data visualization, virtual reality, augmented reality and other technological means, curators present art works to the audience in a new form. For example, the exhibition "Portraits of Life in New York" transforms data about life in New York into intuitive visual images through data visualization and multi-sensory experiences, enabling viewers to quickly understand the exhibition's core themes（Zhen Wen&Huang Guanghui,2024). This deep integration of technology and art not only enhances the interactivity and interest of the exhibition, but also promotes the audience's deep understanding and memory of the exhibition content. The curatorial practice of digital art exhibition is gradually becoming cross-disciplinary.

Curators are no longer limited to the traditional field of art, but combine computer science, psychology, sociology and other multidisciplinary knowledge to explore new curatorial models. For example, Feng Yajie's research points out that digital art exhibitions expand the boundaries of art exhibitions by taking multidisciplinary issues as objects of discussion through interdisciplinary content, criticism and interpretation . (Chai Xiujuan,Cao Hui，2004）This interdisciplinary curatorial practice not only enrichis the content of the exhibition, but also provides the audience with a more comprehensive knowledge acquisition channel.

Visual event design is the visual experience created by the curator through exhibition space and digital technology. Its key elements include the narrative structure of the exhibition, interactive design and multimedia application. For example, the narrative structure of the exhibition can be presented in a linear or non-linear way, affecting the audience's understanding of the exhibition content (ZHANG Hao，2008）; Interactive design promotes knowledge acquisition by enhancing the audience's sense of participation（Chai Xiujuan&Cao Hui,2004)

Multimedia applications enrich the audience's experience through visual, auditory and other sensory stimuli(ZHANG Hao,2008). The audience's cognitive experience in digital art exhibitions is significantly

influenced by the design of visual activities. According to the research of cognitive psychology, the audience's cognitive process involves multiple stages such as attention allocation, information encoding, memory storage and knowledge extraction(Chai Xiujuan&Cao Hui,2004). Exhibition elements with high visual significance are more likely to attract the attention of the audience, while interactive design can enhance the efficiency of the audience's memory encoding (Zhen Wen&Huang Guanghui, 2024)In addition, multimedia applications can promote the audience's deep understanding and long-term memory of the exhibition content through multi-sensory stimulation (ZHANG Hao,2008). The curator's decision in visual activity design directly affects the audience's attention distribution. By using elements of high visual significance, such as shapes, dynamic effects, etc., curators can direct the viewer's attention to the core content of the exhibition (Zhen Wen&Huang Guanghui,2024). Interactive design is an important feature of digital art exhibitions, which promotes in-depth knowledge acquisition by enhancing the audience's sense of participation(ZHANG Hao,2008). According to the theory of cognitive psychology, interactive design can promote deep processing of knowledge and long-term memory by enhancing the audience's sense of self-efficacy (Chai Xiujuan&Cao Hui,2004). Visitors can experience the exhibition in greater depth, thereby enhancing their understanding of the exhibition theme (ZHANG Hao,2008). Through visual, auditory and other sensory stimulation, multimedia application can promote the audience's deep understanding of the exhibition content and long-term memory(ZHANG Hao,2008).

For example, through video, audio and interactive interfaces, curators can provide richer information to help visitors understand the exhibition from multiple perspectives(Chai Xiujuan&Cao Hui,2004）. This multi-sensory stimulation not only enhances the audience's attention, but also facilitates the breadth and depth of knowledge acquisition(ZHANG Hao,2008). The curator's decision of visual activity in digital art exhibition has a significant impact on the audience's knowledge acquisition. Through diversified exhibition forms, deep integration of technology and art, and interdisciplinary curatorial practice, curators can better convey artistic information and stimulate the audience's sense of participation and emotional resonance. In the future, curators should further explore how to enhance the audience's cognitive experience and knowledge acquisition through visual activity design, and provide new ideas and methods for the development of digital art exhibitions.

Regarding interactive behavior in the context of cultural heritage, our initial work found that FDs required less time to complete viewing the exhibition, while FI interacted with more exhibition items while playing the game. In addition to the background of digital culture and art, the research also shows that FDs are generally unwilling to use watching exhibitions for learning activities; FDs prefers to play social games, while FIs prefers to play in relative isolation: in partnership, FDs has a higher frustration tolerance; And FDS deal more effectively with problem-solving strategies in a collaborative environment.

From the perspective of visual behavior, FI is more inclined to pay attention to more important exhibition items than FD, and the duration is longer. In addition, FD tends to take a more holistic approach to the visual appreciation of exhibition scenes, while FI prefers a more analytical and systematic approach. FDs produces more random fixations than FIs, especially in complex tasks; FDs scans the scene in an unsystematic and disorganized manner, with several brief glances at almost all areas (Robert Zheng,2010). FD produces slower fixation (Ming-Shiumn Huang&Brian Byme,1978); FDs produces more shifts to the left, while FIs produces most shifts to the right. In addition, FI has stronger visual fusion ability than FD(Chai Xiujuan&-Cao Hui，2004）.

Regarding knowledge acquisition, several researchers have explored the effects of FD-I on knowledge acquisition and learning. According to Witkin et al. （Cao Qinghui&Huang Jiancheng,2020), FD-I has an important impact on individuals' cognitive behavior and interpersonal behavior. FD-I tends to be more autonomous in the development of cognitive restructuring skills, but less autonomous in the development of interpersonal skills(Maria Economon & Laiapujl-Tost，2011). In contrast, FDs tend to be more autonomous in developing high interpersonal skills and more passive in developing cognitive restructuring skills. In addition, FIs often takes an analytical approach, while FDs is more holistic in its perception, making

it difficult to distinguish the complex organization of parts from the whole. In addition, FIs tend to be intrinsically motivated and prefer personalized learning, while FDs tend to be extrinsic motivated and prefer collaborative learning. In recent years, a number of studies have been conducted on the impact of FD-I on knowledge acquisition and learning, confirming that among the different cognitive styles identified in the literature, FD-I is the most widely used in research related to knowledge acquisition and learning.(Robert Zheng,2010)

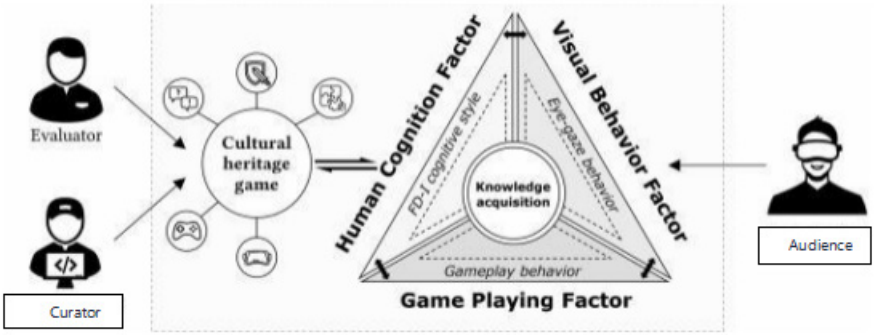

Figure 1: Research model for investigating the interaction between human cognition, visual behavior, and interactive behavior.And knowledge acquisition when viewing cultural heritage exhibition items.

2. 1 Motivation

Based on the above literature review, we conclude that there are scattered studies attempting to support the idea that FD-I affects audience visual behavior, interaction behavior, and knowledge acquisition. However, in the context of digital art, the interaction between the above factors has not been thoroughly studied, and there are still deficiencies in the understanding of visual behavior, interactive activities, and the cognitive mechanisms of human knowledge acquisition in digital art exhibitions.

Thus, although many digital art exhibitions include visual appreciation activities, human cognition is not considered an evaluation factor, despite the wide range of factors currently used to evaluate digital cultural heritage resources, such as cultural presence and aesthetic experience. Therefore, in this paper, we address the following research questions:

Question A: We investigated which curators' decisions about visual search and exploration activities benefit FD or FI users. In the survey, question A will highlight the relationship between certain visual design decisions about search and exploration and FD-I cognitive style factors.

Question B: We study the interaction of FD-I cognitive style, visual behavior and interactive behavior on knowledge acquisition, and research question B will reveal the interactive effects of these factors in the perspective of digital art.

Question C: We studied the correlation effect between the above factors. Studying problem C will enable us to understand the underlying mechanisms and judge whether we can leverage differences in eye-gaze driven FD-I users to create cognitive-centric user models for personalizing digital art exhibitions.

In order to explore the research questions and interpret the results, we propose and adopt a multi-level research and interaction analysis model based on the interaction of three pillars: human cognition (such as individual cognitive characteristics), visual behavior (such as eye movement indicators), and interactive experience (such as interaction performance indicators), in which knowledge acquisition is the core of the model.

Table 1:Digital cultural art exhibitions used in our study

Exhibition Title	Institutional	Culture	Technology	Visual search task types	online viewers
Bordering-fighting" Peking Opera media art interactive space	Beijing Printing Institute Beijing Opera Culture	Peking Opera Cultural art	MR, Information screen	structure	49652
panning six decades: The creative Fire of artificial Intelligence rtboost and Drama · Silent Art Hotel jointly presented the first 7 Environment · AI art Exhibition	Taikang Art Museum	Computer Art, Robot	computer algorithm	structure	42002
	Theatre Silence Art HotelArtboost	AI Painting Technology	AI algorithm	free	about 5000 viewers

3.EXHIBITION ANALYSIS

3. 1 Assumptions

To investigate the research questions QA, QB and QC, we formulated the following null hypothesis:

Hypothesis H0 1: There is no significant difference in visual behavior between FD and FI individuals when looking at digital art exhibitions, which tend towards free or structured visual appreciation tasks (related to QA).

H0 2: A digital art exhibition in which FD and FI individuals have no significant differences in interactive behavior, and it tends to be a free or structured visual appreciation task.

H0 3: There was no significant difference in knowledge acquisition between FD and FI individuals after viewing digital art exhibitions, which tended towards free or structured visual appreciation tasks (QB).

Hypothesis 4: When looking at digital art exhibitions (related to QC), there is no correlation between knowledge acquisition, interactive behavior, and visual behavior of FD and FI individuals

3.2 Exhibition Analysis

This paper selects three meaningful exhibitions that represent the most common art forms of digital art exhibitions (i.e. multimedia art, virtual simulation, digital painting), which are based on different modes of

visual appreciation. Selected exhibitions include “Frontier - Fighting” Peking Opera Media Art Interactive Space, “Spanning 60 Years: The Creative Fire of Artificial Intelligence,” and “Artboost and Yuxi · Silent Art Hotel jointly present the first 7 Frontier ·AI Art Exhibition.” All exhibitions include the acquisition of knowledge content of exhibition information, which is a common purpose of art exhibitions. The acquisition of knowledge content can be a necessary or optional option for the audience, because the audience can view the whole exhibition without fully understanding the information of the exhibition items. Mandatory knowledge content acquisition is related to structured visual appreciation methods, while optional knowledge content acquisition is related to free visual appreciation methods. “Spanning 60 Years: The Creative Fire of Artificial Intelligence” and “Artboost and Youxi · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition” are based on the free visual search task, while “Border-Fighting” Peking Opera media art interactive space is based on the structured visual search task.

All exhibitions are curated and developed by industry experts in collaboration with museums and cultural heritage institutions. Two digital art exhibitions, Spanning 60 Years: The Creative Fire of Artificial Intelligence and “Linjing - Fighting” Peking Opera Media Art Interactive Space, were launched by Taikang Art Museum and the National Peking Opera Theater respectively. 49,000 people visited online and offline during the exhibition of “Linjing - Fighting” Peking Opera Media Art Interactive Space. Publicity and promotion: mainstream media such as Xinhua News Agency, People’s Daily, CCTV CGTN, China Culture Daily, Beijing Youth Daily, Beijing Daily, Beijing TV, China National Peking Opera, China Dance Arts, Beijing Printing Institute, Learning to Power and other public accounts, Xiaored Book, and official accounts of Tiktok have received more than 2 million project publicity, interviews and page views.

The Interactive Space of Peking Opera Media Art is a digital cultural exhibition using mixed reality technology, curated by the team of Beijing Yi Printing Institute and exhibited by the National Peking Opera

Theater. The curators of each exhibition aim to attract the audience through the combination of cutting-edge digital technology and art, and let them understand the cultural knowledge of a certain field (“ The Interactive space of Peking Opera Media and Art “: the combination of national Peking Opera, cultural inheritance, intangible cultural heritage and digital technology; Across Sixty Years: The Creative Fire of Artificial Intelligence: Artificial Intelligence, Robotics, and Computer Art. And “Artboost and Drama · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition: AI, Art, Life, Technology and Beauty (our research scope is AI/ Art/technology)”. An overview of the exhibitions is shown in Table 1.

3.2.1 The Interactive space of Peking Opera Media Art

The Interactive space of Peking Opera Media Art is an immersive media art space with the theme of Peking Opera art, providing a new artistic experience for the audience. The project aims to attract young audiences while inheriting and promoting the art of Peking Opera, digitizing the auditory and visual elements of Peking Opera, such as singing and costumes, to create an immersive visual experience. The audience can interact with the installation through gesture vision, sound hearing or movement to become part of the artistic experience. At the same time, the exhibition guides the audience to explore the context of Peking Opera cultural knowledge in the space of virtual and reality integration. The use of cutting-edge media technology, in the immersive interaction to mobilize the user’s visual, auditory, tactile and other senses, to form a multi-sensory integration of audio-visual experience. Each exhibition area is equipped with a concise text introduction explaining the history, genres and performance forms of Peking Opera. The text description introduces the four major trades of Peking Opera (Sheng, Dan, Jing and Chou) and their characteristics, helping the audience quickly grasp the basic knowledge. Obviously, the more interested the audience is in the exhibition, the more knowledge they will receive. The audience is not a spectator, but a part of the art through interactive installations.

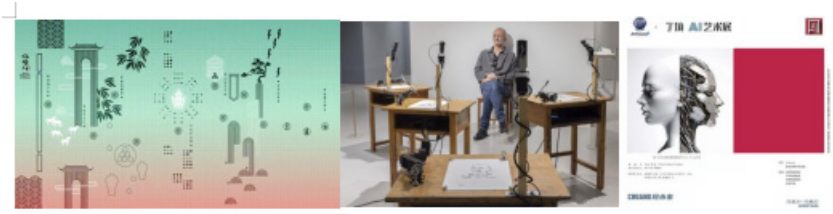

Figure 2: Exhibition studied in the study: "Frontier - Fighting" Peking Opera Media art interactive space (left), Spanning 60 Years: Creative Fire of Artificial Intelligence (middle)Artboost and Drama · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition (right)

3.2.2 Across Sixty Years: The Creative Fire of Artificial Intelligence

Across Sixty Years: The Creative Fire of Artificial Intelligence is exhibited by Taikang Art Museum. Spanning Sixty Years: The Creative Fire of Artificial Intelligence (Figure 2, center) is an exhibition on visual appreciation and knowledge acquisition created by artificial intelligence, robots, and computer art on display at Taikang Art Museum. Based on a structured visual appreciation process, the exhibition is divided into three narrative units.

In the first unit, "History", the audience can visually appreciate the works of the pioneers in the field of art and technology from the 1950s to the end of the 1990s. In this exhibition area, the audience only needs to visually appreciate these exhibits, and through the understanding of these artistic pioneers, combined with today, the spark of the combination of modern technology and art in the past 60 years.

In the second unit," In the part of "Education", the audience's appreciation purpose is to provide the audience with background visual/text information about the history and technology involved in digital art through visual exploration scenes, to provide knowledge reserves for fellow travelers in the AI era before opening, and to provide rich content for the audience with existing knowledge in related fields through focusing on generative art and algorithm design. Understand this area and move on to the next area.

The third unit, "Contemporary," is robot art by renowned international and Chinese artists. Interactive artificial intelligence and computer vision art as well as large projection of generative art. The purpose of this section is to show us the cutting edge of contemporary AI-driven art practice, as well as to explore the future world within reach of all of us.

3.2.3 Artboost and Youxi · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition

Artboost and Youxi · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition (Figure 2, right) Artboost and Youxi · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition," In the future, Artboost × the first 7 environment ·AI Art exhibition "realized the deep dialogue and communication collision of" AI, art, life, science and technology and beauty ", and the exhibition displayed 76 artworks by 7 AI artists from different fields, different life backgrounds and different professions, showing visual visual AI art works with different focuses. Through watching this AI exhibition, the audience learned that Artboost, an AI creation tool for professional design, is committed to leading the innovation of the design industry through AI. Whether you need a quick idea or a detailed design, Artboost provides comprehensive support. This visual display of the visual performance of AI technology provides a powerful and accurate creative tool for working to understand AI art exhibitions, while assisting designers to break traditional design boundaries and explore endless innovation possibilities. The audience learns more about AI technology and also becomes a way to understand the development of advanced technologies in the world.

3. 3 Exhibition appreciation methods and visual behavior indicators

As discussed, the exhibition approach includes visual learning information; Therefore, the audience's behavior can be identified as interactive learning behavior and visual behavior. In order to determine interactive learning behavior, various indicators can be used depending on the type of exhibition and mechanism (e.g., exhibition time, number of exhibits, exhibition level). "Near - Fighting Beijing Opera Art Exhibition Space" is a knowledge learning exhibition mode, requiring the audience to have a certain understanding of Beijing Opera, build knowledge and solve questions, and gain certain harvest after watching the exhibition.

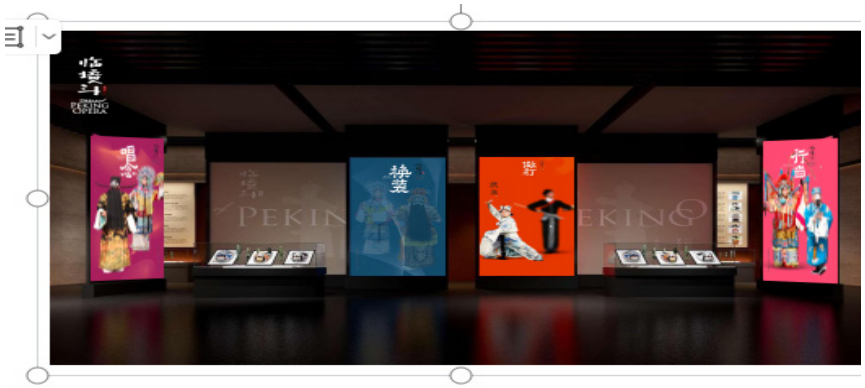

Figure 3:In the quadruple screen, several objects representing knowledge items are displayed in each screen of the information screen (for example: Sheng, Dan, Jing, end, ugly behavior). The objects of these knowledge screens are the AOI of our study, because the Peking Opera Theater provides meaningful information about Chinese Peking Opera when they are collected.

See the last exhibition area within a certain time. The Interactive Space of Peking Opera Media Art is an exhibition that requires the audience to acquire knowledge and experience a certain hobby and understanding of Peking Opera. "Across Sixty Years: The Creative Fire of Artificial Intelligence" is an exhibition popularizing the process of technological and artistic appreciation and digital development, in which the audience participates in the creative process of robots, artificial intelligence and computers, and is also a process of aesthetic experience and knowledge acquisition. All exhibitions include the effectiveness of knowledge acquisition; Therefore, the main indicator of exhibition appreciation is what knowledge is obtained from the exhibition. With respect to visual behavioral indicators, we focus on points of interest, which are the focused gaze points in visual exploration and appreciation behaviors, in research exhibitions. When an individual's eyes remain aligned with the target for a period of time, fixation points/points of interest are formed, which allows for better processing of the details of the visual scene. Taking into account the nature of each exhibition and following regular exhibition habits, visual behavior indicators include the number of knowledge items looked at and the length of their gaze. Each knowledge item provides information about the culture presented in the exhibition and is therefore crucial to the knowledge acquisition process, as the audience gathers information about the various cultures by appreciating and learning from the items on display. For example, in the Interactive Space of Peking Opera Media Art, there is an exhibition area that represents the deconstruction of the artistic connotation of Peking Opera, the reconstruction of its costume, and the combination of modern technology, so that the experience can have a deeper understanding of the costumes of the characters. The exhibition area relies on digital technology to conduct virtual fitting experience in the physical space, and personify Peking Opera actors to deeply understand the artistic charm of Peking Opera. It integrates motion capture technology, face tracking technology and motion sensing interactive technology. By recognizing the face and actions of the experiencer, and giving real-time feedback on the screen, the character's face and the overall dressing process are completed. Therefore, in our study, the knowledge setting of each exhibition area is treated as an area of interest, where the eye tracking indicators

discussed are applied. For example, in Figure 3, we show three such areas of interest in “Linjing - Fighting” Peking Opera Media Art Interactive Space.

3. 4 Visitors

149 participants were recruited (“ Linjing - Fighting “Peking Opera media art interactive space: N= 59; Spanning six decades: The creative Fire of Artificial Intelligence: N= 47; Artboost and Youxi · Silent Art Hotel jointly presented the first 7 Environments ·AI Art exhibition: N= 43), with different ages and genders (Table 2), recruited 17 participants, but due to difficulties in calibrating or recording eye tracking (LinJing-Dou “Peking Opera media Art interactive space: N= 6; Spanning six decades: The creative Fire of Artificial Intelligence: N=4; Artboost was removed after co-presenting the first 7 Realms ·AI Art Exhibition with Drama · Silent Art Hotel: N= 7). To determine whether participants were FD or FI, we used the Group Embedded Graph Test (GEFT) tool, the original FD-I elicitation tool. GEFT is a time-limited tool that consists of a series of pattern recognition tasks of varying complexity, requiring visitors to recognize and identify basic patterns in complex exhibition image information.

Do curators’ decisions related to visual activities affect knowledge acquisition in digital art exhibitions?

Table 2:Demographic characteristics of study participants

Exhibition	Technology	FD-I union	N	sex	age	GEFT grade
Bordering-fighting” Peking Opera media art interactive space	MR technology	Beijing Printing Institute Beijing Opera Culture	22 24	8f/14m 9f/15m	23．08 ± 4.76 26．00 ± 5.74	8.58 ± 2.67 14.69 ± 2.02
			46	**17f /29 m**	24．60 ± 5.44	11.76 ± 3.86
“Spanning six decades: The creative Fire of artificial Intelligence	computer	Taikang Art Museum	23 22	10f/13 m 11f/11 m	27．32 ± 2.25 25．91 ± 3.82	7.82 ± 2.08 14.91 ± 2.23
			45	**21f /24 m**	26．71 ± 2.98	11.24 ± 4.20
Artboost and Drama · Silent Art Hotel jointly presented the first 7 Environment ·AI art Exhibition	AI arts	Theatre Silence Art HotelArtboost	18 18	8f/10m 6f/12m	29．58 ± 5.68 31．84 ± 4.81	8.05 ± 2.79 14.00 ± 1.81
			36	**14f /22 m**	31．10 ± 5.41	11.03 ± 3.81

The test consists of two main parts. Each section contained nine pattern recognition tasks that participants were given 10 minutes to complete. The score is calculated by adding the number of correctly identified patterns; Therefore, the score ranges from 0 to 18 points. The higher the score, the greater the subject’s FI value. Each participant underwent a GEFT test; Their scores range from 1 to 18 points (Table 2), and according to the Shapiro-Wilk normality test, they are normally distributed (“ Linjingdou “Peking Opera media art interaction space: p=.150; Spanning six Decades: The creative Fire of Artificial Intelligence: p=.119; Artboost and Drama · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition: p=.472). Each participant was classified as either the FD or FI group based on a cut-off value. This critical value is an average score (i.e. 11) and is widely used in practical applications. Thus, participants with a score of 11 or less were classified as FD, while those with scores between 12 and 18 were classified as FI. At this point, we should note that despite the limitations of the sample, the age range and gender distribution of the study

sample reflects the age range and gender distribution of most players. In addition, the GEFT score is comparable to that of the general public across demographic groups.

3.5 Programs

To test the null hypothesis, we conducted three experiments during the 6-month study (from September 2024 to March 2025), each consisting of seven phases: participant recruitment, cognitive style extraction, FD-I classification, pre-exhibition cultural knowledge collection, exhibition and post-exhibition knowledge acquisition, and data analysis.

Participant recruitment. We recruit study participants using a variety of methods, including personal contacts, email requests, and social media announcements, designed to attract people with diverse educational backgrounds, professional experiences, ages, and interests. Study participants had to meet at least the following minimum requirements: Never participated in GEFT; Over 19 years of age; Little or no knowledge of Peking Opera culture, artificial intelligence, computer art, AI painting; I've never seen anything like it; And the vision is up to normal standards. All participants were informed of the study content and signed their own informed consent. At the same time, he promised not to disclose the content of the test for six months.

Cognitive style extraction. We arranged cognitive style extraction conversation sessions suitable for the time of the test participants. At the start of each session, participants were asked to fill out a questionnaire about their demographic information before entering a researcher-led GEFT session that lasted 20 minutes. During the GEFT test, the instructions in the official scoring template regarding materials, test procedures and time limits are strictly followed.

FD-I classification. We analyzed the GEFT response and calculated the raw score for each test participant. Based on their raw scores, participants were classified as

During the scoring of the FD or FI (Table 2) GEFT test, we strictly follow the instructions on scoring in the official scoring template.

Pre-test knowledge: To measure an individual's knowledge of the context in which each exhibition item will be displayed, we followed a design approach based on a pre-test/post-test questionnaire.

Pre-test/post-test questionnaires were developed for each game. The questions in the questionnaire reflect the cultural knowledge information presented in the exhibition and the information provided during the exhibition (such as the information introduction of the exhibits). According to the order Alpha reliability analysis of questionnaires, these questionnaires have high internal consistency (" Linjingdou "Peking Opera media art interactive space: 867; Spanning six Decades: The creative Fire of Artificial Intelligence: 798; Artboost and Drama · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition: 815).

The experience of the exhibition is different, and each exhibition is using cutting-edge technologies that are more suitable for the development of The Times, aiming to improve the feasibility and efficiency of research. Therefore, in the use of mixed reality (MR) in the Peking Opera Media Art Interactive Space, for example: "The hats worn by Peking Opera characters are collectively referred to as" helmets "or" helmets ", and the teacher's veil model slowly appears, with transparency 100. "And the master towel is mostly carried by the military generals to create the momentum of handsome and powerful characters." The depth of the model appears, and the transparency increases, and the sound effect is matched with the word "mostly carried by the general". "Across Sixty Years: The Creative Fire of Artificial Intelligence" is highlighted in a demonstration of robotic sketching, during which the human model cannot see the painting in progress, only to see the robot alternating between observation and drawing action, sometimes pausing for a moment. "Artboost and Drama · Silent Art Hotel jointly presented the first 7 Environments ·AI Art Exhibition" is the use of AI creation tools: Artboost to produce AI painting works to improve the efficiency of designers, while broadening the creative horizon. We used Tobii Pro Glasses 2, which records eye movements at a sampling frequency of 50Hz. The fixation point is extracted by the Speed Threshold recognition (I-VT) al-

gorithm provided by Tobii.

There is no time limit for each test participant to visit. Study participants wore Tobii Pro 2 Glasses and completed the setup and calibration process described in the Tobii Pro 2 Glasses Manual.

To improve the quality of eye-tracking analysis, we set a threshold of 0.85 for gaze samples (calculated by dividing the number of correctly identified eye-tracking samples by the theoretical maximum), which is considered a good indicator of data quality. Data collected from participants who experienced difficulties during calibration or had a low percentage of gaze samples were excluded from the analysis. All test participants were explicitly informed of their choice when they visited the exhibition. Next, they visited the exhibition (MR Of the Peking Opera Media Art interactive space "Linjing - Fighting", robot sketching across 60 years: Creative Fire of Artificial Intelligence, and AI painting technology jointly presented by Artboost and Youxi · Silent Art Hotel in the first 7 Environments ·AI Art Exhibition).

Test post-knowledge. We used the apost-test questionnaire to measure the knowledge gained by each test participant after visiting a designated exhibition. Following common practice, post-test and pre-test questionnaires have similar questions. To avoid memory and bias effects, the post-test questionnaire was administered 2 weeks after the game session, an appropriate time to limit such effects. The test participants did not know that they would be asked to complete the post-test questionnaire.

Data analysis: We analyzed the collected data according to statistical methods to answer our research questions.

3.6 Research validity

Regarding internal validity, the study environment and study procedures remained the same for all test participants. Although the sample size is quite limited, the statistical test satisfies all the required hypotheses, as described in the following section. The age span and gender distribution of the study sample as described in Section 3.4 reflects the age span and gender distribution of the majority of the audience. Regarding the research tool, we used the GEFT test to classify individuals as FD or FI based on critical values. Considering that the GEFT test emphasizes cognitive differences on a continuous scale, it may not be possible to correctly classify individuals between the two endpoints using a threshold value;

Therefore, multiple studies use a third dimension called field mixing to characterize individuals with GEFT scores that are close to the average score of the study sample. However, in this literature, the dichotomy that takes the average score as the critical value is widely adopted. With regard to external effectiveness, it is worth mentioning that many cultural heritage exhibition activities are based on visual appreciation and project collection tasks.

Therefore, we expect that similar findings will be replicated in the context of different activities. Regarding the ecological validity of this study, the exhibition test session was rationalized with a time and date convenient for each participant. The laboratory was converted into an exhibition room, equipped with all the necessary technical resources (MR Mixed reality technology, robotic art, AI painting design technology, stable and high-speed Internet connection).

These devices are powerful enough to support the study without affecting the participants' experience, even if they perform poorly. Regarding mixed reality technology, none of the participants had ever used it before, so they had a quick demonstration of how to use the new technology. With regard to eye tracking devices, participants usually do not use such devices while watching the exhibition,

Do designers' decisions related to visual activities affect knowledge acquisition in digital art exhibitions?

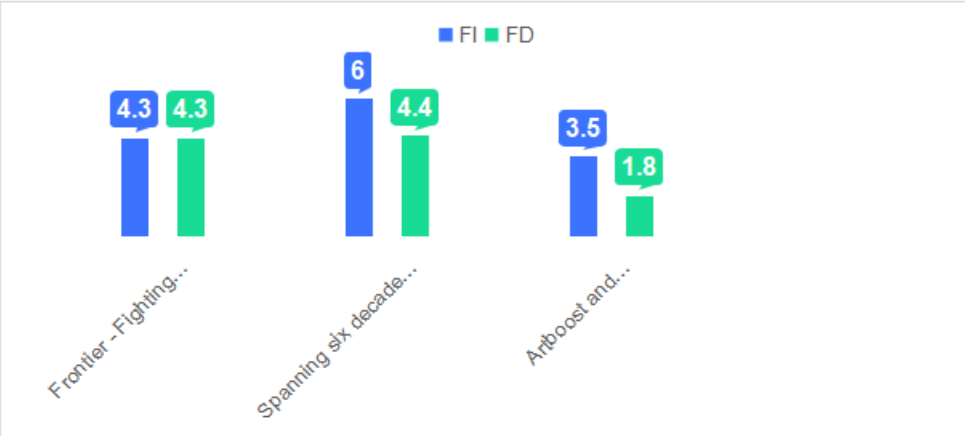

Figure 4: When the exhibition includes free visual appreciation tasks, FI field is dependent on more items than FD field is independent. When the exhibition is based on For structured visual appreciation tasks, we did not find any differences.

But the fact that the device is wearable glasses makes them feel more comfortable after a while because they can interact with the system as usual. At this point, we should mention that due to calibration difficulties or the poor quality of the gaze samples collected, we removed some participants from the analysis, which is discussed in Section 3.5. The research team conducted the study in accordance with the ACM Code of Ethics.

4.RESULTS ON THE EFFECTS OF FD-I

4.1 Effects of FD-I on visual behavior

To investigate H01, we performed statistical tests on indicators of visual behavior: the number and duration of gaze at exhibition objects. With regard to the number of gaze exhibits (Figure 4), we conducted an aMann-Whitney U test for each exhibition experiment. As assessed by visual inspection, the number of exhibition items viewed by FDs and FIs was similarly distributed. The results showed that in the Interactive space of Peking Opera Media Art, the median number of exhibits focused by FIs was significantly higher than FDs (10 vs. 8), (U = 178.400, z= -2.588, p =.008, r =.393). FIs looked at 9.637 ± 2.669 exhibits, while FDs looked at 7.664 ± 2.749 exhibits. For Across Sixty Years: The Creative Fire of Artificial Intelligence, the median number of items viewed by FIs was significantly higher than that of FDs (38 vs. 33), (U = 43.005, z= -3.783, p <.004, r=.628). FIs looked at 38.829 ± 3.444 items, while FDs looked at 33.447 ± 3.124 items. For “Artboost and Drama · Silent Art Hotel jointly present the first 7 environments ·AI Art Exhibition”, the audience needs to learn 9 AI painting production projects, so they are watching all the exhibition projects. Taking into account the fixed time of each exhibition item (Figure 5), we conducted an independent sample test for each competition. According to the procedure provided by Templeton, the fixed time values were standardized and each test satisfied the required assumptions. The analysis showed that when visiting the Interactive space of Peking Opera Media Art, FIs focused on game items significantly longer than FDs (FIs: 4.289 ± 1.671 minutes, FDs: 2.870 ± 2.033 minutes, t= 3.017, p=0.027, d=0.768), and also when visiting Across Sixty Years: The Creative Fire of Artificial Intelligence (FIs: 8.038 ± 2.022 minutes, FDs: 6.634 ± 1.049 minutes, t= 2.873, p=0.006, d=0.869), as well as when visiting Artboost and Drama · Silent Art Hotel to present the first 7 Environments ·AI Art Exhibition (FIs: 27.214 ± 4.149 min, fd: 23.615 ± 4.006 min, t = 2.628, p=0.017, d=886).

4.2 Influence of FD-I on interaction behavior

To investigate H02, we performed the Mann-Whitney U test (Figure 6) for each match, satisfying all the necessary assumptions. Analysis of the results showed that for Across Sixty Years: The Creative Fire of Artificial Intelligence, the median number of FI (8 items) was significantly higher than FD (7 items) (FI: 7.961±3.035 items, FD: 6.291± 2.597 items, U = 210.005, z = -2.004, p=.034, r=.294). For “Artboost and Drama · Silent Art Hotel jointly present the first 7 Realms ·AI Art Exhibition”, the median number of FI is significantly higher than FD (36 items), while FD’s median is 30 items.

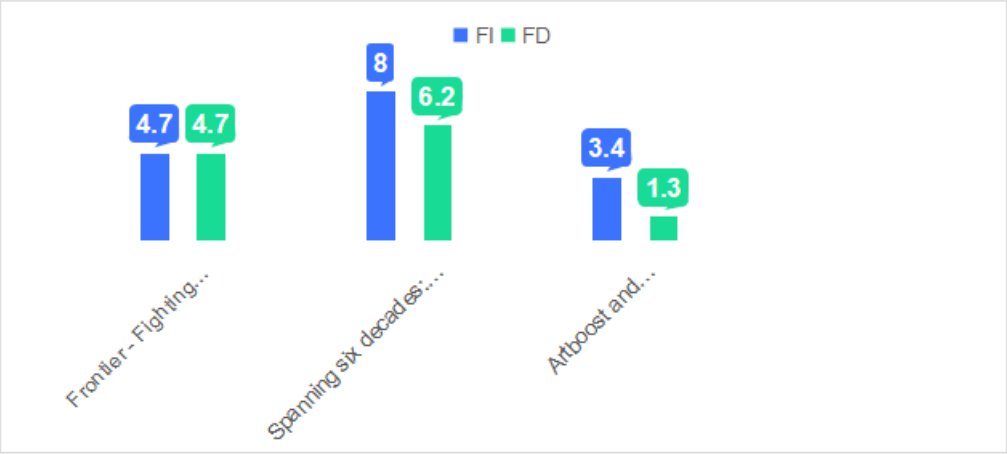

Figure 5: In the free and structured visual appreciation task, FIs focused on game items longer than FDs.

Indicates deeper visual information processing.

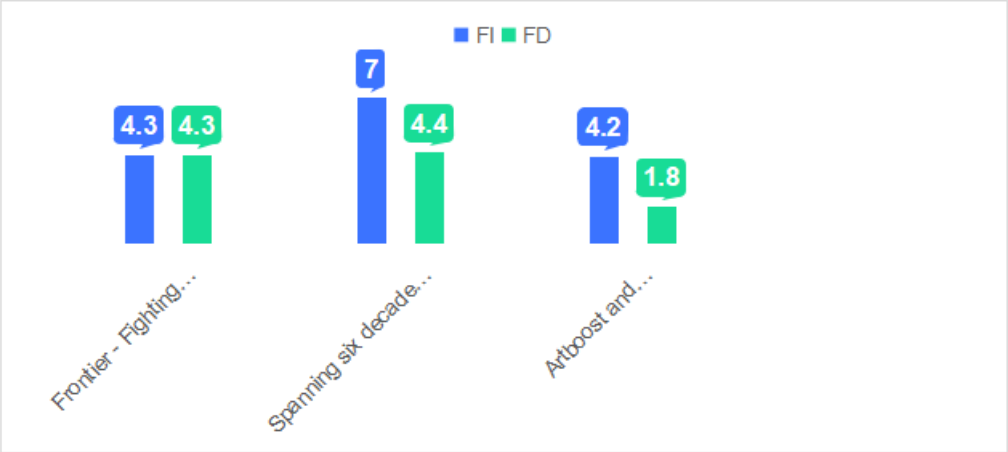

Figure 6:FI collects more items than FD when collecting items is not a mandatory requirement for the visiting method.

4.3 Influence of FD-I on knowledge acquisition

To investigate H003, we performed the Mann-Whitney U test (Figure 7) for each match, satisfying all the necessary assumptions. The analysis revealed that FI(7) had significantly higher median correct answers than FD(5) in Time Over Sixty Years: The Creative Fire of AI (FD: 5.582± 1.246 correct answers, FI: 6.434± 1.298 Correct answer, U= 209.499, z= -2.047, p=.038, r=.300). There was no significant difference in median correct answers between FI(5) and FD(5) for Artboost and Drama · Silent Art Hotel presenting the first 7 Environment ·AI Art Exhibition (FD: 5.164±1.089 correct answers, FI; 5.335± 1.068 Correct answer, U = 234.008, z=-4.48, p=.678). For The Holographic Journey, the median number of correct answers in FI(7) was significantly higher than that in FD(6) (FD: 5.732±0.896 correct answers, FI: 6.829± 1.228, U= 78.499, z= -2.710, p=.009, r=.457). Therefore, FI performs better than FD in the knowledge posttest of exhibitions based on the free visual search task, while there is no significant difference in the performance of exhibitions based on the structured visual appreciation task.

It is worth mentioning that as for each test participant's knowledge of the cultural background of the exhibition they are pointing to, according to the analysis of the answers to the pre-test questionnaire, both FDs and FIs showed low prior knowledge, which is expected. There were no significant differences between FDs and FIs in all the exhibition cases evaluated by the Mann-Whitney U test, which satisfied all the necessary assumptions (across six decades: The Creative Fire of AI: FIs: 401±.315, FDs: 538±.500, U= 297.008, z=.379, p=.708; Artboost and Drama · Silent Art Hotel jointly present the first 7 Environment ·AI Art Exhibition: FIS: 765±.620, FDs: 749 ±.726, U= 297.010, z=.174, p=.859; Beijing Opera media art interactive space: FIS: 1.0075 ±.856, FDs: 587±.466, U = 55.010, z= 1.341, p=.226).

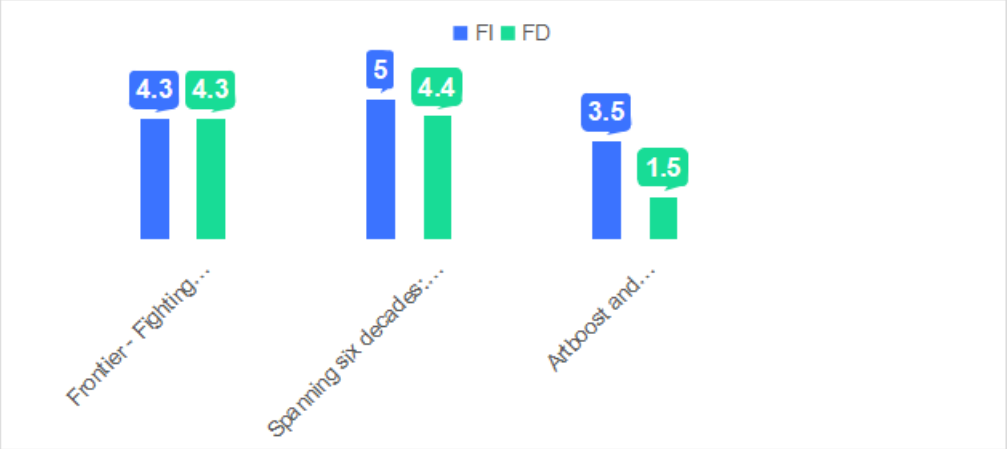

Figure 7:Pre-test and post-test knowledge acquisition (expressed in milliseconds of correct answers) for each exhibition. Before the test it was shown that individuals had the least background and cultural knowledge of each culture, while after the test it was shown that FI performed better than FD.

4.4 Correlation between visual behavior, interactive behavior and knowledge acquisition

To investigate H04, we performed a Pearson correlation test for each match, which satisfied all the required hypotheses. The results of each test (Table 3) are discussed below.

As for the Interactive Space of Peking Opera media art, there is a strong correlation between interactive behavior and knowledge acquisition (r=.571, p=.006). This means that the longer the audience stays with certain exhibits, the more correct answers they get on the post-test questionnaire. Knowledge acquisition is

also related to the visual behavior of the audience, as there is a moderate correlation between the number of fixations and the number of correct answers (r=.326, p=.025), and between the time of fixations and the number of correct answers (r=.305, p=.033). In addition, the more times and the longer the audience looked at the exhibition item, the more correct answers they got on the post-test questionnaire. In addition, visual behavior is closely related to interactive behavior, because the more times the audience looks at the exhibit, the more knowledge and information they acquire (r =.755, p =.006).

For Time Spans Sixty Years: The Creative Fire of Artificial Intelligence, there was a moderate correlation between viewer gaze time on robotics and computer art and knowledge acquisition (r=.329, p=.025). This means that the longer the audience looks at computer art, the more likely they are to answer correctly after the test, and the more they learn about artificial intelligence, generative art, robotics, and virtual reality.

With regard to Artboost and Drama · Silent Art Hotel presenting the first 7 Environment ·AI Art Exhibition, there is a moderate correlation between the information acquired knowledge and the number of exhibits watched (r =.338, p =.036), which means that the more exhibits viewed by the audience, the more knowledge acquired. In addition, there is a strong correlation between the amount of knowledge acquired and the number of correct answers after the test (r=.506, p=.001), which means that the more relevant information players acquire, the more likely they are to answer the correct answers to the questions after the test, and thus the more they understand the culture of AI painting technology.

5.INTERPRETATION OF RESULTS

The results discussed below correspond to the research model shown in Figure 1. Thus, they are presented through the interaction of human cognition and visual behavior, human cognition and interactive play, visual behavior and interactive play, and all factors on knowledge acquisition, as shown in Figure 8.

- Curators' decisions about visual appreciation tasks influence the visual behavior of FDs and FIs. FDs and FIs employ different visual strategies in playing free visual appreciation exhibitions (i.e. situations where users are expected to visually appreciate scenes and identify cultural assets but are not forced to). FIs is more focused on cultural game projects (Figure 4), and over a longer period of time (Figure 5) than FD;

Our findings reinforce and validate the results of other studies, as well as our research on the art of digital cultural exhibitions. This behavior is due to the analytical nature of FIs and their ability to visually identify details from the surrounding environment, as they tend to adopt a deeper visual appreciation, scanning the large layout of the exhibition environment. More prolonged gaze means better memory, greater amount of information extracted and accumulated, and attention in visual appreciation tasks. Given that FI is more efficient at retrieving items from memory) than FDs, the fact that they generate more and longer fixations on key display items helps them pay more attention and better understand the information provided for each culture.

Game designers' decisions about visual search tasks affect the game behavior of FDs and Fls. FDs and Fls follow different gameplay (Figure 6)

When exhibiting free visual appreciation tasks, FIs gather more information than FDS because they follow an analytical approach. Fis have an inherent skill in recognizing key visual information because they tend to focus on detail and can easily distinguish it from their surroundings. When looking at the free visual appreciation exhibition, FI is interested in discovering the curatorial scheme, which is the result of their tendency to develop self-deconstructing goals and execute independently outside of the given rules. However, FDs does not interact with many exhibition items when access to knowledge information is not necessary to complete viewing the exhibition. This may be because FDs tends to adhere strictly to the guiding principles and objectives of the exhibition (e.g., entering the last section to receive the seal); As a result, FDs collect fewer items than FIs because this is not your main goal in the exhibition, and they take a holistic information search approach.

The visual behavior of FDs and FIsi influenced their interactive behavior, and in the free visual apprecia-

tion task, the user's visual behavior influenced their interactive behavior (Table 3).

The more knowledge items they focus on, the more project information they gain as they interact with the items that capture their attention. In addition, the longer the audience looks at an exhibition item, the more likely they are to interact with it and acquire its cultural information, as increased gaze time indicates greater concentration and attention. Therefore, the curators decided to include knowledge items that would attract the audience's visual attention for a long period of time, influencing their interactive behavior and helping them gain access to a wider range of knowledge information, resulting in increased access to cultural knowledge and implying better learning outcomes.

Both visual and interactive behavior had an impact on knowledge acquisition in the cognitive style group, but Fls inadvertently favored knowledge acquisition in the free visual appreciation and immersion exhibitions. In the free visual appreciation game, F learned significantly more about ancient civilizations than FDs, because they answered more post-test questions correctly (Figure 7).

Users' performance in the post-test was affected by interactive and visual behaviors (Table 3). The inclusion of free visual appreciation tasks in design decisions, and the inherent difficulty of FDS in recognizing simple details in complex visual environments, lead FDS to focus on collecting fewer critical knowledge items, which hinders their acquisition of knowledge and ultimately affects learning benefits.

6.DISCUSSION AND REVELATION

Our findings suggest that specific design decisions associated with digital visual activities inadvertently influence interactive behavior and thus knowledge acquisition for individuals with different cognitive characteristics. Considering that the increasing use of digital technologies in the field of art and culture exhibitions makes the evaluation process necessary, such evaluation studies, such as the one described here, take into account the multidimensional nature of the field of art and culture and the cognitive characteristics of its users (such as visitors) to guide the research to explore undiscovered paths. Taking human cognition as an evaluation factor reveals the root cause of unbalanced knowledge acquisition when performing cultural and art exhibition activities involving information processing tasks. Therefore, evaluators should consider the individual cognitive characteristics of visitors when conducting cognitive-centered assessment, which can help them better evaluate the objectives of cultural and art exhibition activities.

Returning to the assessment studies discussed in this article, if our party had used FD-cognitive style as an assessment factor, we might have observed average knowledge acquisition in free visual viewing tasks, but could not understand the root cause of the observed results. This can lead not only to inaccurate interpretations of research findings, but also to faulty design recommendations and guidelines (for example, avoiding free visual appreciation tasks). By using cognitive characteristics as assessment factors, we reveal new dimensions of individual diversity through factor analysis and gain a deeper understanding of why activities meet (or fail to meet) their goals.

A "one size fits all" approach is not the best way to deliver meaningful cultural experiences to the end audience. Through cognitive-centered assessment, cultural heritage stakeholders will not only be able to identify differences in knowledge acquisition among users with different cognitive characteristics when interacting with cultural heritage resources, but also understand the reasons behind these differences and better interpret them. Cognitive-centered assessments therefore point to the importance of considering how the type of task (e.g., free or structured modes of visual appreciation) better fits each exhibition environment and user cognitive characteristics, especially within the field of cultural exhibitions. However, in some cases, an imbalance in knowledge acquisition may be related not only to the visualization of the content or the type of task, but also to other factors, such as the content itself. For example, for those who process visual information more effectively than verbal information (such as visual-linguistic cognitive styles), content should be provided in graphical form; For those who process verbal information more effectively than visual information, of course, the content should be provided in text form. Activity types should also be con-

sidered as evaluation parameters because different types of activities benefit individuals with different cognitive characteristics. It is worth mentioning that the effects discussed apply not only to digital art cultural exhibitions, but also to cultural heritage activities that include information processing tasks, such as virtual Tours and guided Tours, which have also been shown to be influenced by cognitive characteristics. In addition, in our study, we only focused on visual interaction; However, cultural heritage activities can also include audio - and space-based interactions, such as storytelling and location-aware applications. Therefore, it is necessary to investigate whether other cognitive characteristics, such as auditory cognitive style, affect the audience's behavior and experience in such situations. The lessons learned from our research are as follows:

Cognitive-centered digital culture exhibition activities and resource evaluation help us better understand the underlying causes of different behavior patterns among individuals with different cognitive characteristics.

Cognitive-centered evaluation connects information processing methods (e.g., visual information seeking, information understanding) with different aspects of human cognition (e.g., style, skills) to help us effectively evaluate the final audience experience and suggest ways to improve it based on the audience's cognitive preferences and needs.

The evaluation of the Cognitive Center points out the importance of considering the type of task (e.g. free or structured visual search) that is more appropriate to the context of each exhibition project and the cognitive characteristics of the audience in the field of cultural heritage.

The cognitive-centered evaluation takes into account all aspects of digital cultural heritage resources, as it is closely related not only to the types of tasks, but also to the mechanisms of visualization, types of high-level activities, modes of interaction, etc.

Cognitive-centered assessment contributes to a deeper understanding of the importance of the assessment process and its necessity, aiming to have a better impact on the short - and long-term experience of the end audience. This is especially important given that cognitive traits, such as cognitive styles, rarely change over a person's lifetime.

In human-centered curatorial design, evaluation is used to drive the optimization of design or information systems. Therefore, we assess that the interpretation of research results can lead to the formation or optimization of specific recommendations and rules for designing and adapting cultural heritage activities to support the diverse information processing needs of audiences with different cognitive characteristics and to best serve their information understanding and knowledge acquisition. Focusing on the FD-I cognitive style, FDs has difficulty recognizing details in complex visual environments and therefore may miss valuable information when performing free visual appreciation tasks. Therefore, in activities based on free visual appreciation tasks, the system should be designed to help FDs acquire such information. This can be achieved by employing a variety of techniques: a focus on a specific area of interest, which can be applied when the FD user approaches a knowledge item within a predetermined distance.

Considering that FDs benefits or has a significant effect when information is provided in light color recolor, such alternative visualizations can be provided for event items/areas that provide critical information about the civilization/culture that the event is showcases.

In order to increase gaze time and focus the viewer's attention on key areas of interest, the entire scene can be blurred, except for known knowledge items. Blurring effects is a sufficient technique to keep the audience

The system can support a sequential dual-track approach for supporting both structured search and free appreciation tasks. In this approach, all tasks are initially based on structured viewing until a certain threshold is reached. This threshold can be a collection of specific items, a collection of a predefined number of items, and so on. Once the threshold is exceeded, the task transforms into a visual free-viewing task designed to stimulate the user's sense of self-efficacy and autonomy, thereby facilitating the knowledge acqui-

sition process.

- In project collection activities, some items are important for users to build knowledge, while others are complementary. Therefore, the collection of important items can be based on structured search, while the collection of complementary items can be based on free search.

Thus, the evaluation studies reported in this paper provide insights into which mechanisms enable users with different cognitive characteristics to better meet activity goals. Considering that certain types of tasks may not benefit users with specific cognitive characteristics, appropriate assistance mechanisms can be introduced to ensure that the audience finds the intended content. In order to support these diverse mechanisms, cultural and art exhibitions should provide adaptive interventions aimed at specific cognitive characteristics to enable personalized access to cultural information. Cultural heritage activities should be adapted to the cognitive characteristics of each user. This adaptation can be achieved through the use of different technical means. Following a rule-based adaptation approach, rules implement visual information functions and content presentation mechanisms, tailored to the cognitive characteristics of the audience. These rules are derived from studies like the one reported here. For example, in a free visual appreciation task, recolor or highlight effects can be applied to knowledge items while the FD user performs the activity. Cognitive-centered assessments thus construct rule-sets that can be used to accommodate the unique cognitive preferences and needs of cultural activities.

Given the nature of the field of cultural and art exhibitions, many visitors are considered first-time visitors because they are interacting with digital cultural heritage resources for the first time (and possibly the only time in their lives). We note the importance of runtime and dynamic adaptation of cognitive-focused interventions in digital cultural heritage activities. In order to provide this run-time cognitive center personalization activity, it not only ADAPTS to the cultural heritage activity at run time (which has been adequately addressed in other works in the field of cultural heritage), but also acquies the user's cognitive characteristics (e.g. cognitive style) in real time at the initial stage of the activity, when the audience experience is not yet fully formed. To adapt the content and seamlessly, ensuring that the adaptation mechanism does not affect the established user experience. Given that current extraction tools (such as GEFT) are not suitable for runtime adaptation because they are based on explicit and time-consuming processes that require manual work, we can use eye tracking methods to implicitly reveal the cognitive characteristics of the audience in the early stages of the exhibition, as our research shows that there is a correlation between visual behavior and cognitive characteristics. This revelation can be done at the tutorial level before the audience begins to play the cultural heritage game, so as not to affect the viewing experience.

Finally, the high-level implication of our study is that a cognitive-centered framework must be adopted for design and evaluation purposes. The framework inspires, stores and maintains cognitive-centered user models through implicit extraction and cultural activities based on the output of recommendations and rules from evaluation studies, as described here, with the aim of providing each visitor with an optimized personalized cultural heritage experience. A cognitive-centred framework will help evaluators effectively evaluate digital cultural heritage exhibition activities, resulting in a better understanding of end-user interactions and highlighting differences in information-seeking approaches that can lead to imbalances with the objectives of the activities; Designers are able to create personalized cultural heritage activities that meet the unique cognitive characteristics of end users; As a result, the audience will have a better experience, a deeper understanding of the information presented, increased knowledge acquisition and, ultimately, improved learning benefits. Taking into account the involvement of multiple stakeholders in the field of cultural heritage (e.g., visitors, evaluators, designers, curators, institutions), the Cognitive Centre framework is expected to be able to identify the needs and interests of each stakeholder in the ecosystem, as well as the interdependencies, and to provide the most appropriate and impactive cultural heritage activities.

Do curators' decisions about visual activities affect knowledge acquisition in digital art exhibitions

Table 3:Correlation matrix

		"Bordering-fighting" Peking Opera media art interactive space		
Measurement Type (3) (4)	Indicators	(1)	(2)	
1Visual behavior	fixed number of exhibitions	1		
2	Fixed time	r=. 182 P= . 212		
3 Interactive behavior	acquisition knowledgeevaluation	r= .753 p= .003**	r=. 132 P= . 360	
4Knowledge to obtain	the correct answer numbe	r = .324 p = .022*	r = .301 p = .034*	r = .571 p = .006** 1
		Spanning six decades: The creative Fire of artificial Intelligence		

Measurement Type	Indicators	(1)	(2)	(3) (4)
1Visual behavior	fixed number of exhibitions	1		
2	Fixed time	n/a 1		
3 Interactive behavior 4Knowledg e to obtain	acquisition knowledge evaluation	n/a	n/a 1	
	the correct answer numbe	n/a r=. 331n/a 1 p=.028*		
			Artboost and Youxi Mo Art Hotel jointly presented	

			the first 7 environme nt AI art exhibition	
Measurement Type	Indicato rs	(1)	(2)	(3) (4)
1Visual behavior	fixed number of exhibitions	1		
2 3 Interactive behavior 4Knowledg e to obtain	Fixed time	r=. 1353		
	acquisition knowledge evaluation	P= .424 r= .147 p= .028* p= . 592	1	
	the correct answer numbe	r= .734 r= . 179 r= .505 p= .086 p= . 297 p= .002** 1		

The correlation was significant at the 0.05 level (two-tailed).

The correlation is significant at the 0.01 level (2-tailed).

n/a. Since at least one variable is a constant, it cannot be calculated.

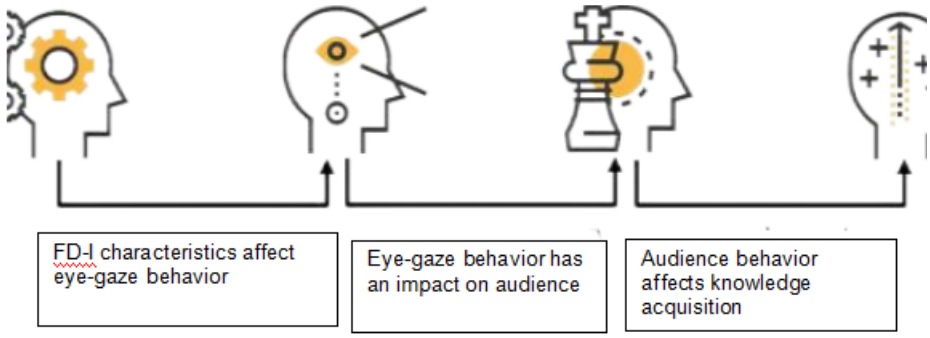

Figure 8: Players' perception of FD-I characteristics influenced their visual and game behavior, and thus had an impact on the knowledge acquisition process.

7.CONCLUSIONS

In this paper, we assess whether and how the decisions of different curators regarding visual appreciation activities affect the acquisition of knowledge in digital art exhibitions, adopting a human cognitive perspective. We conducted three intersubject eye tracking user studies. A total of 149 participants were classified as either FD or FI based on their performance on the GEFT. For each study, participants were divided into two groups according to their cognitive style and visited several popular digital art exhibitions (" Linjing - Fighting "Peking Opera Media Art Interactive Space" : N= 59; Across Sixty Years: The Creative Fire of Artificial Intelligence: N=47; "Artboost and Drama · Silent Art Hotel jointly present the first 7 Environments ·AI Art Exhibition" N=43).

Quantitative analysis shows that curators' decisions about visual search favor FI, while hindering FD's knowledge acquisition. In particular, in free visual viewing tasks (that is, tasks in which the audience visually explores the scene and interacts with the item without being forced by activity rules), FD and FI take different approaches to processing visual information, leading to unintentional knowledge acquisition imbalances.

However, in a structured visual search task (where the rules of the event force players to visually search and collect a specific number of items), there is no understanding of the knowledge imbalance between FD and FI, as all viewers are required to view the same display items and thus access the same level of critical information.

The findings highlight the impact of human cognition on viewing visual information in the context of digital culture and art, and the need to support individuals with specific cognitive characteristics, such as FDs, to engage in interactive activities including information search and understanding tasks. Stakeholders of cultural heritage should consider the cognitive characteristics of individuals during the design and evaluation phase, aiming to provide audiences with personalized access to cultural information and help them enhance learning benefits and experiences. We envision that cognitive-centered personalization mechanisms can be used by stakeholders of digital cultural arts to adapt to cultural experiences.

Do curators' decisions related to visual activities affect knowledge acquisition in digital cultural art exhibitions?

Cognitive characteristics of the audience (e.g., museum visitors). This personalization mechanism will alleviate the observed imbalance and help audiences improve knowledge acquisition when participating in digital cultural and art exhibitions. Given that we are moving toward more immersive technologies (e.g., mixed reality), we expect this cognitive-focused personalized experience to further help users, as these technologies have been found to amplify the effects of cognitive differences.

REFERENCES

Cao, Qinghui. (2020). Digital exhibition Resources (2010 - 2019) and Research trends of Chinese Modern Art. Fine Arts, (06).

Chai, Xiujuan, & Cao, Hui. (2004). Related theories and Cognitive Context view. Journal of Zaozhuang Normal College, (04).

Efi, Nisiforou, & Laghos, Andrew. (2016). Field dependence - Independence and eye movement patterns: Investigating user differences through eye tracking studies. Interacting with Computers, 28(4), 407 - 420.

Feng, Liyuan, & Ding, Gege. (2023). Research on Dynamic Design of Art Exhibition Based on digital media. Contemporary Artists, (04).

Feng, Yajie. (2023). The decentralized narrative Logic in Chinese contemporary Digital Art Exhibition. China National Expo, (22).

George E., Laptis, Christos A., Fidas, & Nikolaos M., Avoris. (2016). Differences between dependent/ independent players in cultural heritage games: Preliminary findings from the Eye tracking study. In M. Ioannides, E. Fink, A. Moropullo, M. Hagedorn - Sope, A. Freisa, G. Liestøl, et al. (Eds.), Digital Heritage: Progress in the Recording, Protection and Preservation of Cultural Heritage (pp. 199 - 206). Springer International Publications.

George E., Laptis, Christos A., Fidas, Cristina, Cazini, & Nikolaos M., Avoris. (2018). Cognitive - oriented personalization framework to realize the personalization of cultural heritage content. In Extended Summary of CHI Conference 2018 on Human Factors in Computing Systems (CHIEA '18) (Article LBW011). ACM.

Han, Yali. (2015). The integration of Science and Technology and Art -- Comments on the exhibition "The Story behind Digital Art". Journal of Tianjin Academy of Fine Arts, (08).

Huang, Guanghui, & Zhen, Wen. (2024). Thinking on the Digital Narrative Paradigm of Contemporary Art Museum Exhibition. Journal of Nanjing University of the Arts (Fine Arts and Design Edition), (03).

Jia, Wenhan. (2021). The Return and transcendence of immersive art exhibitions in the era of digital media. Art Review, (23).

Ju, Yao. (2023). Recent Situation and Reflection on the development of digital art exhibition mode -- Taking media art promotion exhibitions and activities as an example. Television Research, (11).

Joseph R., Fanfarelli, & Rudy, McDaniel. (2015). Individual Differences in Digital Badges: Do Learner Characteristics matter? Journal of Educational Technology Systems, 43(4), 403 - 428.

Li, Dingkai, Du, Ping, & Liu, Tao. (2021). Emergency map design considering user visual processing. Science of Surveying and Mapping, 46(12).

Li, Mingjia. (2015). Cross - border design of digital media in Museum art exhibition. News Front, (24).

Li, Min. (2008). Research on Semantic Processing of Information resources from a cognitive Perspective. Library Work and Research, (06).

Maria, Economou, & Laiapujl - Tost. (2011). Evaluate the use of virtual reality and multimedia applications for demonstrating the past. In Handbook of Technical and Cultural Heritage Studies (pp. 223 - 239). IGI Global.

Maria, Kozhevnikov. (2007). Cognitive styles in the context of modern psychology: Towards a comprehensive framework of cognitive styles. Psychological Bulletin, 133(3), 464 - 481.

Ming - Shiunn, Huang, & Brian, Byrne. (1978). Cognitive style and lateral eye movement. British Journal of Psychology, 69(1), 85 - 90.

Richard, Riding, & Indra, Cheema. (1991). Cognitive style -- Overview and integration. Educational Psychology, 11(3 - 4), 193 - 215.

Robert, Zheng. (2010). The influence of situational learning on students' knowledge acquisition: An individual difference perspective. Journal of Educational Computing Research, 43(4), 467 - 487.

Song, Yiqin, & Yu, Jing. (2017). Research on the influence of Chinese contemporary art curators on contemporary art exhibitions. Popular Art, (11).

Tze Wei, Liew, Su - Mae, Tan, & Rouzbeh, Seydali. (2014). The effects of learners' field dependence

and personalized narration on learners' computer perception and multimedia learning task - related attitudes. Journal of Educational Technology Systems, 42(3), 255 - 272.

Wang, Xue. (2021). Application Research of Digital Interactive Technology in Contemporary art Exhibition. Chemical Fiber and Textile Technology, 50(12).

Wu, Jian. (2022). A New mode of presenting cultural heritage digital art: Taking digital Dunhuang exhibition concept and visual communication as an example. Art Review, (10).

Yang, Hong, Yan, Han, & Tang, Jiayue. (2024). From "Visual Immersion" to "Data Immersion" : Value characteristics and iterative trends of digital exhibitions: A case study of the urban Digital exhibition "Portrait of Life in New York". Journal of Nanjing University of the Arts (Fine Arts and Design Edition), (03).

Zhang, Yizhi, & Huang, Jiancheng. (2020). Logical strategy and Design translation of virtual digital Exhibition: Taking the Online Graduation Exhibition of Global art colleges in 2020 as a clue. Art Design Research, (05).

Zhang, Hao. (2008). Discussion on the development process of Visual Culture. Audio - visual Education Research, (04).