Research on Analysis and Spatial Optimization of Museum Visitor Experience Empowered by Digital Intelligence

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ABSTRACT

With the deep integration of digital intelligence technology,the exhibition space design and visitor experience optimization of smart museums have become the core issues of common concern to the academic community and the industry. This study breaks through the perspective of a single discipline, innovatively integrates museum science, psychology, design and communication theory, introduces the SOR (Stimulus-Organism-Response) theoretical framework, constructs a four-dimensional linkage model of "technology-space-psychology-behavior", and systematically analyzes the formation mechanism and spatial optimization path of museum visitor experience under the empowerment of digital intelligence. This study not only expands the application boundaries of SOR theory in the field of cultural heritage, but also proposes the core design strategy of "technology embedding needs to serve cultural narrative", which provides a practical paradigm of "experience first"for the digital intelligence transformation of museums, which is of academic innovation and industry reference value.

Keywords: digital intelligence empowerment; visitor experience; spatial optimization; SOR theory; mediating effect; museum;

1.Introduction

As a guardian of cultural heritage, museums carry the mission of protecting and displaying human history, art and scientific achievements , and have played a positive role in acting as a booster for local economic development. In the age of intelligence, "digital intelligence empowerment" has become a hot topic in various fields, and museums are no exception. The development of digital intelligence technology has brought opportunities and challenges to museums. While providing a wealth of display methods, it has also put forward new requirements for museum exhibitions to ensure that visitors can get a good experience during the exhibition .

2.Museum Visitor Experience and Exhibition Spatial Optimization

The museum visitor exists in two types: obvious visitor and potential visitor, with diversity and learning. The use of digital technology and intelligent means to bring a positive impact on the museum visitor experience belongs to the category of museum "digital intelligence empowerment". The Turpan Museum and China Grand Canal Museum have been successful cases in optimizing the effect after digital intelligence empowerment for the exhibition. For example, the technological sense of the Turpan Museum's digital exhibition hall and the zero-distance contact between the online digital platform and the visitor "cloud" show a new form of cultural experience; the visitor gets various feelings and impressions such as emotion, cognition and aesthetics during the visit to the museum. The China Grand Canal Museum restores the immersive experience of the 20-meter-long 1:1 sand spaceship, and conducts big data

analytics on visitor flow, behavioral paths, and interest preferences to optimize exhibition layout and services to enhance visitor participation. The intervention of digital technology not only reconstructs the narrative of the museum, but also deepens the visitor's culture and experience through emotional resonance and cognitive interaction.

(1)Research on Museum Visitor Experience

A representative study on improving the museum visitor experience by means of digital intelligence, in which Zhou Jingjing (2021) re-understood the concept of "visitor-centered" in the museum, emphasizing the importance of museum visitor experience; Zhang Fan (2024) and other scholars have studied the immersive experience design of museums, pointing out that immersive experience is an important strategy to enhance the visitor experience. The four-dimensional experience model proposed by the Smithsonian Institution and the "learning context model" and "visitor experience model" proposed by Falk et al. provide an important framework for the complexity of the visitor experience. Existing models focus on cognitive and emotional dimensions, but ignore the synergy effect of technology-space-psychology. This paper makes up for this deficiency by introducing the SOR framework. Gu Yingkang (2023) and other scholars have provided an important reference for this paper to improve the museum visitor experience through the research results of cognitive experience, physical experience and social experience.

(2)Analysis of the Optimization of Museum Exhibition Spaces

Hang Jinfeng (2020) conducted research on the integrated design of the spatial composition and exhibition modes of museums, and proposed design strategies such as the integration of spatial circulation lines and exhibition structures, as well as the functional combination of spaces and exhibitions . The author believes that, on the basis of functionality and practicality, the physical space of a museum should focus on the conveyance of emotional experiences and cultural connotations. In a cultural space that combines movement and stillness, visitors can feel the vitality and charm of the exhibitions. Lin Deqi (2024), based on experience and perceptual judgment, carried out an investigation and research on elderly visitors to the Palace Museum. It was found that elderly visitors tend to choose classic visiting routes, and the results of this study still need to be supported by scientific empirical studies. Guan Hong (2024) conducted research on the design strategies of digital media exhibitions in museums based on visitors' experiences in the new media era, and proposed design strategies such as the scientific and appropriate application of digital media, strengthening online services, and optimizing the software and hardware facilities in exhibition halls.

3.Variable Influence Relationships

A smart museum differs from ordinary leisure and entertainment spaces; it is a hyperlinked technological field that combines knowledge-based, educational, heritage-preserving, and experiential functions . Based on previous research, this paper identifies dimensions such as personalized interactive experiences, digital technology exhibitions, public psychology, and spatial dimension exhibitions as variables for study.

Personalized interactive experiences can attract visitors to engage more deeply with exhibition content, triggering them to perceive that their viewing needs and interests are valued by the museum. This interactivity helps maintain visitor attention and increases their level of engagement with museum exhibits . Through personalized interactions, visitors can establish connections with others sharing similar interests, thereby forming social circles. Such social interactions also contribute to visitors' sense of identity. Additionally, personalized interactive experiences enhance visitor loyalty to the museum brand or content creators: when visitors feel their needs are met, they are more likely to return and recommend the museum to others.

The hypothesis regarding the role of spatial dimensions in exhibitions posits that the layout, design, and spatial planning of museum exhibition spaces can facilitate visitor comprehension of exhibition content while fostering stronger identification with it. This includes integrating interactive elements, multisensory

experiences, or guided tours/recommendations to immerse visitors more deeply in the exhibition environment . Exhibition space design also enhances navigational clarity, enabling visitors to easily locate content or themes of interest and traverse the displays with greater ease.

Digital technologies enable museums to offer more personalized and interactive exhibition approaches, allowing visitors to explore content according to their interests and pace. Through digital guidance and interpretation, visitors gain deeper insights into collection information and establish emotional connections with exhibits, thereby enhancing visitor identification . Virtual reality (VR) and augmented reality (AR) technologies simulate diverse historical or cultural environments, helping visitors better understand different cultures and eras while strengthening their identification with exhibition content. Through digital interactions, visitors can actively engage with exhibition content rather than passively consume it.

When visitors perceive alignment with public psychology or social trends, they establish a sense of identity. This identity stems from sharing similar beliefs, values, interests, etc., with others . Public psychology influences visitor sense of direction: when visitors feel congruent with popular trends, they more readily form emotional connections, thereby strengthening their sense of identity. It also impacts visitor participatory experience, meaning visitors are more likely to actively engage in or invest in activities/events aligned with public psychology (Li Zhaobin, 2017). Public psychology plays a vital role in cultural contexts, shaping individual identity, participatory experience, and sense of direction.

In the paper "Exploring the Key Drivers of User Continuance Intention to Use Digital Museums: Evidence From China's Sanxingdui Museum," the authors constructed 14 hypotheses to demonstrate the impacts of user continuance intention toward digital museums and other variables. Their research findings enriched relevant academic theories and exerted a significant impact on this study. Based on the above inferences, this study proposes hypotheses H1~H16.

H1: personalized interactive experiences influence visitor sense of direction.

H2: personalized interactive experiences influence visitor sense of direction.

H3: personalized interactive experiences influence visitor participatory experience.

H4: spatial dimension exhibitions influence visitor sense of direction.

H5: spatial dimension exhibitions influence visitor sense of direction.

H6: spatial dimension exhibitions influence visitor participatory experience.

H7: Digital technology exhibitions influence visitor sense of direction.

H8: Digital technology exhibitions influence visitor sense of direction.

H9: Digital technology exhibitions influence visitor participatory experience.

H10: Public psychology influences visitor sense of direction.

H11: Public psychology influences visitor sense of direction.

H12: Public psychology influences visitor participatory experience.

H13: Public psychology mediates the relationship between digital technology exhibitions and visitor participatory experience.

H14: Public psychology mediates the relationship between spatial dimension exhibitions and visitor participatory experience.

H15: Public psychology mediates the relationship between personalized interactive experiences and visitor participatory experience.

H16: Public psychology mediates the relationship between visitor sense of direction and visitor participatory experience.

4. Analysis of Research Results

Based on a preliminary survey of Chongqing Natural History Museum, this study collected experiential information from visitors regarding their museum experiences. Invalid questionnaires that did not meet the criteria were removed, and the measurement scales

were screened and optimized before re-distribution. Through online collection channels, a total of 724 valid questionnaires were recovered, with an effective response rate of 90.5%.

Among the survey samples, 378 respondents (52.21%) affirmed their prior experiences visiting exhibitions or participating in activities at smart museums, while 346 respondents (47.79%) held negative views. The research sample demonstrates good representativeness, fundamentally reflecting the overall characteristics of the visiting population.

To further validate the effectiveness of the "Chongqing Natural Resources Museum" measurement scale, confirmatory factor analysis (CFA) was conducted on the revised questionnaire. In terms of measurement relationships, all absolute values of standardized factor loadings exceeded 0.6 and demonstrated statistical significance, indicating good measurement reliability. CFA was performed on 7 factors and 62 analyzed items. With an effective sample size of 724 cases (exceeding 10 times the number of analyzed items), the sample size met the minimum requirements for analysis. Measurement relationships showed standardized loadings with absolute values >0.6 and significant levels, confirming robust measurement validity.

By using correlation analysis, this paper studies the correlation between public psychology and visitor participatory experience, digital technology exhibitions, spatial dimension exhibitions, personalized interactive experiences, visitor's sense of direction and visitor sense of direction, and uses Pearson correlation coefficient to express the strength of the correlation. From the concrete analysis, it can be seen that there are significant relationships between the public psychology and the visitor participatory experience, the digital technology exhibitions, the spatial dimension exhibitions, the personalized interactive experiences, the visitor's sense of direction and the visitor's sense of identity, and the correlation coefficient values are 0.767, 0.663, 0.685, 0.624, 0.622 and 0.620 respectively, and the correlation coefficient values are all greater than 0. It means that there is a positive correlation between the public psychology and the visitor participatory experience, digital technology exhibitions, spatial dimension exhibitions, personalized interactive experiences, visitor's sense of direction and visitor sense of direction. As shown in Table 1.

As can be seen from Table 2, the public psychology, digital technology exhibitions, spatial dimension

Table 1 Pearson Correlation Analysis Results (Standard Format)

Pearson Correlation Analysis Results (Standard Format)							
	Public Psychology	Visitor Participatory Experience	Digital Technology Exhibitions	Spatial Dimension Exhibitions	Personalized Interactive Experiences	Visitor Sense of Direction	visitor sense of direction
Public Psychology	1						
Visitor Participatory Experience	0.767**	1					
Digital Technology Exhibitions	0.663**	0.730**	1				
Spatial Dimension Exhibitions	0.685**	0.669**	0.853**	1			
Personalized Interactive Experiences	0.624**	0.718**	0.650**	0.666**	1		
Visitor Sense of Direction	0.622**	0.715**	0.652**	0.666**	0.882**	1	
Visitor Sense of Direction	0.620**	0.653**	0.733**	0.785**	0.678**	0.786**	1
*p<0.05 ** p<0.01							

Source: Compiled by this study

exhibitions and personalized interactive experiences are taken as independent variables, while the visitor sense of direction is taken as dependent variable for linear regression analysis. As can be seen from the above table, the model formula is: visitor sense of direction =0.005+0.058* public psychology +0.143* digital technology exhibitions +0.455* spatial dimension exhibitions+0.239* personalized interactive experiences. The R-square value of the model is 0.667, which means public psychology, digital technology exhibitions, spatial dimension exhibitions and personalized interactive experiences can explain 66.5% of visitor sense of direction. The F-test of the model shows that the model has passed the F-test (F=360.709, p=0.000<0.05), which means that at least one of public psychology, digital technology exhibitions, spatial dimension exhibitions and personalized interactive experiences will have an impact on visitor sense of direction. In addition, the multiple collinearity of the model is tested, and it is found that all VIF values in the model are less than 5, which means there is no collinearity problem; And the D-W value is near the number 2, which shows that the model has no autocorrelation and there is no correlation between sample data, so the model is better. The final concrete analysis shows that the regression coefficient of public psychology is 0.058(t=1.850, p=0.065>0.05), which means that public psychology will not have a significant impact on the visitor sense of direction. The regression coefficient of digital technology exhibitions is 0.143(t=3.397, p=0.001<0.05), which means that digital technology exhibitions will have an impact on the visitor sense of direction. The regression coefficient of the spatial dimension exhibitions is 0.455(t=10.469, p=0.000<0.01), which means that the spatial dimension exhibitions will have a significant impact on the visitor sense of direction. The regression coefficient of personalized interactive experiences is 0.239(t=7.796, p=0.000<0.01), which means that personalized interactive experiences will have a significant impact on visitor sense of direction.

Overall analysis indicates that digital technology exhibitions, spatial dimension exhibitions, and personalized interactive experiences significantly influence visitor sense of direction. However, public psychology does not significantly affect visitor sense of direction.

As can be seen from Table 3, the public psychology, digital technology exhibitions, spatial dimension exhibitions and personalized interactive experiences

Table 2 Results of Linear Regression Analysis (Visitor Sense of Direction)

	Results of linear regression analysis (n=724)						
	Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity Statistics	
	B	Std. Error	Beta			VIF	Tolerance
Constant	0.005	0.022	-	0.210	0.834	-	-
Public Psychology	0.058	0.032	0.058	1.850	0.065	2.132	0.469
Digital Technology Exhibitions	0.143	0.042	0.145	3.397	0.001**	3.928	0.255
Spatial Dimension exhibitions	0.455	0.044	0.462	10.469	0.000**	4.217	0.237
Personalized Interactive experiences	0.239	0.031	0.239	7.796	0.000**	2.036	0.491
R2	0.667						
Adjusted R2	0.666						
F	F(4,719)=360.709,p=0.000						
D-W Value	2.152						
Dependent variable: visitor sense of direction							
*p<0.05 **p<0.01							

Source: Compiled by this study

are taken as independent variables, while the visitor participatory experience is taken as dependent variable for linear regression analysis. As can be seen from the above table, the formula of the model is: visitor participatory experience =0.009+0.431* public psychology+0.361* digital technology exhibitions-0.140* spatial dimension exhibitions+0.304* personalized interactive experiences, and the R-square of the model is 0.723, which means public psychology, digital technology exhibitions and spatial dimension exhibitions, and personalized interactive experiences can explain 72.3% change of the visitor sense of direction of direction. The F-test of the model shows that the model has passed the F-test (F=468.848, p=0.000<0.05), which means that at least one of the public psychology, the digital technology exhibitions, the spatial dimension exhibitions and personalized interactive experiences will have an impact on the visitor participatory experience. In addition, the multiple collinearity of the model is tested, and it is found that all VIF values in the model are less than 5, which means there is no collinearity problem; And the D-W value is near the number 2, which shows that the model has no autocorrelation and there is no correlation between sample data, so the model is better. The final concrete analysis shows that the regression coefficient of public psychology is 0.431(t=15.053, p=0.000<0.01), which means that public psychology will have a significant impact on the visitor participatory experience. The regression coefficient of digital technology exhibitions is 0.361(t=9.428, p=0.000<0.01), which means that digital technology exhibitions will have an impact on the visitor participatory experience. The regression coefficient of the spatial dimension exhibitions is -0.140(t=-3.551, p=0.000<0.01), which means that the spatial dimension exhibitions will have a negative impact on the visitor participatory experience. The regression coefficient of personalized interactive experience is 0.304(t=10.928, p=0.000<0.01), which means that personalized interactive experience will have a significant impact on the visitor sense of direction.

Overall analysis indicates that public psychology, digital technology exhibitions, and personalized interactive experiences significantly positively affect visitor participatory experience. In contrast, spatial

Table 3 Results of Linear Regression Analysis (Visitor Participatory Experience)

	Results of Linear Regression Analysis (n=724)						
	Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity Statistics	
	B	Std. Error	Beta			VIF	Tolerance
Constant	0.009	0.020	-	0.461	0.645	-	-
Public Psychology	0.431	0.029	0.431	15.053	0.000**	2.132	0.469
Digital Technology Exhibitions	0.361	0.038	0.367	9.428	0.000**	3.928	0.255
Spatial Dimension Exhibitions	-0.140	0.039	-0.143	-3.551	0.000**	4.217	0.237
Personalized Interactive Experiences	0.304	0.028	0.306	10.928	0.000**	2.036	0.491
R2	0.723						
Adjusted R2	0.721						
F	F(4,719)=468.848,p=0.000						
D-W Value	1.972						
Dependent variable: Visitor Participatory Experience							
*p<0.05 **p<0.01							

Source: Compiled by this study

dimension exhibitions significantly negatively affect visitor participatory experience.

As can be seen from Table 4, the public psychology, digital technology exhibitions, spatial dimension exhibitions and personalized interactive experiences are taken as independent variables, while the visitor sense of direction is taken as dependent variable for linear regression analysis. As can be seen from the above table, the formula of the model is: visitor sense of direction =0.000 + 0.065* public psychology+0.061* digital technology exhibitions+ 0.060* spatial dimension exhibitions+0.757* personalized interactive experiences, and the R-square of the model is 0.793, which means public psychology, digital technology exhibitions and spatial dimension exhibitions, and personalized interactive experiences can explain 79.3% change of the visitor sense of direction of direction. The F-test of the model shows that the model has passed the F-test (F=688.501, p=0.000<0.05), which means that at least one of the public psychology, the digital technology exhibitions, the spatial dimension exhibitions and personalized interactive experiences will have an impact on the visitor sense of direction. In addition, the multiple collinearity of the model is tested, and it is found that all VIF values in the model are less than 5, which means there is no collinearity problem; And the D-W value is near the number 2, which shows that the model has no autocorrelation and there is no correlation between sample data, so the model is better. The final concrete analysis shows that the regression coefficient of public psychology is 0.065(t=2.602, p=0.009<0.01), which means that public psychology will have a significant positive impact on the visitor sense of direction. The regression coefficient of digital technology exhibitions is 0.061(t=1.845, p=0.065>0.05), which means that digital technology exhibitions will not have an impact on the visitor sense of firection. The regression coefficient of the spatial dimension exhibitions is 0.060(t=1.766, p=0.078>0.05), which means that the spatial dimension exhibitions will not have an impact on the visitor sense of direction. The regression coefficient of personalized interactive experience is 0.757(t=31.424, p=0.000<0.01), which means that personalized interactive experience will have a significant positive impact on the visitor sense of direction.

Overall analysis indicates that public psychology and personalized interactive experiences significantly positively affect visitor sense of direction. In contrast, digital technology exhibitions and spatial dimension

Table 4 Results of Linear Regression Analysis (Visitor Sense of Direction)

	Results of Linear Regression Analysis (n=724)						
	Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity Statistics	
	B	Std. Error	Beta			VIF	Tolerance
Constant	0.000	0.017	-	0.017	0.987	-	-
Public Psychology	0.065	0.025	0.064	2.602	0.009**	2.132	0.469
Digital Technology Exhibitions	0.061	0.033	0.062	1.845	0.065	3.928	0.255
Spatial Dimension Exhibitions	0.060	0.034	0.062	1.766	0.078	4.217	0.237
Personalized Interactive Experiences	0.757	0.024	0.761	31.424	0.000**	2.036	0.491
R2	0.793						
Adjusted R2	0.792						
F	F(4,719)=688.501,p=0.000						
D-W Value	2.060						
Dependent variable: Visitor Sense of Direction							
*p<0.05 **p<0.01							

Source: Compiled by this study

exhibitions do not affect visitor sense of direction.

There are three models involved in the application of mediating effect analysis, as shown in Table 5 below:

Public psychology ~ digital technology exhibitions+spatial dimension exhibitions+personalized interactive experiences+visitor sense of direction.

Visitor participatory experience ~ digital technology exhibitions+spatial dimension exhibitions+personalized interactive experiences+visitor sense of direction.

Visitor participatory experience ~ digital technology exhibitions+spatial dimension exhibitions+personalized interactive experiences+visitor sense of direction+public psychology.

The Bootstrap sampling test method is used to study the mediating effect, and the sampling times are 5000. The results show that the 95% interval does not include the number 0(95% CI:0.023~0.144) in view of the mediating path of' digital technology exhibitions ⇒ public psychology ⇒ visitor participatory experience, indicating the existence of this mediating effect path. Continuing with the analysis of the chain mediating effect path, regarding the mediating path of 'spatial dimension exhibitions ⇒ public psychology ⇒ visitor participatory experience', the 95% interval does not include the number 0 (95% CI: 0.070~0.206), indicating the existence of this mediating effect path. Regarding the mediating path of 'personalized interactive experience ⇒ public psychology ⇒ visitor participatory experience', the 95% interval does not include the number 0 (95% CI: 0.008-0.132), indicating the existence of this mediating effect path. From the perspective of the mediating path of 'visitor sense of direction ⇒ public psychology ⇒ visitor participator experience', the 95% interval includes the number 0 (95% CI: -0.006~0.123), indicating that this mediating effect path does not exist, as shown in Table 6.

5.Conclusion

The rapid development of digital intelligence

Table 5 Mediating Effect Model Testing

Mediating Effect Model Testing (n=724)															
	Public Psychology					Visitor Participatory Experience					Visitor Participatory Experience				
	B	SE	t	p	β	B	SE	t	p	β	B	SE	t	p	β
Constant	0.021	0.025	0.833	0.405	-	0.018	0.022	0.808	0.420	-	0.009	0.019	0.463	0.644	-
Digital Technology Exhibitions	0.193**	0.049	3.917	0.000	0.196	0.432**	0.043	10.070	0.000	0.439	0.351**	0.038	9.234	0.000	0.357
Spatial Dimension Exhibitions	0.310**	0.050	6.223	0.000	0.317	-0.019	0.044	-0.434	0.664	-0.019	-0.150**	0.039	-3.819	0.000	-0.153
Personalized Interactive Experiences	0.156**	0.055	2.829	0.005	0.157	0.250**	0.048	5.185	0.000	0.252	0.184**	0.042	4.334	0.000	0.185
Visitor Sense of Direction	0.145**	0.056	2.602	0.009	0.145	0.219**	0.048	4.522	0.000	0.220	0.158**	0.043	3.710	0.000	0.159
Public Psychology											0.421**	0.029	14.757	0.000	0.421
R2	0.535					0.646					0.728				
Adjusted R2	0.533					0.644					0.726				
F Value	F(4,719)=206.995,p=0.000					F(4,719)=327.454,p=0.000					F(5,718)=384.489,p=0.000				
*p<0.05 **p<0.01															

Source: Compiled by this study

Table 6 Summary of Effect Analysis Process

Summary of Effect Analysis Process							
Effect	Item	Effect	SE	t	p	LLCI	ULCI
Direct Effects	Digital Technology Exhibitions⇒Visitor Participatory Experience	0.351	0.038	9.234	0.000	0.277	0.426
	Spatial Dimension exhibitions⇒Visitor Participatory Experience	-0.150	0.039	-3.819	0.000	-0.226	-0.073
	Personalized Interactive Experiences⇒Visitor Participatory Experience	0.184	0.042	4.334	0.000	0.101	0.267
	Visitor Sense of Direction⇒Visitor Participatory Experience	0.158	0.043	3.710	0.000	0.075	0.242
Indirect Effect Process	Digital Technology Exhibitions⇒Public Psychology	0.193	0.049	3.917	0.000	0.096	0.289
	Spatial Dimension exhibitions⇒Public Psychology	0.310	0.050	6.223	0.000	0.213	0.408
	Personalized Interactive Experiences⇒Public Psychology	0.156	0.055	2.829	0.005	0.048	0.264
	Visitor Sense of Direction⇒Public Psychology	0.145	0.056	2.602	0.009	0.036	0.253
	Public Psychology⇒Visitor Participatory Experience	0.421	0.029	14.757	0.000	0.365	0.477
Total Effects	Digital Technology Exhibitions⇒Visitor Participatory Experience	0.432	0.043	10.070	0.000	0.348	0.516
	Spatial Dimension Exhibitions⇒Visitor Participatory Experience	-0.019	0.044	-0.434	0.664	-0.104	0.066
	Personalized Interactive Experiences⇒Visitor Participatory Experience	0.250	0.048	5.185	0.000	0.155	0.344
	Visitor Sense of Direction⇒Visitor Participatory Experience	0.219	0.048	4.522	0.000	0.124	0.314
Note: LLCI = 95% lower limit of confidence interval for estimated value; ULCI = 95% upper limit of confidence interval for estimated value							

Source: Compiled by this study

technology has opened new possibilities for optimizing museum exhibition design and enhancing visitor experience. Based on the Stimulus-Organism-Response (SOR) theory, this study constructs an interdisciplinary theoretical model to systematically explore the influence mechanisms of personalized interactive experiences, spatial exhibition design, digital technology applications, and public psychology on visitors' directional perception, positional identity, and engagement. Empirical analysis validates the proposed hypotheses and yields the following key conclusions.

First, digital technology exhibitions, spatial dimension exhibitions, and personalized interactive experiences demonstrate significant positive effects on visitor sense of direction. Among these factors, spatial dimension exhibitions (β=0.462) and personalized interactive experiences (β=0.239) make particularly prominent contributions, indicating that rational physical space planning and innovative interactive design are critical pathways to enhance visitor cultural identity. Second, personalized interactive experiences exhibit the strongest explanatory power for visitor sense of direction (β=0.761), highlighting visitors' demand for deep engagement with exhibition content through autonomous exploration. Additionally, public psychology plays a significant mediating role between digital technology, spatial exhibitions, and visitor participatory experience, though its direct effect on directional identity is insignificant. This suggests that herd mentality influences experience enhancement primarily through emotional resonance rather than direct impact. Notabl, spatial dimension exhibitions show a negative effect on participatory experience (β=−0.143), possibly due to cognitive overload caused by overly complex spatial layouts, empirically supporting the "less is more" design principle.

This study holds dual theoretical and practical significance. Theoretically, it expands the dimensions of visitor experience research through an interdisciplinary perspective, revealing how digital intelligence technology reconstructs museum narrative logic via multiple emotional, cognitive, and behavioral pathways. Practically, museums are advised to prioritize the synergistic optimization of technology-space-interaction in exhibition design. Strategies include leveraging virtual reality and personalized navigation tools to enhance content accessibility, simplifying spatial flowlines to balance immersion and comfort, and strengthening visual communication of cultural symbols. Caution must be exercised to avoid the “overload effect” of technology, ensuring digital media do not overshadow the cultural essence of exhibits.

Limitations of this study include its focus on specific domestic museums. Future research could extend to cross-cultural comparisons and incorporate objective data (e.g., eye-tracking, behavioral trajectory monitoring) to address subjective biases in questionnaires. Exploration of experiential differences among elderly visitors and special-needs groups is also warranted. Overall, digital intelligence enablement injects new momentum into museum sustainability. However, realizing its economic value requires centering on visitors’ authentic needs and balancing technological innovation with cultural heritage preservation.

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