Evaluating the Affordances of Museum Online Digital Resource Services in the Context of Cultural Digitization

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Abstract

Abstract: [Purpose/Significance] Museums, as vital components of public cultural service institutions, rely on the accessibility of their cultural content resources to support the facilitation and equalization of public cultural services. The overall layout of Digital China and the introduction of the national cultural digitization strategy have imposed higher requirements on museum online digital resource services. Scientific evaluation of the affordances of museum online digital resource services in China will become a crucial lever for fulfilling these requirements. [Method/Process] Based on principles of affordance theory and characteristics of museum online digital resource services in China, this study constructs an affordance evaluation index system comprising 3 first-level indicators, 9 second-level indicators, and 25 third-level indicators, employing a combined weighting model utilizing the Analytic Hierarchy Process (AHP) and entropy weight method to determine the weights of indicators at all levels. On this basis, this study selects 175 national first-class museum websites to conduct an assessment of their online digital resource service affordances. [Results/Conclusions] (1) Museums with higher levels of online digital resource service affordance have conducted thorough exploration and extension across three dimensions—cognitive affordance, functional affordance, and emotional affordance—by leveraging their own resource characteristics; (2) The development of affordance levels for museum online digital resources in China is unbalanced, generally exhibiting an “east high, west low, central rising” pattern; (3) The affordance levels of museum online digital resource services across provinces and municipalities in China are basically consistent with the urban cultural-technological integration and innovation development landscape.

Full Text

Construction and Verification of the Evaluation Index System on the Affordance of Digital Resources Services in Chinese Museums From the Perspective of Digital Culture

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Abstract:
[Objective] Museums, as vital components of public cultural service institutions, play a crucial role in facilitating convenient and equitable public cultural services through the popularization of their cultural content resources. The overall layout of Digital China and the National Digital Culture Strategy have put forward higher requirements for digital resources services provided by museums in China. A scientific evaluation of the affordance of online digital resource services offered by Chinese museums will become a critical means of achieving these requirements. [Methods] Based on affordance theory and the characteristics of museum digital resources, this paper constructs an evaluation index system consisting of three primary indices, nine secondary indices, and twenty-five tertiary indices. The analytic hierarchy process and entropy weight method were introduced to calculate the weight of each index. Based on this, this paper selects 175 first-level national museums for evaluation. [Conclusions] (1) Museums with higher levels of online digital resource service affordance have fully explored and extended their capabilities across three dimensions—cognitive affordance, functional affordance, and affective affordance—based on their own resource characteristics; (2) The development of online digital resource service affordance in Chinese museums is uneven, showing an overall pattern of "high in the east, low in the west, and moderate in the central regions"; (3) The level of affordance in online digital resource services provided by museums in different provinces and cities in China is generally consistent with the pattern of development in urban cultural-technology integration and innovation.

Keywords: Cultural digitization; Museum; Digital resources; Affordance

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In 2023, the General Office of the Communist Party of China Central Committee and the General Office of the State Council successively issued the *Overall Layout Plan for Digital China Construction* (hereinafter referred to as the "Plan") and the *Opinions on Promoting the Implementation of the National Cultural Digitization Strategy* (hereinafter referred to as the "Opinions"). The former adheres to the scientific logic of promoting high-quality development through

digitalization and has formed a relatively complete top-level design, while the latter articulates a people-oriented philosophy of "cultural digitization for the people, with cultural digitization achievements shared by the people," and makes major arrangements for promoting the implementation of the national cultural digitization strategy during the 14th Five-Year Plan period through to 2035. The national cultural digitization strategy provides necessary conditions for the diversified dissemination of cultural achievements and points the way toward achieving equalization and facilitation of cultural resources. Museums serve as important carriers of cultural resources. By the end of 2021, there were 5,772 museum institutions nationwide in China, with a collection of 46.65 million items/sets. Museums have developed into large-scale institutions with rich collections, representing key components of national cultural resource construction and public cultural services. The advancement of the national cultural digitization strategy has put forward higher requirements for comprehensively enhancing the supply capacity of digital cultural content and the level of digital cultural services for public cultural digital platforms, including museums.

Traditional digital resource services mainly include digital resource lending, consulting, dissemination, and technical support services [1]. Museum online digital resource services primarily focus on digital resource dissemination, such as online access to cultural relic exhibitions, online learning of course resources, and online lectures and training, aiming to better fulfill museums' positive roles in cultural dissemination, education, and science popularization. The rapid development of information technology has exerted increasingly profound influences on social lifestyles, while public demand for cultural resources continues to grow. Against this backdrop, strengthening the construction of museum online digital resource services has become increasingly urgent. Currently, most museums in China provide website access services, aiming to present their digital cultural resources to the public by leveraging the advantages of online platforms in sensory interaction and media communication. This approach seeks to achieve effective knowledge extension in the virtual space constructed by digital technology, mobilize people's sense of immersion and experience, and bring "sleeping" historical culture to life. However, the level of online digital resource services among Chinese museums is uneven, with certain differences in resource richness and digital technology application across different institutions. Whether museum online digital resource services can effectively bridge the gap with audiences and lower the threshold for the public to access cultural resources still lacks objective and standardized evaluation criteria. Therefore, this paper proposes an evaluation system for Chinese museum online digital resource services from the perspective of affordance, conducting assessments across three dimensions—"cognitive," "functional," and "affective"—to explore feasible strategies for improving public cultural digital service levels based on observations and comparisons of digital resource service quality.

2.1 Museum Online Digital Resource Services

As protectors and inheritors of cultural heritage, museums shoulder the important task of presenting and disseminating knowledge and culture through digital means. Existing scholarship has already addressed museum online digital resources. Some studies focus on the construction of museum online resource services. For instance, Yin Zhen [2], Yuan Xiaodong [3], Wu Jianping [4], and Wang Guangjun et al. [5] examine presentation methods and immersive interaction design for online digital resource services, attempting to expand display formats and enhance resource interest and appeal. Su Yuliang [6] and Zhao Feng [7] focus on management and sharing mechanisms for museum online digital resource services, exploring the importance of online digital resource management and sharing for improving digital resource and application efficiency and activating collection resources. Other research perspectives concentrate on development dilemmas and countermeasures for museum online resource services in the new era. For example, Lai Siyuan [8] and Wang Qi [9] discuss the value, problems, and development paths of museum online digital resources in the new era context. Wu Jianping [4], Yuan Xiaodong [3], Chen Tianlun [10], Su Yan et al. [11], and Wang Guangjun et al. [5] summarize and analyze the role of AR, VR, and other virtual reality technologies in online digital resource space design and interaction, as well as future development directions. Additional research discusses the functions of museum online digital resource services, providing reference suggestions for enriching museum roles under the cultural digitization strategy from perspectives such as cultural relic protection [12,13], educational extension [14], and cultural dissemination [12].

Precisely because museum online digital resource services hold significant meaning for cultural dissemination, public education, and social development, scholars have attempted to construct evaluation indicators for these services to help improve and optimize them, providing assessment and feedback on digital service quality and effectiveness. Regarding evaluation methods, scholars have employed qualitative research methods [15], case study methods [16–18], analytic hierarchy process [19], aspect-based sentiment analysis [20], and hierarchical grey relational calculation methods [21] to evaluate online digital resource services. In terms of evaluation theories and models, the theoretical foundations and models referenced mainly include encoding-decoding theory [19], Norman's theory [15], grey theory [22], scene theory [23,24], usability theory [25], Kano model [21], and Musetech model [26]. Regarding evaluation content, some studies start from platform display design, exploring evaluation system construction around information communication effectiveness in museum digital interactive displays [27] and aesthetic evaluation of virtual museum interface layouts [22]. Other studies adopt a user perspective, analyzing factors affecting user experience in museum digital services [21,28–30]. Some research combines scene theory [23,24] to propose integration strategies for virtual cultural scenes, providing suggestions for innovative museum digital development.

In summary, current research on museum online digital resource service con-

struction and development is relatively rich, providing directional guidance to some extent for how museums can strengthen functions such as cultural dissemination and public education in the context of Digital China. However, online digital resource services in traditional museums currently expose some problems, such as insufficient content richness, interaction quality needing improvement, and monotonous online cultural display models. Whether museum online digital resource services have truly achieved accessibility of cultural resources lacks effective evaluation systems for assessment. Meanwhile, museum online digital resource service development is unbalanced, with differences in resource construction status and technology usage levels. Currently, no research analyzes and identifies advantages and shortcomings in museum online digital resource services from an affordance perspective. Therefore, this study can fill gaps in museum online digital resource service research and help museums better realize their role functions in digital construction.

2.2 Service Affordance Evaluation

Affordance theory was proposed by American psychologist J.J. Gibson in the late 1950s as a theory describing the reciprocal relationship between organisms and their environment, originally referring to the possibilities for action that the environment provides users [31]. With theoretical evolution and development, Norman introduced affordance theory into interaction design in 1988, pointing out that the affordances of objects themselves can indicate their usage methods and realize corresponding functions [32]. Gaver's research played a promoting role in affordance application, arguing that product design should fully consider technological affordances and limitations, improving product usability from the perspective of interaction between users and technology [33]. In other words, designs with strong affordances can help service intentions and functions be achieved more accurately, efficiently, and satisfactorily, enhancing user experience and satisfaction. The level of affordance directly determines service design quality [34].

Precisely because of affordance's prominent advantages in service design, affordance evaluation has been widely conducted across different fields. First, in product design, many scholars have conducted evaluations based on affordance theory. For example, Li Hongyu [35] and Elham et al. [36] use affordance as an evaluation coordinate to provide references for enhancing user product interaction experiences. Bai Zhonghang et al. [37] construct a product modeling design method based on functional affordance, cognitive affordance, behavioral affordance, and sensory affordance, verifying method feasibility and effectiveness through evaluation. Wang Minyan [38] explores the correlation between affordance and emotional design, proposing product emotional design approaches guided by affordance.

In the social media domain, increasing numbers of scholars use affordance concepts as entry points to construct service evaluation systems. Fox developed scales for evaluating perceived affordances, advancing communication re-

searchers' understanding of social interaction [39]. Rice identified six reliable and valid affordance dimensions for evaluating organizational media [40]. Brian [41] and Laszlo et al. [42] evaluated affordances of social media platforms, providing suggestions for designing basic elements such as content and form to enhance usability. In 2017, Pan Zhongdang introduced the concept of "media affordance" to domestic journalism and communication academia, proposing a theoretical framework for "production affordance," "social affordance," and "mobile affordance" in new media. Based on this, domestic journalism and communication scholars began extensive research. For instance, Wang Ailing et al. [43] analyzed and evaluated content dissemination affordances of professional media WeChat platforms. Zeng Peilun et al. [44] attempted to construct an evaluation system for county-level integrated media center construction effects under an affordance framework. Zhang Shuqi [45] evaluated and reflected on content production, media technology, and communication terminals of the "People's Video" website and client platform. Some scholars have also introduced affordance concepts into education [46–49], information systems [50], healthcare [51], and e-commerce [52–54] domains.

In summary, evaluation system construction based on "affordance" has been widely applied across multiple fields. Scholars have leveraged affordance theory's advantages in objectively and multidimensionally describing relationships between subjects, technology, and people to evaluate different service types. However, in the public cultural domain, the application of "affordance theory" remains underexplored. As the cultural digitization strategy places increasingly higher demands on digital content supply capacity, museums, as important carriers of cultural dissemination, need to achieve high reachability and timeliness of digital resources while enhancing public sense of gain from cultural services. Affordance theory possesses the capability to examine the interactive relationships between museum online digital resource service technology investment, cultural scene connection, and user experience, providing a fresh analytical perspective for evaluating museum online digital resource service construction. Addressing existing research gaps, this study constructs an evaluation system from the "affordance" perspective, helping assess the extent to which museums have achieved accessibility in digital resource services. Simultaneously, based on museums' affordance levels, this paper proposes targeted recommendations aimed at promoting museums' important roles in inheriting excellent traditional culture and satisfying people's spiritual and cultural life needs under the background of cultural digitization.

3.1 Indicator System Construction

This study references the four affordance elements (functional affordance, cognitive affordance, behavioral affordance, and sensory affordance) proposed by Xu Xiaofeng et al. [34], selecting cognitive affordance and functional affordance as evaluation dimensions. Sensory affordance can be regarded as an attribute of cognitive affordance that plays a key auxiliary role [55]; therefore, this pa-

per incorporates it into cognitive affordance evaluation indicators. Behavioral affordance relates to actions performed by users and required physical and physiological scales [34], making it more suitable for evaluating physical products and less aligned with this study's focus. On this basis, this paper introduces the "affective affordance" concept proposed by Zhao et al. [56], forming an evaluation system centered on "cognitive-functional-affective" affordances. The final constructed museum online digital resource service affordance evaluation indicator system is shown in Table 1 , including 3 primary indicators, 9 secondary indicators, and 25 tertiary indicators, comprehensively revealing factors affecting museum online digital resource service affordance construction.

[Figure 1: see original paper] Cognitive-Functional-Affective Affordance Evaluation Framework Diagram

(1) Cognitive Affordance: Refers to the cognitive information and interaction methods that environments or objects can provide users. According to Norman's perspective, cognitive affordance plays an extremely important role in interaction design and represents one of the most important user-centered design characteristics in interactive systems [55]. Cognitive affordance provides clues through the physical characteristics of interactive systems [34], assisting users in understanding platform usage methods [38]. Museum websites with good cognitive affordance should have aesthetic interfaces—featuring comfortable page element design, reasonable navigation layout, and unified color matching—thereby providing users with good sensory experiences. Simultaneously, website design should have usability that helps users quickly locate needed digital resources during use and intuitively and clearly understand website operations and information content. Therefore, cognitive affordance is primarily evaluated through website aesthetics and usability.

(2) Functional Affordance: Refers to the achievable functions and operation methods provided by environments or objects. Functional affordance emphasizes the combination of "usefulness" and "usability," requiring functions to maximize the realization of users' original intentions in an easy-to-use manner [34]. Function plays a dominant role in design. Museum online digital resource services are mainly divided into three categories: digital collections, digital exhibitions, and digital knowledge. Different museums vary in digital resource richness and technology application levels, which further affect user experience; therefore, evaluating museum functional affordance is important. Evaluation of the digital collections section primarily focuses on collection description completeness, image display function comprehensiveness, related display richness, and classification search function comprehensiveness. Digital exhibition evaluation examines the functional richness of three exhibition types: graphic online exhibitions, real-scene 3D exhibitions, and 3D virtual exhibitions. Digital knowledge evaluation assesses the richness of multimedia resources and academic research presentations provided by websites.

(3) Affective Affordance: Refers to the emotional experiences and value extensions evoked in users by environments or objects. Affective affordance

influences user emotional experiences. Positive affective affordance can promote natural and pleasant emotional reactions. In Norman's three-level theory of emotional design, he emphasizes that product design should improve users' cognition and experience of products, stimulating users' emotional reactions at three levels: visceral, behavioral, and reflective [57]. Visceral-level emotion is the most direct emotional feeling users generate during initial platform use, typically reflected in whether the platform can provide good sensory experiences. Behavioral-level emotion is the "usability" perceived and experienced by users during product interaction and the satisfaction brought by resulting "high efficiency"—that is, whether users are generally satisfied with museum online digital resource services [58]. Reflective-level emotion is users' deeper reactions after understanding products, representing sustained emotional projection. For museum online digital resource services, this is mainly reflected in whether digital resource presentation methods and interaction processes provide good entertainment experiences and whether websites give users comprehensive understanding of history and culture, generate interest, and stimulate willingness to deeply contemplate their significance [59]. Thus, good affective affordance results from the coordinated functioning of cognitive affordance and functional affordance. Therefore, affective affordance evaluation can be conducted from three dimensions reflecting users' actual feelings when obtaining online digital resource services: digital resource service satisfaction, digital resource entertainment interactivity, and digital resource cultural experience.

3.2 Indicator Measurement

Cognitive affordance and affective affordance are closely related to users' actual experiences; therefore, they are measured qualitatively through expert scoring using a 5-point Likert scale with descriptions of "very dissatisfied, dissatisfied, neutral, relatively satisfied, very satisfied," corresponding to scores of "1, 2, 3, 4, 5." The scoring experts are researchers in the field of information resource management. Functional affordance primarily measures the level of digital resources provided by museums, evaluated quantitatively from three aspects: digital collections, digital exhibitions, and digital knowledge. Functional affordance tertiary indicators are assigned values of 0 or 1 to indicate whether a specific function exists, with values summed to obtain each museum website's functional affordance score. Finally, data for indicators at all levels are normalized to eliminate differences in data magnitude. Specific indicators are shown in Table 1.

3.3 Indicator Weight Determination

This paper adopts a combined weighting method using the analytic hierarchy process (AHP) and entropy weight method to determine indicator weights. AHP is based on evaluators' knowledge and experience, offering strong interpretability and systematicity but suffering from large subjective arbitrariness. The entropy weight method can avoid subjective arbitrariness, but weight results may not match actual conditions. Combined weights integrate objective factors from

the entropy weight method and subjective factors from AHP, achieving close connection and complementary advantages between the two methods, reducing analysis bias from single methods, and making results more comprehensive, fair, and reasonable. AHP established judgment matrices by sending questionnaires to 15 experts, asking them to pairwise compare the importance of primary and secondary indicators using a 1–9 scale based on the established evaluation indicator system. All judgment matrices had random consistency ratios (CR) less than 0.1, passing the random consistency test, ultimately yielding AHP subjective weights α . Subsequently, the entropy weight method calculated objective weights β for each indicator. Finally, a preference coefficient = 0.5 was used to calculate final indicator weights , i.e., = 0.5(α + β). Results are shown in Table 1.

Table 1 Museum Online Digital Resource Service Affordance Evaluation Indicator System and Weights

Primary Indicator	Weight	Secondary Indicator	Weight	Tertiary Indicator
C1 Digital Resource Service Cognitive Affordance (DRS-Cognitive)	0.338	C1.1 Digital Resource Presentation	0.500	C1.1.1 Website page component design comfort
				C1.1.2 Website layout navigation rationality and clarity
				C1.1.3 Website color matching uniformity and coordination
		C1.2 Digital Resource Website Usability		C1.2.1 Website digital resource location convenience
				C1.2.2 Website result feedback clarity and timeliness
				C1.2.3 Website content comprehensibility
				C1.2.4 Website operation and browsing intuitiveness

Primary Indicator	Weight	Secondary Indicator	Weight	Tertiary Indicator
F2 Digital Resource Service Functional Affordance (DRS-Functional)		F2.1 Digital Collection Affordance		F2.1.1 Collection description completeness
				F2.1.2 Image display diversity
				F2.1.3 Extended knowledge comprehensiveness
				F2.1.4 Cultural relic search convenience
		F2.2 Digital Exhibition Affordance		F2.2.1 Graphic online exhibition function completeness
				F2.2.2 Real-scene 3D exhibition function completeness
				F2.2.3 3D virtual exhibition function completeness
		F2.3 Digital Knowledge Affordance		F2.3.1 Multimedia resource richness
				F2.3.3 Academic research presentation comprehensiveness
A3 Digital Resource Service Affective Affordance (DRS-Affective)		A3.1 Digital Resource Service Satisfaction		A3.1.1 Digital resource satisfaction level
				A3.1.2 Digital resource usefulness level

Primary Indicator	Weight	Secondary Indicator	Weight	Tertiary Indicator
				A3.1.3 Digital resource recommendation willingness
		A3.2 Digital Resource Entertainment Interactivity		A3.2.1 Presentation method interestingness
				A3.2.2 Interaction process interestingness
				A3.2.3 Browsing process pleasantness
		A3.3 Digital Resource Cultural Experience		A3.3.1 Cultural knowledge communication
				A3.3.2 Cultural interest arousal
				A3.3.3 Cultural value extension

On February 22, 2023, the National Cultural Heritage Administration announced the 2021 National Museum Directory. By the end of 2021, China had 6,183 registered museums, including 4,194 state-owned museums and 1,989 non-state-owned museums. There were 1,218 national first-, second-, and third-level museums, including 204 national first-level museums, 448 national second-level museums, and 566 national third-level museums. This study selected national first-level museums as research objects, removing museums without websites or with temporarily inaccessible websites, ultimately determining 175 samples for evaluation across three dimensions: cognitive affordance, functional affordance, and affective affordance.

4.2 Data Calculation

This study uses a 100-point scoring system for national first-level museum websites. Let dimension indicators be i, specific indicators under each dimension be j, P be actual values of each indicator, Q be absolute weights of each indicator, and O be target values of each indicator (using ideal maximum values; for example, for aesthetics, the target value is the sum of tertiary indicator total scores, i.e., 15 points; for other cumulative indicators, target values are sums of

ideal maximum sub-items). The 100-point score S for the three dimensions—cognitive affordance, functional affordance, and affective affordance—is calculated as:

$$S_i = \sum P_j \times Q_j \times 100$$

Since the baseline score is 60 points, each dimension's total score requires standardization to obtain standardized scores F:

$$F_i = \frac{(S_i - S_{i\,\min}) \times 40}{S_{i\,\max} - S_{i\,\min}}$$

The total affordance score Z for each provincial museum website can be obtained by multiplying the three dimensions' standardized scores by corresponding weights and summing them:

$$Z = \sum F_i \times Q_i$$

4.3 Evaluation Results Analysis

Based on the aforementioned data calculation method, this paper evaluated 175 museum websites, obtaining museum online digital resource service affordance scores and rankings shown in Table 2 , which intuitively reflects museum website affordance construction status.

Table 2 Museum Online Digital Resource Service Affordance Scores and Rankings

Museum Website Name	Score	Rank
Aihui History Exhibition Hall	…	20
Linyi Museum	…	…
Wenzhou Museum	…	…
China (Hainan) South China Sea Museum	…	…
…	…	…
Yunnan Nationalities Museum	…	…
Jiangxi Lushan Museum	…	…
China Maritime Museum Shanghai	…	…
Shanghai Science and Technology Museum	…	…
Xinjiang Uygur Autonomous Region Museum	…	…
Qinghai Provincial Museum	…	…
Hubei-Henan-Anhui Soviet Area Capital Revolutionary Museum	…	…
Daqing Museum	…	…
Hangzhou West Lake Museum	…	…
Ganzhou Museum	…	…

Museum Website Name	Score	Rank
Pingxiang Museum	...	...
Huaibei City Museum	...	...
Anyuan Road and Mine Workers' Movement Memorial Hall	...	...
China Agricultural Museum	...	...
Shanxi Geological Museum	...	...
Chengdu Du Fu Thatched Cottage Museum	...	...

This study employs two-step clustering (TSC) to cluster the 175 museum samples. Two-step clustering can automatically determine the optimal number of clusters, offering greater precision compared to traditional clustering methods. Based on museum website scores, this study clusters samples into three categories: comprehensive affordance leaders, affordance catch-up developers, and affordance breakthrough potentials, with results shown in Table 3 . Simultaneously, this study visualizes clustered museum website scores, creating a scatter plot of museum online digital resource service affordance scores shown in Figure 2 [Figure 2: see original paper]. Finally, this study calculates average affordance scores for museums across provinces and cities, presenting them as a heatmap shown in Figure 3 [Figure 3: see original paper]. Based on this data, research findings reveal the following characteristics of Chinese museum online digital resource service affordance construction:

Table 3 Two-Step Clustering Results of Museum Online Digital Resource Service Affordance

Cluster Type	Cognitive Affordance	Functional Affordance	Affective Affordance	Proportion
Comprehensive Affordance Leaders	High	High	High	28.0%
Affordance Catch-up Developers	Medium	Medium	Medium	35.4%
Affordance Breakthrough Potentials	Low	Low	Low	36.6%

[Figure 2: see original paper] Scatter plot of museum online digital resource service affordance scores
[Figure 3: see original paper] Heatmap of museum online digital resource service affordance by province and city

From the perspective of individual museum online digital resource service affordance construction, Chinese museums with higher online digital resource service affordance levels have conducted full exploration and extension across cognitive, functional, and affective dimensions based on their own resource characteristics. In terms of cognitive affordance, outstanding museum websites not only focus on color matching but also demonstrate ingenuity in layout and page component design. For example, the Changsha Bamboo Slips Museum displays news in bamboo slip format, cleverly integrating the museum's characteristics and increasing user immersion (Figure 4 [Figure 4: see original paper]). The Chengdu Wuhou Shrine Museum attracts user interest through video guidance (Figure 5 [Figure 5: see original paper]). In functional affordance, outstanding museums provide audiences with more possibilities in collection, exhibition, and knowledge display. For instance, the Anhui Museum offers rich online interactive functions, allowing users to collect, comment on, and share collection information (Figure 6 [Figure 6: see original paper]). The Shanghai Museum's graphic exhibitions feature carefully designed page layouts and transition animations with chapter content set for different themes, creating progressive layers (Figure 7 [Figure 7: see original paper]). The Shaanxi History Museum conveys historical knowledge in 3D virtual form based on themes, such as "Exploring the Past and Present of the Du Tiger Talisman," and also sets up online interactive games, creating extremely strong audience engagement and an immersive experience (Figure 8 [Figure 8: see original paper]). The Suzhou Museum invites field experts and scholars to teach historical and cultural knowledge online, effectively enhancing the depth and breadth of knowledge dissemination (Figure 9 [Figure 9: see original paper]). In affective affordance, outstanding museum websites emphasize audience-website interaction and create strong cultural atmospheres to extend historical identity and value. For example, the Chengdu Jinsha Site Museum allows secondary creation of 3D cultural relics, leaving deeper impressions on users' minds through reprocessing of historical and cultural information. It also features live streaming and playback functions, combining with the most popular contemporary cultural dissemination methods to expand resource accessibility (Figure 10 [Figure 10: see original paper]). In addition to presenting collection resources online, the Museum of the Chinese People's War of Resistance Against Japanese Aggression also provides links to Chinese Anti-Japanese War Memorial Halls and international WWII museums, connecting sites and remains across the country and globally to strengthen audience historical identity (Figure 11 [Figure 11: see original paper]).

[Figure 4: see original paper] Changsha Bamboo Slips Museum news display
[Figure 5: see original paper] Chengdu Wuhou Shrine Museum video introduction
[Figure 6: see original paper] Anhui Museum collection interaction functions
[Figure 7: see original paper] Shanghai Museum graphic exhibition
[Figure 8: see original paper] Shaanxi History Museum virtual exhibition
[Figure 9: see original paper] Suzhou Museum online classroom
[Figure 10: see original paper] Chengdu Jinsha Site Museum cultural relic sec-

ondary creation and live playback
[Figure 11: see original paper] Museum of the Chinese People's War of Resistance Against Japanese Aggression website links

From the perspective of national provincial and municipal museum online digital resource affordance construction, Chinese museum online digital resource affordance levels show unbalanced development, generally presenting an "east high, west low, central rising" pattern. Specifically, under the radiation effect of deep integration of Beijing-Tianjin-Hebei industrial and innovation chains, North China has achieved outstanding digital construction results, providing necessary conditions for museum online digital resource service construction. The Yangtze River Delta region shoulders the responsibility of being a pioneer in China's science, technology, and industrial innovation, actively seizing the commanding heights of digital development, thus its online digital resource service affordance level also leads. As a key region receiving policy encouragement and support, Southwest China has gradually improved its digital industry service platform, establishing Southwest digital entertainment industry bases and Southwest art and animation industry bases. Cities like Chongqing, Chengdu, and Xi'an have also accelerated digital economy infrastructure construction, developing smart cities and digital industries, providing significant opportunities for digital resource service affordance construction. By contrast, Northwest China's online digital resource service affordance construction is somewhat insufficient. Affected by economic foundations, natural environments, and social conditions, its museum online digital resource service affordance level shows considerable gaps compared with eastern and central regions.

Regarding the relationship between national provincial and municipal museum online digital resource service affordance levels and urban cultural-technology integration innovation development patterns, the two development patterns are basically consistent. To date, the Ministry of Science and Technology and the Publicity Department of the CPC Central Committee, together with relevant departments, have recognized 85 national cultural and technological integration demonstration bases in four batches, initially forming a pattern with "Beijing, Zhejiang, and Guangdong" as leaders, eastern regions occupying dominant positions, and central and western regions following up—largely matching the construction level of museum online digital resource service affordance across Chinese provinces and cities. These bases fully utilize digital technologies such as big data, cloud computing, and artificial intelligence to revolutionize digital protection and inheritance methods for cultural heritage and expand application scenarios for cultural big data. Therefore, regions with cultural-technology integration advantages play important leading and demonstrative roles in promoting transformation and upgrading of traditional cultural industries and cultivating emerging cultural industries, providing good technical conditions and development guidance for museum online digital resource service construction.

5 Countermeasures and Recommendations for Museum Online Digital Resource Service Construction Based on Affordance

To advance museum online digital resource service construction and enable easier public access to high-quality museum digital resources, this study, based on affordance theory and from three dimensions—cognitive affordance, functional affordance, and affective affordance—forms an evaluation system with 3 primary indicators, 9 secondary indicators, and 25 tertiary indicators. The system is operable and practical, comprehensively evaluating online digital resource service levels of 175 national first-level museums. Evaluation results reflect current advantages and shortcomings in museum online digital resource service affordance, helping museums clarify the "distance" between service status and public expectations, and providing references for how museums can enhance digital resource service levels under the background of cultural digitization. Based on evaluation results, this study proposes corresponding countermeasures and recommendations from the three affordance dimensions to optimize Chinese museum online digital resource service affordance levels and better realize their role functions.

First, improve page layout and integrate sensory interaction design to create immersive psychological experiences, enhancing museum online digital resource service cognitive affordance. Museum website browsing experiences can easily cause user disorientation; therefore, museum websites should comprehensively improve cognitive affordance, enabling users to gain perception and imagination through website design and achieve immersive experiences through interaction between perception and thinking. Museums should provide clear navigation, concise information organization, comprehensive search functions, and clear webpage layouts and icon designs, allowing users to easily find needed information. Additionally, websites should fully leverage digital technology advantages to activate users' sensory worlds, extending space through the combined effects of vision, touch, hearing, and other senses to enhance psychological immersion. Finally, website design should emphasize deepening interactive experiences, such as adding animation settings during page browsing and interactive operations during information acquisition, enhancing audience participation experiences and strengthening user information acquisition stickiness.

Second, utilize digital technology to expand resource application scope based on museum resource characteristics, optimizing museum online digital resource service functional affordance. The core of museum websites is digital resources. Digital resource collection, processing, dissemination, and display constitute the main content of digital museums and directly reflect functional affordance. Museums should first make full use of big data technology to enrich narrative methods, presenting historical relic information to audiences in diversified ways and giving users more possibilities for knowledge acquisition. For example, digital exhibitions need not be limited to 3D reproductions but can use technology to break free from physical exhibition hall constraints, design story architectures, and create completely virtual story scenes. Second, current museum online dig-

ital resource services have not fully excavated and utilized their own cultural characteristics to provide quality learning resources for the public; the cultural education attribute needs further expansion. For example, the Palace Museum has created a series of applications such as *Yinzhen's Beauty* and *Auspicious Symbols of the Forbidden City*, using collections as the core, academic achievements as support, and integrating multimedia information to cleverly bridge the gap with the public, enabling people of all ages and cultural backgrounds to access cultural experiences without barriers. Finally, museums can expand application scenarios for digital resources, such as cooperating with short video platforms like Douyin for diversified digital resource creation and encouraging more user-generated content, thereby truly bringing digital knowledge to life.

Third, focus on diverse experiences and extend cultural value through knowledge interaction and reprocessing, strengthening museum online digital resource service affective affordance. Traditional museum communication was limited to obtaining finite information within cultural display spaces. Virtual reality technology expands cultural relic display space, and diverse presentation methods make cultural knowledge display more three-dimensional, enriching people's experiences. Museum website construction should be more "human-centered," with emotional design being particularly important. Miao Ling proposed four levels of museum emotional design: visceral, behavioral, reflective, and expressive levels [60], comprehensively summarizing pathways for providing audiences with diverse emotional experiences. At the visceral level, museum websites create virtual atmospheres for different themes and mobilize multi-sensory experiences to activate rich and diverse emotions. At the behavioral level, museum websites can provide users with more possibilities for interactive operations, such as adding game elements and message exchange functions in virtual exhibitions to realistically restore offline physical venue visit experiences. At the reflective level, museums need to deeply excavate emotional power behind historical culture, promoting dialogue between audiences and exhibition content through scene restoration and plot construction, stimulating audiences' subjective judgment, and prompting deep thinking about historical and cultural connotations. At the expressive level, museums can set up free creation sections for exhibition themes, allowing audiences to create personalized content. Historical and cultural information then leaves deeper impressions on users' minds through reprocessing and endows users with unique emotional experiences.

Museums are important carriers of cultural inheritance and innovation. Online digital resource service affordance construction helps maximize museum power. Under the guidance of the national digitalization strategy, museums should not only play roles in traditional cultural protection and display but also actively explore digital technology applications to create more convenient, vivid, diverse, and public-oriented online digital resource services that satisfy public needs for cultural resource access and experience, playing more active roles in the concrete practice of achieving "cultural digitization for the people, with cultural digitization achievements shared by the people."

6 Conclusion and Outlook

Currently, China is striding into the digital era, and the cultural digitization strategy represents an important deployment by the Party for prospering cultural undertakings and industries. Museums should leverage their unique collection advantages to comprehensively advance online digital resource service affordance construction, satisfying public cultural needs and playing more important roles in advancing the cultural industry digitization strategy and building a socialist cultural powerhouse. Future research can build upon this study for further exploration. For example, comparative studies of domestic and foreign museum online digital resource service affordance can be conducted to learn from advanced international experiences and propose targeted suggestions for Chinese museum digital resource construction. Additionally, research can further explore key factors affecting regional museum online digital resource service affordance from dimensions such as regional economic benefits, policy support investment, and talent and technical support, providing scientific basis and practical guidance for further improving and enhancing museum digital construction. In summary, improving museum online digital resource service affordance can more comprehensively demonstrate the precious value of cultural resources, greatly enhance museums' endogenous momentum, fully exert cultural influence of cultural institutions, and play an important role in advancing the cultural digitization strategy.

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Note: Figure translations are in progress. See original paper for figures.