

Research Hotspots and Characteristics of Mural Color—Based on Citespace's Knowledge Graph Visualization Analysis

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Abstract: *The enhancement of cultural confidence symbolizes the importance and urgency of higher-quality cultural heritage preservation in China. On this basis, this paper utilizes Citespace software to conduct a visualized analysis of knowledge maps on literature from the CNKI database with "mural color" as the main theme. By analyzing basic information such as the number of publications, authors, and research institutions, the results show that the number of publications is steadily increasing, but there is still a lack of collaborative connections among scholars. By constructing a knowledge map from multiple perspectives using keywords, we can understand the research hotspots at various stages and anticipate future development trends. By clarifying the characteristics of existing research and identifying shortcomings, it is hoped that future scholars can conduct more comprehensive and in-depth research on mural color.*

Keywords: *Mural, Color, Citespace, Visual analysis, CNKI*

1. Introduction

The research on mural color primarily involves the cultural heritage protection law, as well as laws and regulations on the protection of both domestic and abroad key cultural relics. The popularity of this research topic is closely related to national policies. The "Notice of the State Council on Strengthening the Protection of Cultural Heritage," issued in 2005, is a document formulated and implemented to strengthen cultural heritage protection in China. It focuses on issues related to the preservation, research, and utilization of cultural heritage. At the same time, the notice also clarifies the direction and measures for the development of China's cultural heritage protection business. In addition, the notice also explicitly encourages scholars to conduct research on mural color, making a positive contribution to the protection and inheritance of China's cultural heritage. Therefore, 2005 was a significant turning point for domestic research on mural color. More and more scholars began to pay attention to mural color research, leading to a surge of theoretical and applied studies on mural color. The study of mural color involves multiple professional perspectives such as art, chemistry, and archaeology. In-depth exploration of this subject requires a multidimensional approach. For example, pigment composition analysis can be conducted using spectrometers, historical background and artistic styles can be understood through relevant books and literature, and ancient architectural structures can be studied using knowledge from architectural engineering. This comprehensive approach aims to fully showcase the value of these precious historical relics.

2. Research design

2.1 Data source

To explore the specific development of mural color research in China and trace its development trajectory, this study conducted an "advanced search" in the CNKI (China National Knowledge Infrastructure) database. The search was limited to journal articles with a cutoff date of March 30, 2023, using the search terms "mural color" included in theme, keywords and titles. A total of 897 results were obtained from the search. After excluding conference papers, book reviews, column prefaces, and other irrelevant literature, a total of 874 relevant results were obtained. The earliest literature found on "mural color" was an article titled "Exploration of Mural Issues" by Yuan Yunfu, Yuan Yunsheng, Li Huaji, and Hou Yimin^[1], published in 1980 in the journal "Fine Arts Study". This article mainly discussed four

aspects: the overall design of murals and architecture, the discussion on the nationalization and modernization of murals, the selection of mural materials and techniques, and the decorative treatment of murals. It also provided an overview of the rise and decline of Chinese murals. Based on these 874 selected literature, Citespace was used for data analysis and visualization. The literature was exported and transformed into the required format in Citespace, establishing a new project with a time span from 1980 to 2023, and the time slicing was set to once per year. Visualizations were created based on authors, publishing institutions, and keywords to depict the research networks and trends in mural color research.

2.2 Research tool

Currently, there is relatively little integration of mural color research and visualization analysis in the academic community. Therefore, in this study, Dr. Chen Chaomei's Citespace software, developed in 2004 using Java programming language, was used as a tool for bibliometric analysis. Based on the results obtained from the CNKI database search, various elements such as the number of publications, keywords, and authors were analyzed and processed. Through visual knowledge maps, the development trends and research structure of "mural color" in China were displayed, aiming to understand the hot topics and development trends in this research field.

2.3 Research method

The research method used in this study is bibliometric analysis, which focuses on the literature information as the research object. The theoretical foundation is bibliometrics, which examines the phenomena of citation and being cited between documents. It applies mathematical, statistical, and logical methods to describe, infer, and predict the research landscape, research themes, and disciplinary structure in a particular field^[2]. Combined with content analysis, starting from the thematic perspective and emphasizing logical reasoning, the integration of bibliometric analysis and content analysis can broaden the existing advantages and complement each other's shortcomings^[3]. By utilizing the Citespace analysis software, the important factors of the literature can be visualized, making them more tangible and specific.

3. Overview of mural color research

3.1 Distribution of literature count by year

With the development of China's economy and the enhancement of comprehensive national strength, the state has attached increasing importance to cultural soft power and has put forward higher requirements for the inheritance and development of China's excellent traditional culture^[4]. Domestic scholars have conducted in-depth discussions and research on mural colors from different perspectives, and the number of related literature has increased year by year since 1980, attracting widespread attention. According to the results of advanced searches, there are 897 literature, with an average of 19.9 publications per year. The Figure 1 intuitively presents the research trend of mural colors in China.

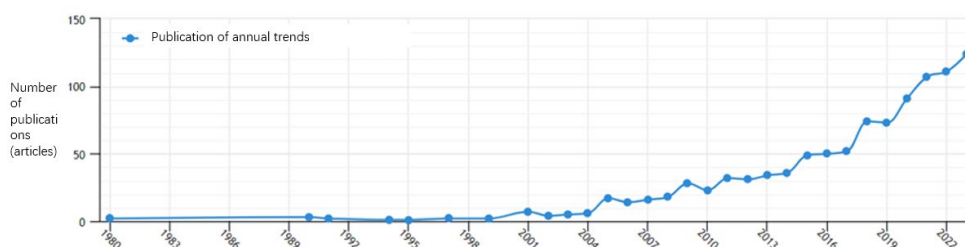


Figure 1: Number of relevant literature publications

Figure 1 shows that the number of relevant literature on mural color research was less than 7 from 1980 to 2004, indicating an early stage with steady but low publication output. From 2005 until now, mural color research has entered a stage of rapid development, with a significant increase in publication output, attracting widespread attention from scholars. During this period, relatively fruitful results have been produced. It is predicted that the number of publications in 2023 will reach 124, indicating that mural color research has entered a relatively prosperous stage.

In 2005, domestic mural color research reached a turning point, which was closely related to the

release of relevant national policies. The Notice on Strengthening the Protection of Cultural Heritage issued by the State Council in 2005 emphasized the importance and urgency of protecting cultural heritage. This became a guiding principle for domestic scholars studying mural colors, leading to a significant turning point. More and more scholars began to research mural colors, and the development trend has been positive.

3.2 Distribution of literature source institutions

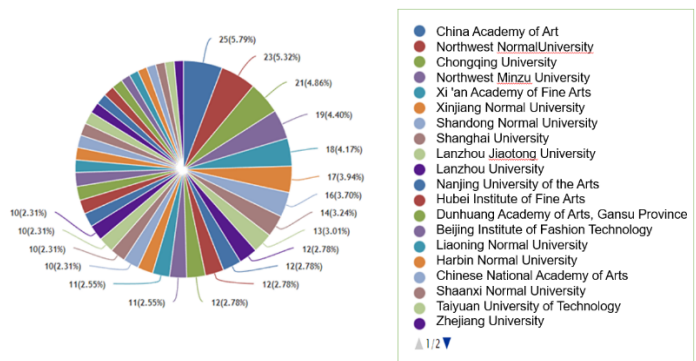


Figure 2: Distribution of literature source institutions

As shown in Figure 2, according to the distribution chart of high-frequency publishing institutions in mural color research in the CNKI database, there are 20 institutions that have published 10 or more articles. Among them, China Academy of Art has the highest number of publications with 25 articles, followed by Northwest Normal University with 23 articles, and Chongqing University with 21 articles. Other universities have less than 20 articles. The chart indicates that there is an imbalance and insufficiency in the development of mural color research among different institutions, each with its own differences.

3.3 Author distribution

By utilizing Citespace, this article analyzes the authors of relevant literature in mural color research. Since the "publication output" can to some extent reflect the influence, authority, and research level of authors in the field, while the "collaboration rate among authors" can reflect the degree of collaboration and knowledge contribution among scholars in the field [5].

Using Citespace software to analyze the co-occurrence of authors, the figure shows 461 nodes and 40 edges, with a network density of only 0.0004. This indicates a relatively low level of collaboration among scholars conducting mural color research in China, resulting in a research characteristic that is relatively independent and isolated. Among the search results, representative scholars with the highest number of publications as the first author include Kelsang Yeshe, Zhang Yali, Zhao Jianzhong, Liu Yongkui, Lv Shaohua, Li Yamei, et al. Among them, Kelsang Yeshe has the highest number of publications with 4 articles. However, the collaboration among these scholars is relatively weak, and there is an urgent need to enhance cooperation among them.

3.4 Distribution of published journals

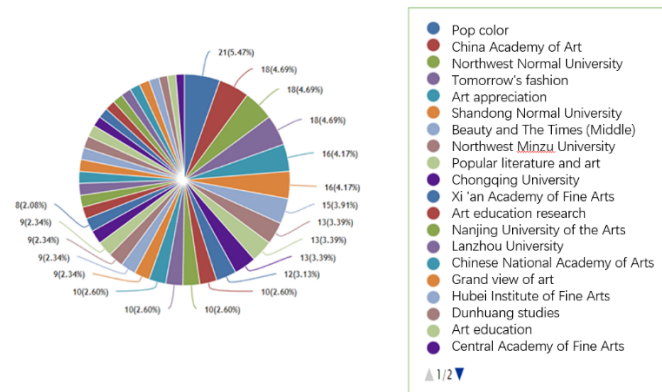


Figure 3: Distribution of published journals

A statistical analysis was conducted on all the results, and the distribution of literature journals in the field of mural color research is shown in Figure 3. A total of 894 articles on mural color research from 1980 to present were included in the CNKI database. The top 15 journals in terms of publication volume accounted for 55.49% of the total results. Among them, influential journals in this field include "Pop Color," "China Academy of Art," "Northwest Normal University," "Tomorrow's Fasion," and so on.

4. Research characteristics and development trend analysis

Due to the version problem of Citespace and the number of papers published on the study of mural color, the study period is from 2005 to 2023 (March), and the visual analysis is carried out.

4.1 Keywords co-occurrence analysis

Keywords reflect the research core and hotspots of literature, and co-occurrence analysis of keywords can reveal their connections. Therefore, in this article, Citespace was used to analyze the co-occurrence of keywords in the search results exported from the CNKI database. The keyword co-occurrence in Figure 4 shows a total of 497 nodes and 704 edges. The larger the node, the more frequently the keyword appears. The thicker the line, the higher the correlation between the keywords. Based on the analysis, the top nine keywords in terms of frequency are "Dunhuang mural" (201 times), "color" (149 times), "mural" (125 times), "Dunhuang" (29 times), "mural art" (22 times), "Tang Dynasty" (18 times), "tomb mural" (17 times), "traditional mural" (16 times), and "creation" (13 times). These top-ranking keywords are all research hotspots in recent decades.

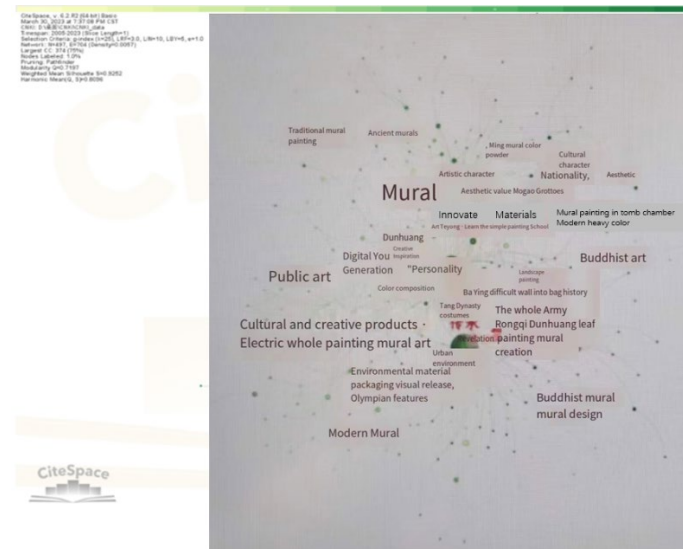


Figure 4: Keywords co-occurrence analysis

4.2 Keywords cluster analysis

Cluster analysis of keywords using CiteSpace helps accurately depict the latest trends in the research field. The ModularityQ value in the keyword cluster analysis in Figure 5 is 0.7197, within the range [0, 1) and $Q > 0.3$, indicating a significant division structure. The Mean Silhouette $S = 0.9252$, which is greater than 0.5, indicates acceptable clustering results. The Figure 5 highlights the 17 clusters with the strongest intra-cluster similarity and the most keywords: #0 Dunhuang mural, #1 mural, #2 color, #3 mural art, #4 modern mural, #5 technique, #6 traditional mural, #7 Tang Dynasty, #8 Buddhist art, #9 mural color, #10 tomb mural, #11 cultural and creative products, #12 Chinese language, #14 formal language, #15 health brands, #22 relief mural, #23 multi-dimensional intervention.

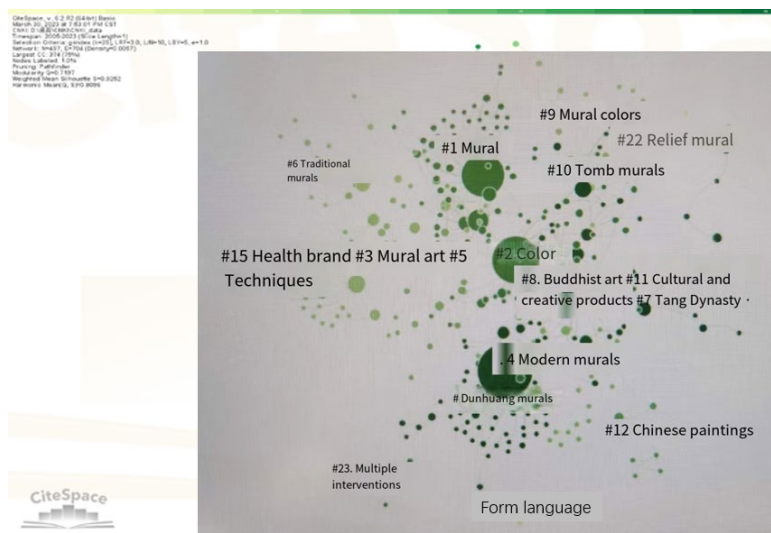


Figure 5: Keywords cluster analysis

#0 Dunhuang mural: Research on the color of ancient murals aims to reveal the sources, techniques, and color combinations used. The grand scale, rich content, and long history of the Dunhuang Mogao Grottoes murals have contributed to a comprehensive development of subsequent artistic endeavors, facilitating the study of Chinese painting history. Therefore, numerous scholars have conducted research on Dunhuang murals, starting from analyzing specific patterns and individual walls to describing the rich cultural connotations. Additionally, researchers have combined Dunhuang murals with modern animations and ballet, showcasing their cultural charm.

#1 Mural: Murals refer to images or patterns painted on the walls, ceilings, or other surfaces of buildings using inorganic pigments, possessing historical, cultural, or artistic value. Scholars discuss the changes in mural styles, shifts in content, and distinct temporal characteristics, as well as focus on the protection, care, and conservation of murals to ensure the long-lasting preservation of these artistic treasures with deep historical and cultural significance.

#2 Color: Color is an important element in mural creation. It is used to depict images, create atmosphere, and convey emotions through chiaroscuro and tone coordination. Color management and control are essential techniques in modern visual design and printing industries. These techniques ensure the accurate handling, identification, and adjustment of colors for precise image display. Furthermore, scholars conduct diverse studies on color, often drawing inspiration from precious artifacts inherited from ancient times for their creative works.

4.3 Keywords burst analysis

Burst terms are keywords that suddenly increase or significantly grow in frequency of use within a specific period. Analyzing burst terms can provide initial insights into the preamble of the "mural color" research. As shown in Figure 6, there are a total of 4 burst keywords. Begin indicates the start time of the keyword, while End represents the decline time, indicating that the keyword is in a period of sudden growth with strong burstiness during this duration. Strength represents the burst intensity, sorted by the strength of the bursts. The red and blue bars in the graph directly indicate the burst periods of the corresponding keywords. "Mural art" has the earliest burst time and declined in 2016. Both "mural art" and "modern mural" have longer burst durations, indicating that they received more attention. Cultural

and creative products may continue to receive attention and garner more importance. Although other factors have also received some attention, their burst intensities are weaker, indicating relatively less attention received.

Top 4 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2005-2023
Mural art	2005	3.76	2005	2016	
Modern mural painting	2006	3.41	2006	2013	
Tomb murals	2005	4.97	2019	2020	
Cultural and creative products	2019	3.73	2019	2023	

Figure 6: Keywords burst analysis

4.4 Keywords timeline analysis

By visualizing the analysis of keywords using a Timeline View, the keywords timeline analysis graph is obtained. From the figure7, it can be observed that different stages exhibit different research hotspots. The content connection among the first 12 clusters is closer, while the internal connection within the last 5 clusters is weaker, indicating relatively less attention received. However, clusters #0 "Dunhuang murals," #1 "mural," and #2 "color" have consistently remained popular research topics throughout the analyzed time period. They also show promising prospects and continue to be focal points of scholarly attention.

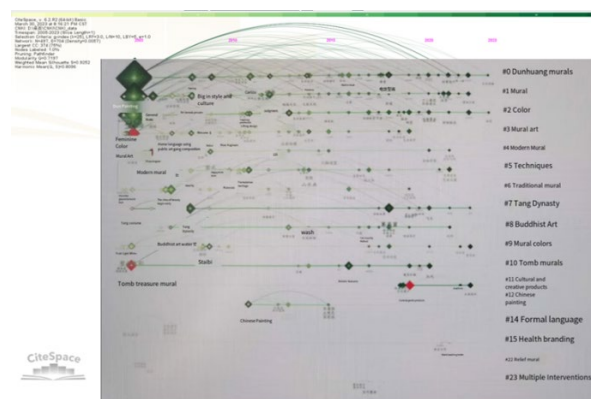


Figure 7: Keywords timeline analysis

5. Research conclusion and prospect

(1) The research characteristics of scholars on the analysis of mural colors can be summarized as follows:

① Adopting multiple techniques: Unlike traditional visual observation, scholars now commonly use various technological means to analyze colors, such as X-ray diffraction, infrared measurement, and UV fluorescence, in order to obtain more detailed and accurate information.

② Combining archaeological background and cultural context: Scholars not only focus on the color and compositional contrasts of murals, but also place emphasis on examining the historical period and cultural background in which they were created, further interpreting the meaning and artistic value of the images.

③ Exploring from multiple perspectives: Scholars comprehensively and deeply explore ancient murals from various perspectives, such as architecture, materials, painting techniques, and craftsmanship. The aim is to recreate the living scenes of the past era, providing a more intuitive way for contemporary people to understand ancient culture.

④ Emphasizing preservation and inheritance: At the same time, scholars strongly advocate for the protection and inheritance of cultural relics. They exchange ideas, draw on others' strengths, and formulate a series of comprehensive management and restoration plans, dedicated to preserving these precious historical sites for more people to understand and appreciate.

⑤ Modern creation: Scholars extract the essence from murals and use VR technology, program design, and other means to showcase the artistic images with an antique charm. Meanwhile, they apply these techniques to modern artistic creations, such as contemporary Chinese painting, modern dance movements, modern fashion and jewelry design, etc., combining the essence of ancient art with contemporary trendy ideas.

(2) There are still some shortcomings in the current research on mural colors:

① Limited by technological means and time constraints, existing studies lack in-depth analysis of mural colors. Currently, the discussion is mainly focused on the basics, such as pigments and contrast, without delving into the processes and techniques used in their creation and presentation.

② Current research mainly focuses on the color aspects of ancient murals, while paying less attention to the color characteristics of contemporary murals, urban graffiti, and other new forms of murals. There is a lack of systematic studies in this area.

③ Many murals are severely damaged, and some patterns cannot be restored. Regarding the color evolution, damage, and restoration of ancient murals, existing research has not been able to provide a comprehensive analysis from a meticulous technical perspective due to a lack of understanding of ancient color materials and descriptive techniques.

In summary, future research needs to further explore the technical origins, cultural connotations, and modern presentation methods of mural colors. It is necessary to strengthen related research in both technology and theory, and make efforts to reveal the historical, cultural, and artistic value of mural colors more deeply and comprehensively. In addition, greater efforts are needed to protect and restore ancient murals, avoiding further damage, in order to ensure the inheritance of these rare treasures for generations to come.

Acknowledgement

Fund Project: This study is one of the research achievements of Sichuan Minzu College Level Research Project "Color Analysis and Innovative Research on Murals in Ganzi Region" (XYZB2223SB).

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