Artistic heritage conservation: the relevance and cultural value of Guangzhou clan building paintings to traditional rituals from a kinship perspective through perceptual assessment and data mining

Weicong Li[1†], Shangbing Ma[1†], Wenwen Shi[2*], Haopai Lin[3], Yueling Liu[4], Yitong Cui[2] and Jinghui Ao[3]

Abstract

The study of clan paintings reveals a shift in perspective from art aesthetics to cultural connotations to cultural identity, yet literature seldom discusses the relationship between art and kinship culture. Taking the murals of ancestral hall architecture in Guangzhou as an example, this paper utilizes text mining to identify factors influencing its decorative art. It reveals the traditional rites' artistic expression through dimensions of characters' demeanor and the transmission of content values, offering a fresh perspective for heritage value research. Findings: (1) themes and implications are mostly oriented towards positive value transmission, transitioning from idealistic layman life to the realism of lower-class existence, emphasizing humanization; (2) the extroverted portrayal of characters contrasts with the dignified, restrained etiquette of traditional rites, with some characters' portrayal and facial expressions exuding approachability; (3) murals conveying positive emotions are mostly related to longevity, auspiciousness, fortune, and heroic deeds, while those conveying negative emotions mainly involve elderly male figures, reflecting a content bias related to characters; (4) historical allusion murals with complex content reduce the emotional resonance and arousal efficiency of the viewer; (5) incomplete mural content increases negative emotions in perceivers, highlighting the impact of mural preservation on emotional resonance. To delve into the formation of clan painting art, it is essential not only to interpret the diversity of its patterns but also to demonstrate the representation of its social attributes in decorative art. The formation of clan painting decorative art exhibits kinship cultural attributes, epitomizing the essence of traditional ceremonial thought.

Keywords Ancestral hall, Mural, Kinship culture, Patriarchal rituals, Decorative art, Heritage, Portrayal, Theme and moral, Text mining, Perceptual evaluation

†Weicong Li and Shangbing Ma contributed equally to this study and shared the first authorship.

*Correspondence:
Wenwen Shi
20140512@zufedfc.edu.cn
Full list of author information is available at the end of the article

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Introduction

The formation of the art of painting is the result of the confluence of multicultural influences and historical contexts, reflecting humanity's pursuit of aesthetics and symbolism [1]. As interconnected pieces of art, the cultural formation of architectural mural art represents a combination of historical accumulation and artistic creation, showcasing the resonance of regional characteristics and cultural memory [2]. Serving as the spatial carriers for clan murals, the preservation of cultural heritage related to ancestral hall architecture has become a globally discussed topic, with the heritage value of ancestral hall murals elevated to the dimensions of "identity symbolism and cultural identity" [3]. The "Cultural Heritage Protection Policy" enacted by the Guangdong Provincial Government [4] emphasizes the historical value and urgency of protecting tangible heritage art, encouraging the application of scientific methods and local cultural sensitivity in restoration.

However, the pluralistic development of urban culture presents challenges of cultural loss and homogenization to ancestral hall murals: (1) a discordance between original content and modern restoration methods; (2) the potential for modern materials and techniques to conflict with the original style; (3) the possibility of historical authenticity distortion during the image restoration process. These issues stem from a lack of understanding of the cultural connotations of mural art, leading to a disconnection between protection strategies and cultural values.

The study by Guo and Singyabuth [5] focuses on Shaolin Temple murals, revealing how these works embody traditional Chinese martial arts culture and play a significant role in shaping national ideology. This art form possesses a unique power in conveying cultural values and historical context. Meanwhile, the research by Vucetic et al. [6] on Colombian mural art emphasizes the close relationship between art and politics, suggesting murals may reflect specific socio-political environments. Rolston [7] shifts focus to analyze social issues behind murals, such as inequality issues in Chile, demonstrating how murals can reflect social issues. Źrałka et al. [8] enrich this discussion further, arguing that the fictional elements in murals reflect people's aspirations for an ideal life and serve as carriers for social and cultural identity.

Li et al. [2] explore the changes in human postures in ancestral hall building murals, reflecting cultural shifts, particularly the dilution of ritual concepts and the gradual loss of traditional cultural genes. This finding suggests a transition in the cultural values and social norms reflected in the artworks. Rolston [9] focuses on the symbolic significance of murals in Northern Irish communities, especially their expression of collective memory and peace. Government demolition plans could harm this cultural memory, highlighting the importance of murals in maintaining community identity and historical continuity. Yan [10] shifts the perspective to Guangzhou ancestral hall murals, emphasizing their role as material links between the past and present, showcasing the core position of murals in transmitting and interpreting cultural values. Chen [11] reveals the clan lineage colors in ancient Chinese tomb murals through analysis, and the materials and techniques used symbolize wealth and status, highlighting the role of murals in expressing social hierarchy and clan glory.

Recent studies have primarily focused on the representation of mural art within cultural and political contexts, and how these murals reflect social and cultural identities. There has been a shift in research perspectives from art aesthetics to cultural significance and cultural identity, leading to two scholarly questions: (1) How do murals exhibit regional characteristics, historical contexts, and social changes on a local level? (2) How does mural art contribute to cultural transmission and identity formation within families and communities? Although Li et al. [2], Qi [12], and Shi and Wang [13] have explored the correlation between Chinese mural decoration and Confucian culture, they have not delved into the ritual components influencing decorative arts.

Research on the artistic elements of tangible heritage represents one of the most fundamental aspects of Chinese traditional culture and a cornerstone of national prosperity [14]. Ancestral halls, as crucial carriers of Chinese clan culture, are products of the interplay between regional culture and social history, with the mural art in Guangzhou's ancestral halls exhibiting distinctive artistic styles and social functions [2]. According to incomplete statistics, approximately 4097 murals have been documented in Guangzhou's ancestral halls [15], with detailed descriptions provided in relevant series [16, 17], which form the foundational data for this study.

Addressing the scholarly inquiry into how kinship influences clan mural decorative art and the representation of traditional rituals in artworks, this study aims to identify the ritual factors impacting the mural art in Guangzhou's ancestral halls. By analyzing the artistic manifestations of ritual factors through the demeanor and expressions of figures and the thematic content, this research seeks to uncover the cultural formation processes behind clan mural art. The study proposes two hypotheses: (1) Traditional rituals shape the positive thematic content and humanistic value transmission of Guangzhou's ancestral hall murals, and their decorative art possesses both idealistic and realistic significance; (2) The demeanor and expressions of the figures in the murals reflect both material and spiritual

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kinship, and the overall narratives and symbolism of the murals are positive. This research provides empirical support for the application of text mining and perceptual evaluation in cultural heritage studies and incorporates traditional rituals as influential factors in the formation of clan mural art, thereby broadening the research perspective in art studies.

Although data mining aids researchers in extracting common features from 521 murals, text-based analysis may have limitations in fully elucidating the correlations between spatial functions and mural themes, content, and decorative elements. This is mainly due to the following reasons: (1) The complexity of spatial functions and artistic expressions. Due to policy impacts, some literature has noted the integration of lecture halls and sacrificial functions during the Ming and Qing dynasties [18], raising questions about whether mural content creation in specific cases was influenced by functional transitions; (2) The diversity of historical and cultural contexts. The changing status of Confucianism in different periods in China may influence clan culture, which could, in turn, affect the ritual components in the creation of ancestral hall mural content. For instance, during periods when Confucianism was highly esteemed, the decorative art in ancestral halls might have emphasized rituals and moral education [19], whereas in other periods, the content might lean towards everyday life or practical themes [20]. Sometimes, visual art may not fully and accurately reflect the underlying cultural meanings [21]. Ao et al. [22] highlighted this point and stressed the importance of integrating multiple perspectives and methods.

Methodology
Research framework

Figure 1 illustrates the research methodology of this paper. Stage 1 (Sect. "Introduction") involves defining the research question by understanding the history and progress of clan paintings through literature review, identifying research gaps to specify research objectives and hypotheses, thereby positioning the study's academic value within the field. Stage 2 (Sect. "Data sources") focuses on extracting, categorizing, and coding textual materials and deriving influencing factors on the formation of clan painting art through descriptive statistics of adjectives and emotional words. Stage 3 (Sect. "Constructing evaluation scales") utilizes the co-occurrence network generated from coded groups to reveal potential interrelations between cluster groups and their elements, refining 'posture and expressions' and 'character coloring' as two core themes. Stage 4 (Sect. "Results") centers on the analysis and evaluation of clan painting art. It discusses how kinship relationships shape clan painting art and how these two core themes are expressed by analyzing typical painting samples. Additionally, it employs the Semantic Differential Method and factor analysis for perceptual evaluation of Mural Content to validate the results of emotional analysis. Stage 5 (Sect. "Discussions") discusses the results and introduces new academic questions. This stage responds to the research questions, hypotheses, and inferences made in the introduction, compares findings with those of peers, and identifies unresolved issues. It also discusses the potential and technical challenges of applying text mining in the art field and creates an academic contribution map to
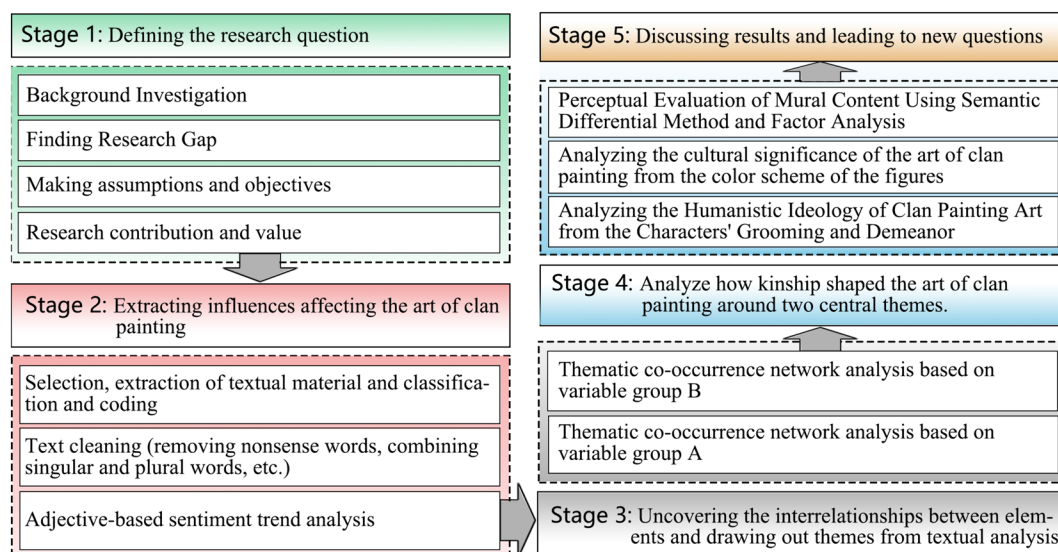

Fig. 1 Research technology pathway map

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highlight the study's value. Lastly, it acknowledges limitations and suggests improvements.

The data processing procedure in Stages 2–3 includes [23, 24]: (1) selecting appropriate textual materials, summarizing them in Excel in the form of excerpted sentences, and categorizing and coding these cells for theme analysis; (2) during data cleaning, writing "Force Pick up" and "Force Ignore" scripts to extract compound words and filter out meaningless words, checking for expanded words, and handling singular and plural words in the frequency list; (3) conducting co-occurrence networks analysis based on grouped coded variables. High co-occurrence words in the compiled database are displayed in a network graph, analyzing patterns and similarities between words for theme mining. The thickness of the connecting lines indicates the degree of relevance, numbers represent co-occurrence frequency, and the size of word circles indicates frequency, with nodes having multiple branches typically being thematic due to their centrality.

Data sources

Chinese scholar Liu's "Guangzhou Ancestral Hall Murals", volumes one and two, published in 2015, is where the research material for this study came from [16, 17]. These two books were originally intended as a methodical way to go through and examine the distinctive mural painting that may be found in ancestral halls around Guangzhou. Murals are a type of art that is both unique and prone to deterioration, so it is important to preserve and share them through publications like books. The 521 artistically valuable ancestral hall murals were painstakingly arranged by Liu with the goals of cultural preservation, scholarly investigation, and educational popularization. Using a combination of text and imagery,

he cataloged the murals' origins, content, artistic techniques, and qualities, along with their connections to the ancestral halls in which they are located.
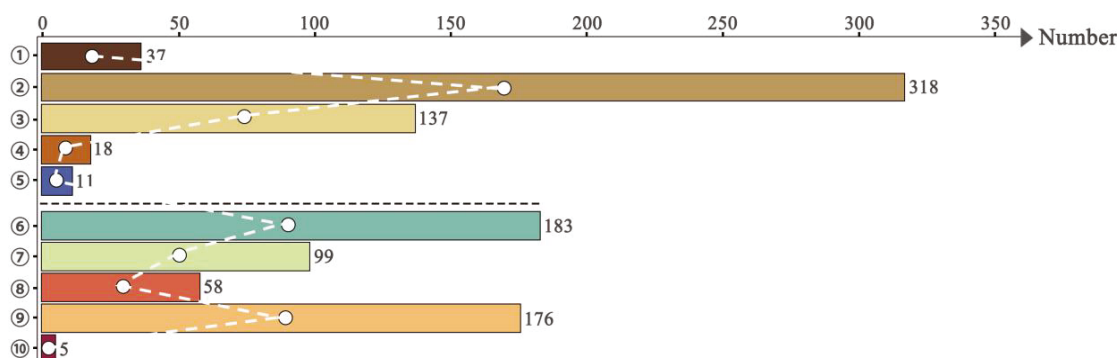
To focus on the theme, only descriptive details about the paintings will be taken out and analyzed. Textual analysis will not consider details from the books, including images, authors, inscription dates, painting names, ancestral hall locations, and scroll specs. This data has been collated by the team into an Excel document that has 521 groups of cell text prior to extraction for analysis. In addition, new list columns were established by information filtering and the mural subjects and tale contents were split into external variables Group A and Group B in preparation for the subsequent coding investigation. The initial subject and material categorization is listed in Table 1. Figure 2 illustrates the number of murals in groups A and B following classification, highlighting the process's objectivity.

Constructing evaluation scales

The factors affecting an individual's perception of a material form are complex and include a variety of aspects such as its substance itself, individual experience, environmental factors, non-environmental factors, and sensory abilities [25]. To assess the authenticity of the value transmission in mural content, this paper employs the Semantic Differential Method (SD), factor analysis, and cluster analysis to evaluate murals from the perspectives of emotional perception and value dimensions. The SD method, also known as the sensory recording method, proposed by Osgood [26], is a psychometric technique for assessing participants' psychological reactions to verbal scales. Utilizing Stratified Sampling Method, this study selects 25 murals with varying themes from a pool of 318 for perceptual evaluation surveys. The evaluation

Table 1 Initial coding table for external variables group A and group B

Group A: Topic Selection/Coding			Group B: Content/Coding		
Landscapes(a),Character Scene(b), Flowers & Birds(c),Portfolio Pictures(d), Bird & Beast(e), Plant(f), Flowers & Birds- Patterned(g), Flowers & Birds & Rare Birds(h), People(i), Fish & Insects(j), Scenes(k)			Aspiring life(a), Historical Allusion(b), Myths & Legends(c), Beautiful yearning(d), Good Luck(e), Harmonic Allegory(f), Strive For Prestige(g), Folk Stories(h), Legendary Stories(i), Fables(j), History People(k), Fisherman Farming(l), Character Image(m), Folklore(n), Life as a resident(o), Birds & Flowers(p)		
Variable group A			**Variable Group B**		
Code	Number	Component elements	Code	Number	Component Elements
Scenery ①	37	a、k	Historical Allusion ⑥	183	b、g、l
Character ②	318	b、i	Legendary Story ⑦	99	c、k、h、n、j
Floral Plant ③	137	c、f	Aspiring Life ⑧	58	a、d、o
Portfolio Pictures ④	18	d、g	Auspicious Parable ⑨	176	e、f、p
Bird & Beast ⑤	11	e、h、j	Celebrity Story ⑩	5	k、m

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Fig. 2 Number of murals in both subgroups

dimensions are built upon the Affective Arousal Theory, which is grounded in cognitive psychology principles and explores the interaction between environmental stimuli and individual emotional states [27]. This theory introduces a multidimensional measurement tool named the Environmental Emotional Response Index (EERI), aimed at quantitatively analyzing the impact of the environment on human emotions. EERI assesses the environment on two main dimensions, pleasure and arousal, measuring both the positivity/negativity of emotions triggered and the level of mental activation. The constructed evaluation scale includes ten pairs of adjectives, six derived from the Affective Arousal Model (happy-unhappy-1, excited-calm-2, relaxed-tense-3, interested-monotonous-4, inspiring-depressed-5, arousing-tedious-6), three from the aesthetic senses of murals (comfortable-uncomfortable-7, warm-desolate-8, harmonious-inharmonious-9), and one pair from the content and value aspect, emphasizing the pursuit of basic material desires versus the aspiration for spiritual ideals such as simplicity, immortality, prosperity, and peace (Materialistic-Spiritual-10). These 10 sets of adjectives were coded using numbers from 1 to 10 to facilitate subsequent analysis.

The assessment is broken down into five indicators, each of which has a separate score: neutral-3, comparably closer to negative adjectives-2, near to negative adjectives-1, neutral-5, and comparatively closer to positive adjectives-4. The evaluative representation of the mural contents is shown in Table 2.

Results

Co-occurrence network based on coded B groups

KH Coder is an AI-based text analysis tool that facilitates discourse analysis by employing artificial intelligence algorithms [28]. Using KH Coder, this study created "co-occurrence" networks for two groups of coded content, comprising "nodes" and the "edges" that connect these nodes. In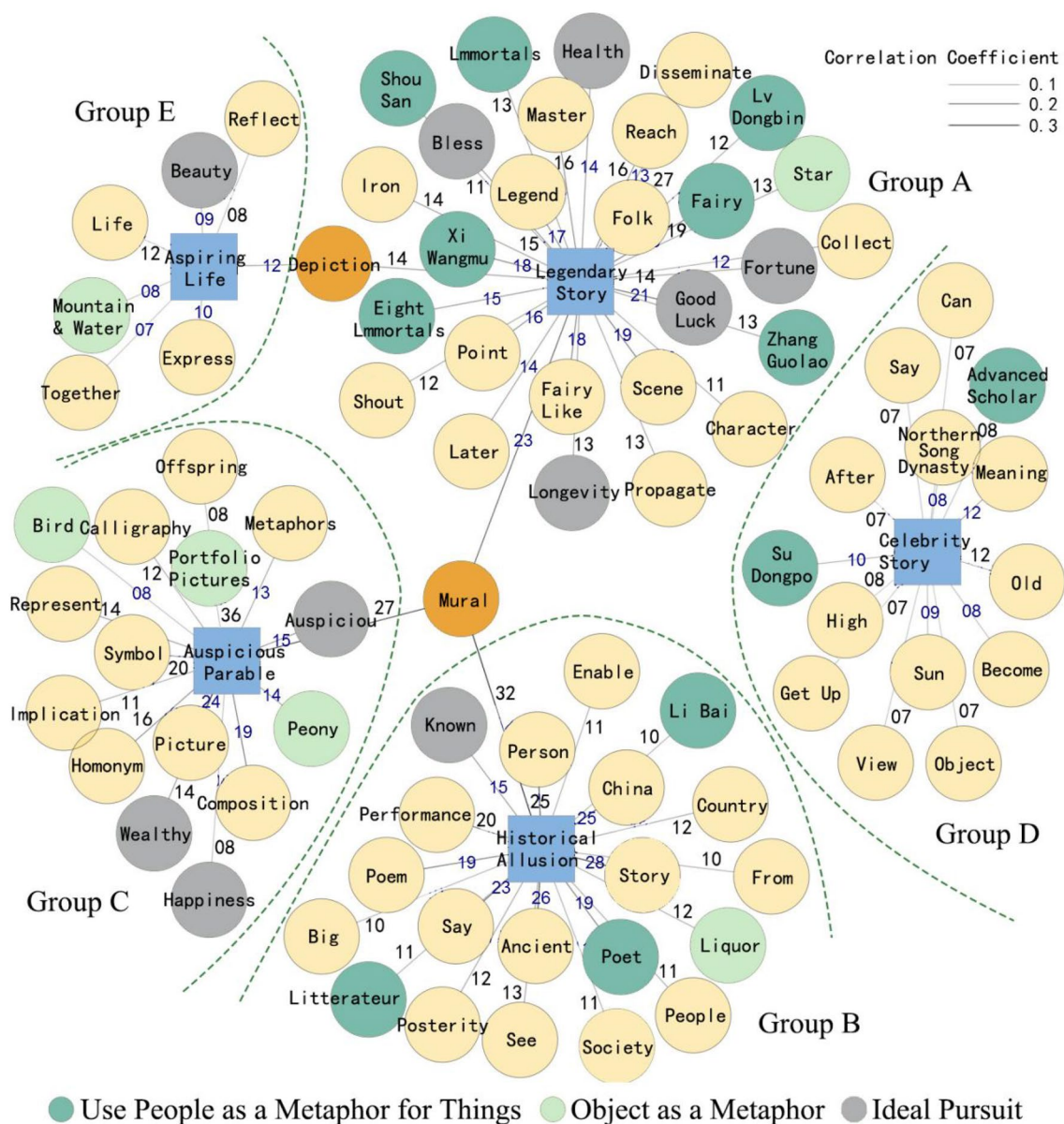 this network, nodes connected by edges share close relationships, with an increase in edges indicating higher relevance. The Reading Value (RV) at each node is generated based on textual semantics, with the software classifying words into clusters of different colors based on RV and textual relevance. This study extracted words with the Top 100 Term Frequency (TF) for display and outputted the minimum spanning trees (Figs. 3, 4).

Figure 3 illustrates the thematic network formed by Group A's coding, with thematic clusters differentiated by dashed lines. The central cluster is formed around "Character" and "Floral Plant," with "Bird and Beast" and "Portfolio Pictures" forming secondary clusters. Due to a lower number of Top 100 vocabulary in the "Scenery" cluster, its core content is not prominently represented, leading to its classification as an ineffective cluster. The connection between "Character" and "Floral Plant" clusters through "Murals" suggests a symbiotic relationship between the two clusters, inferring that floral plants are a primary element in ancestral hall mural decoration [29]. Additionally, the link between "Floral Plant" and "Bird and Beast" clusters through the word "Symbol" and the internal vocabulary of both clusters, such as "Longevity Stone," "Peony," "Magpie," "Fairy Crane," "Pine," etc., suggests that floral plants and birds and beasts primarily serve metaphorical and symbolic roles in mural decoration [30]. They collectively underscore the profound implications of the story content, employing the technique of metaphorical representation (highlighted in green vocabulary). The accompanying vocabulary between "Floral Plant" and "Portfolio Pictures" clusters, including words like "happiness," "beauty," "wealth," "couple," "longevity," etc., underscores that elements composing mural compositions typically carry consistent implications [31], reflecting a specific societal aspiration for a desirable life.

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Table 2 Example of a perceptual evaluation table for murals contents

Mural sample:		Type:						Mural name:
Mural title	Basic information	Positive adjectives	5	4	3	2	1	Negative adjectives
The Golden Jade of the Book	This mural was created in the nineteenth year of the Guangxu Emperor's reign (1893) but was later restored due to damage. The content of the mural encourages clan members to diligently pursue their studies, highlighting that success in the imperial examinations can be achieved through hard work	Happy						Unhappy
		Excited						Calm
		Relaxed						Tense
		Interested						Monotonous
		Inspiring						Depressed
		Arousing						Tedious
		Comfortable						Uncomfortable
		Warm						Desolate
		Harmonious						Inharmonious
		Materialistic						Spiritual

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Fig. 3 Thematic co-occurrence network based on coding group A

Figure 4 presents a thematic network based on coding group B. The term "Depiction" serves as a link between the themes "Legendary Story" and "Aspiring Life," grouping them into clusters while illustrating their separation and symbiotic relationship. Hence, it can be inferred that ancestral hall murals express a beautiful aspiration towards life through the depiction of life stories [32]. Dark green terms highlight the figurative elements referenced in the murals, such as well-known figures like "Lv Dongbin (吕洞宾, RV = 12)," "Zhang Guolao (张果老, RV = 13)," "Xi Wangmu (西王母, RV = 18)," "Eight Immortals (八仙, RV = 15)," "Shou Shan (寿山, RV = 15)," "Immortals (仙人, RV = 13)," and "Fairy (神仙, RV = 19)," predominantly associated with the theme "Legendary Story." Their frequent appearance emphasizes the method of 'using people as metaphor for things (以人喻事)' in mural decoration, reflecting a thought evolution from ancient to modern times [33]. Light green terms reveal the presence of object elements in the murals, primarily surrounding the theme "Auspicious Parable." For instance, terms like "Bird (RV = 6)," "Portfolio Pictures (RV = 36)," and "Peony (RV = 14)" suggest that object elements in the murals may use the method of 'object as a metaphor (托物喻志)'. Grey terms denote the adjectives used to describe the murals, such as "Health (RV = 14)," "Bless (RV = 11)," "Fortune (RV = 14)," "Good Luck (RV = 21)," "Longevity (RV = 13)," "Auspicious (RV = 15)," "Wealthy (RV = 14)," and "Happiness (RV = 8)," which predominantly appear alongside the themes "Legendary Story" and "Auspicious Parable." Therefore, it reflects that the portrayal of people and objects in ancestral hall murals generally conveys consistent implications and emotional tendencies, mainly transmitting people's ideal pursuit of life.

The humanistic thought reflected in grooming and appearance: from pluralism to the return of traditional thinking

The posture, demeanor, and dynamic gestures and facial expressions of figures in Guangzhou ancestral hall murals reflect, to some extent, the trajectory of socio-cultural changes and the speculative process concerning traditional etiquette standards. This phenomenon is primarily manifested in the rich portrayal of characters' emotions and the delicate depiction of their expressions, revealing subtle shifts in social mood and cultural trends.

The diversity in the depiction of characters' emotions vividly presents the social landscape of the Guangzhou area in modern times (Table 3). As the sole port open to foreign trade before the Opium Wars, Guangzhou's trade surplus propelled local prosperity [34]. During this period (accounting for 16.6% of the total murals), the

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Fig. 4 Thematic co-occurrence network based on coding group B

murals depicted characters with joyful faces and graceful demeanors, embodying harmonious emotions and reflecting the material wealth of the populace at the time. However, between 1840 and 1900 (accounting for 50% of the total murals), there was a diminution in the portrayal of characters' emotions, reflecting public concern over social unrest and resonance with internal and external troubles. For instance, the 1831 'Sanda Waka (三田 和合)' showcased a harmonious coexistence among the people of Luoyang (洛阳), Putian (莆田), and Hetian (河田), embodying a yearning for peace and expectations for future prosperity. The 1893 'The Golden Jade of the Book

(书中金玉)' used the image of a scholar to express the belief that knowledge can change one's fate, while also revealing concerns and helplessness regarding the social situation through facial expressions.

In studies of Guangzhou ancestral hall murals, the detailed capture of characters' expressions and everyday behaviors reflects a re-examination of the "demeanor" requirements in traditional etiquette, while also revealing deep reflections on human nature and societal values. Among the analyzed 318 murals, characters' expressions mainly showcased aspirations towards both spiritual and material lifestyles (Table 4), reflecting the pursuit of the

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Table 3 Character expressions of positive and negative emotions

Emotion	Types	Emotional and spiritual portrayal of fresco characters			
positive	Murals				
	Name	The Longevity of Life-1806 (寿享无疆)	Sunbathing in the Belly-1822 (晒腹图)	The Drunkenness of Tai Bai-1829 (太白醉酒图)	Sanda Waka-1831 (三田和合)
	Scenes	Gathering of Immortals (群仙聚会)	Leisurely and cozy (休闲惬意)	Li Bai's Drink (李白对饮)	Harmony and Harmony (和谐融洽)
	Emotion	Joyful and laughing about life	Smiling, living with abundance and confidence	Get drunk with joy	Laughter and Drunkenness
	Position	Tan Bu Town, Dong Feng Village, Jigong Book House (炭步镇东风村积公书舍)	Zhong Ancestral Hall of the 14th and 15th Communes of Liantang Village (莲塘村十四、十五社钟氏宗祠)	Zhang Ancestral Hall of Nanyangzhuang, Qingding Village (清饰村南阳庄张氏宗祠)	Xie's Ancestral Hall in Wen Er Village, Tan Bu Town (炭步镇文二村谢氏宗祠)
	Murals				
	Name	Fortune from heaven-1882 (福自天来)	Universe in a Gourd-1887 (葫里乾坤)	Three Stars in Merriment-1838 (三星耍乐)	Complete Blessings, Prosperity, and Longevity-1872 (福禄寿全)
	Scenes	Outdoor play	The Taoist Life of the Immortals	Tea break and laughter	Life Scene of the Three Stars of Longevity
	Emotion	Idle and indifferent to fame and fortune	Indulgence and freedom	Be at ease and enjoy the moment	Amuse yourself, talk and laugh
	Position	Zhong Family Ancestral Hall of the Fourteenth and Fifteenth Associations in Liantang Village, Chini Town (赤坭镇莲塘村十四、十五社钟氏宗祠)	Guo Family Ancestral Hall of the Twelfth Association in Changang Village, Chini Town (赤坭镇缠岗村十二社郭氏宗祠)	Wen Zhan Luo Public Ancestral Hall of the Fourth and Fifth Associations in Liantang Village, Chini Town (赤坭镇莲塘村四、五社文湛骆公祠)	Quanshi Luo Public Ancestral Hall of the Tenth Association in Liantang Village, Chini Town (赤坭镇莲塘村十社泉石骆公祠)

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Table 3 (continued)

Emotion	Types	Emotional and spiritual portrayal of fresco characters			
negative	Murals				
	Name	Figure Drawing-1859 (人物图)	The Drunkenness of Liu Ling-1872 (刘伶醉酒)	The Ishigaki Matsushika-1885 (益寿松芝)	The Golden Jade of the Book-1893 (书中金玉)
	Scenes	look at each other in dismay	Chatting	Praying for blessings	Sighing and resting
	Emotion	worried about the country and the people	drown one's sorrows in wine	Gloom and doldrums	Hope to save the country through study
	Position	Lu's Ancestral Hall in the 13th community of Liantang Village (莲塘村十三社卢氏宗祠)	Ye Ancestral Hall of Longtang Natural Village (龙塘自然村叶氏宗祠)	Maoying Lu Gong Ancestral Hall, Lian Tang Village, Twelve Communes (莲塘村十二社茂英卢公祠)	Tianxin Village Mai Clan Ancestral Hall (田心村麦氏大宗祠)
	Murals				
	Name	White Goose Exchanges Scriptures-1897 (白鹅换经)	Wang the Hermit Refines Elixirs-1845 (王野人炼丹)	Empty Fort Strategy-1900 (空城计)	Hero Sits Alone-1887 (英雄独坐)
	Scenes	Ask for knowledge	Work hard on a potion	The era of war and chaos	Furn over a new leaf
	Emotion	Learning with an open mind, bartering	Learning from failure	Pray for peace	Commit a sin and be ashamed of yourself
	Position	Li Family Ancestral Hall in Buyun Village, Tanbu Town (炭步镇步云村李氏宗祠)	Bozhao Tang Public Ancestral Hall in Jun Tian Village, Shi Ling Town (狮岭镇军田村伯昭汤公祠)	Xu Public Ancestral Hall at Donghu in Xihua Community, Sanhua Village, Xinhua Street (新华街三华社西华社洞湖徐公祠)	Ancient Emperor Temple in Hengsha Village, Chini Town (赤坭镇横沙村帝王古庙)

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"unity of knowledge and action" philosophy in social culture and concern for individual value and dignity. The 1893 'The Return of the Storm (风雨归舟)' depicted a fisherman in a manner that was down-to-earth and relatable, contrasting sharply with the dignified, reserved, and discreet etiquette advocated by traditional rites. Although the majority of murals still maintain a reserved, implicit, and self-restrained portrayal of characters' demeanor and expressions, some works have begun to exhibit more approachability, reflecting a humanized, back-to-basics societal value system.

Perceptual evaluation of mural contents based on semantic differential method and factor analysis.

Drawing on the Delphi method [35], this paper invites 24 experts from related fields to appreciate and evaluate 25 randomly selected mural samples. The career fields of the assessment experts cover art history, anthropology, architecture, fashion design, visual communication design, environmental design, color studies, Chinese language and literature, fusion design, oil painting, cultural and creative design, and neuroscience. The coverage and diversity of the assessment experts' professional fields make the assessment results more scientific.

First, an average score (AS) is determined by compiling all evaluation indicators created by the 24 experts. Next, a statistical analysis is conducted on the AS of the assessment indicators for every category of murals. The statistical data are displayed in Table 5. The Delphi technique aids in focusing expert viewpoints, while the SD scale makes the range of positive and negative ratings more clear. An AS > 3 denotes that the murals' content transmission is favorable in one or more dimensions [36].

After that, the data in Table 5 will be statistically analyzed using SPSS software. The data's appropriateness for factor analysis will be determined using the Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity. The dataset is considered acceptable for factor analysis with a KMO measure of sample adequacy value of 0.794, above the suggested threshold of 0.8, and a significance level of 0 in Bartlett's test of sphericity. After that, components are extracted using principal component analysis to make sure they account for more than 80% of the total variance explained. Three major factors are identified, with a cumulative total variance explained of 84.634%. Subsequently, principal component analysis rotates the component matrix to better extract common factors. In Table 6, the dominant values (when these values are greater than 0.4, it means that there is a correspondence between the item and the factor.) represent the principal components of different adjective pairs. These factors are named 'Emotional Response (Component 1)', 'Value Orientation (Component 2)', and 'Vitality Arousal (Component 3)'.

By multiplying the component score coefficients matrix with the standardized adjective pair scores and summing them, scores for three factors (y1, y2, y3) are calculated. Then, using Equation I to perform weighted calculations on the Rotated Sums of Squared Loadings, a comprehensive score ranking for emotional perception and value dimensions is obtained. Finally, employing the between-groups linkage method as the clustering strategy and squared Euclidean distance as the measurement standard, cluster analysis generates a dendrogram (Fig. 5), categorizing the murals into four groups: Positive Emotion Group, Negative Emotion Group, Low Stimulation Group, High Stimulation Group.

Discussions

The perception analysis results demonstrate that: (1) both the Low Stimulation Group and Positive Emotion Group exhibit characteristics capable of conveying positive implications, regardless of their leaning towards spiritual values or material pursuits. These 2 groups together constitute 80% (20 murals) of the sample, indicating that the majority of murals are capable of stimulating positive emotional responses in viewers, primarily due to the consistency between the murals' content and aesthetic elements; (2) the murals in the Positive Emotion Group are mostly named after themes related to longevity, auspiciousness, blessings, and heroic deeds, while the Negative Emotion Group predominantly features elderly male characters, reflecting content preferences related to character depiction; (3) the murals in the Low Arousal Efficiency Group are associated with complex historical allusions such as classic texts, seeking advice from sages, and Confucian education, whose complexity may hinder audience resonance, thereby reducing arousal efficiency; (4) the murals in the Materialistic Group are typically named after wealth and official career achievements, demonstrating a high degree of consistency between the clusters derived from factor analysis and the content, reflecting the unidirectionality of mural content, implications, and emotional responses. Among the 25 samples selected, the materialistic group accounted for 16% of the murals (4), while the remaining 21 showed pro-spiritual tendencies, suggesting that the viewing experience was more spiritually oriented (AS = 2.382 < 3); (5) murals in the High Stimulation Group and Low Stimulation Group, such as 'The Divinatory Diviner (卜卦卜翁)', showcase negative emotions due to the portrayal style of the characters or damage to the painting, reflecting the impact of painting style and preservation status on emotional responses.

In terms of locality, ancestral hall murals serve as carriers of cultural continuity through the use of unique elements, colors, and symbols, showcasing local culture,

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Table 4 Materiality and spirituality in the depiction of character expressions

Expression	Types	Name	Scenes	Express	Position
Materiality	Murals	The Four Phase Chart-1858 (四相图)	Appreciation of flowers and sealing	Longing for the life of the literati	Quan Shi Luo Gong Ancestral Hall, Liantang Village, 10th Community (莲塘村十社泉石公祠)
		The Drunken Music of Penglai-1838 (蓬莱醉乐图)	Drinking for pleasure	Yearning for a divine life	Liantang Village, four, five community Wenzhan Luo Gong Ancestral Hall (莲塘村四、五社文湛路公祠)
		The Scripture Transmission Chart-1893 (传经图)	Cultural Heritage	Pursuit of learning	Tianxin Village Mai Clan Ancestral Hall (田心村麦氏大宗祠)
		JI Qin Ruan Xiao-1847 (稽琴阮啸)	drums and blowing piths	A carefree life	Huang Ancestral Hall of Shawan Natural Village (沙湾自然村黄氏宗祠)
		Tao Yuanming Appreciating Chrysanthemums-1911 (渊明赏菊)	Appreciate the chrysanthemums	Aspire to the free life of the literati	Tan Family Ancestral Hall in Wen Yi Village, Tanbu Town (炭步镇文一村谭氏宗祠)
	Murals	Three Abundances and Auspicious Celebrations-1910 (三多吉庆)	Combination of a birthday boy and a child	The pursuit of many sons, many blessings, and many lifetimes	Huang Family Ancestral Hall in Wushi Village, Chini Town (赤坭镇乌石村黄氏大宗祠)
		Eighteen Grand Scholars-1887 (十八大学士)	Academic discussion	pursue knowledge without concern for fame or fortune	Guo Family Ancestral Hall of the Twelve Communities in Changan Village, Chini Town (赤坭镇缰岗村十二社郭氏宗祠)
		Paying Homage to the Master-2004 (拜师图)	Seek knowledge and ask questions	Learning and self-recognition	Tang Gong Ancestral Hall in South Cha Tang Community, Tanbu Town (炭步镇茶塘南社明峰汤公祠)

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Table 4 (continued)

Expression	Types	The expression of mural character			
Spirituality	Murals				
	Name	The Return of the Storm-1893 (风雨归舟)	The Divinatory Diviner-1893 (卜卦卜翁)	The Woodcutter-1875 (樵夫)	The Rakugo Map-1807 (烂柯图)
	Scenes	Fishing	Busy making a living	Woodcutter fetching firewood	Watch the chess game
	Express	Exhaustive fishing and hunting	Look serious and formal	Tired, hard work and sweat	Slacking off at work
	Position	Tianxin Village Mai Clan Ancestral Hall (田心村麦氏大宗祠)	Tianxin Village Mai Clan Ancestral Hall (田心村麦氏大宗祠)	Dongkeng Natural Village Nanzhi Wang-gong Ancestral Hall (东坑自然村南校王公祠)	Chao Bo Zhang Gong Ancestral Hall of Duck Lake Village, Tan Bu Town (炭步镇鸭湖村朝伯张公祠)
	Murals				
	Name	The Three Heroes of the Storm-1893 (风尘三侠)	Fishing, Woodcutting, Farming, and Reading-1894 (渔樵耕读)	Liu Ling's Wine Battle-1911 (刘伶斗酒)	Portrait of the Fifth Lady-1893 (五娘图)
	Scenes	Discuss how to govern the country	Gathering of Fisherman, Farmer and Scholar	Make merry while drinking	Women as masters of their own house
	Express	The look of determination, the pursuit of power	Praise for hard work, thrift and learning	Satisfying the affluent life of the moment	Praying for an ordinary life
	Position	Mai Family Ancestral Hall in Tianxin Village, Chini Town (赤坭镇田心村麦氏大宗祠)	Li Public Ancestral Hall of Tingfang in Lantian Village, Chini Town (赤坭镇蓝田村廷芳李公祠)	Tan Family Ancestral Hall in Wenyi Village, Tanbu Town (炭步镇文一村谭氏宗祠)	Mai Family Ancestral Hall in Tianxin Village, Chini Town (赤坭镇田心村麦氏大宗祠)

Table 5 Results of perceptual evaluation of 25 murals under different emotional dimensions

Samples	Mural emotion classification codes									
	1	2	3	4	5	6	7	8	9	10
1	3.792	2.250	3.792	3.667	3.667	4.083	3.625	3.625	3.792	2.500
2	4.000	3.250	4.167	3.667	3.542	3.250	3.917	3.708	4.083	2.250
3	3.625	2.833	3.458	3.667	3.667	3.875	3.583	3.958	4.250	1.875
4	3.750	3.292	3.292	3.708	3.875	3.667	3.583	3.292	3.833	2.042
5	2.750	3.958	2.542	3.458	3.583	3.917	2.833	2.750	2.917	2.333
6	3.625	2.375	3.625	3.458	3.333	3.250	3.792	3.333	3.750	2.708
7	3.958	3.083	4.292	3.875	3.125	3.625	4.042	3.625	3.792	2.042
8	4.167	2.875	4.292	3.833	3.667	3.417	4.000	3.875	3.708	2.500
9	4.250	3.500	3.833	3.917	3.542	3.667	4.000	3.792	4.083	2.292
10	3.792	2.833	3.500	3.542	3.917	3.875	3.875	3.708	4.167	1.792
11	4.458	3.083	4.208	3.875	3.458	3.625	3.917	4.042	4.000	1.708
12	4.292	3.375	4.292	4.042	3.708	3.500	4.042	3.833	3.708	1.750
13	4.250	3.292	4.083	3.875	3.625	3.625	3.792	3.833	3.833	1.792
14	4.458	3.708	3.875	3.875	4.167	3.708	4.042	3.875	4.083	3.083
15	4.583	3.542	4.375	3.958	3.750	3.625	4.167	4.417	4.292	1.750
16	4.667	3.792	4.333	3.917	3.875	3.583	4.250	4.208	3.875	2.167
17	4.500	3.542	4.167	4.083	4.083	3.708	4.083	3.667	4.000	3.083
18	4.208	3.375	4.000	3.917	3.708	3.708	4.042	3.708	4.208	2.500
19	3.958	3.083	4.083	3.833	3.667	3.667	4.083	3.625	3.958	1.833
20	4.208	3.292	4.083	3.833	3.583	3.417	4.125	4.000	3.958	2.250
21	2.875	2.750	2.958	3.083	2.833	3.083	2.833	2.875	3.083	3.292
22	2.875	2.792	3.083	3.167	2.708	2.917	3.125	2.833	3.458	2.917
23	3.458	3.292	3.542	3.292	3.292	3.458	3.208	2.958	3.625	3.875
24	4.250	3.208	4.250	3.833	3.542	3.458	4.125	4.375	4.208	2.250
25	3.875	3.167	3.625	3.8750	3.625	3.792	3.542	3.375	4.042	2.958

historical connotations, and social backgrounds through depictions of traditional stories, local historical events, and social customs. Regarding kinship, ancestral hall murals play a key role in strengthening cultural identity through carefully selected narrative content (enhancing unity) and the presentation of symbolic values (emphasizing clan virtues).

This study goes into further detail into the social implications layer by examining three different dimensions (Fig. 6): "shape and content," "symbols and elements," and "culture and phenomena." Early researchers primarily examined the materiality and formal beauty of art, with Bell-Villada [37], Gathercole [38], and Welch [39] focusing on the material art form. The breadth of art and the intricacy of material shaping mechanisms have led to the expansion of this field into semiotics, sociology, and phenomenology [40]. Carrabine [41], for example, examined how the narrative turn in criminology contributes to the understanding of mural pictures, contending that depictions of excessive violence do not accurately capture the realities of medieval life. The phrase "material culture" has gained prominence in recent years. Zubieta

[42], Douglass and Badham [43] and Arroyo-Lemus [44] contend that artworks are crystallizations of artisanal and multicultural techniques as well as results of aesthetic demands. Building a bridge for interdisciplinary integration, Chicoine [45] shifted the research attention to the sources of visual symbols and their ornamental aspects. He argued that studying traditional art should go beyond form and technique to include an exploration of the work's underlying cultural and historical meanings, emphasizing the social aspects of material legacy. Using information technology tools, this paper offers a broad perspective, framework, and examples from a cultural and ritual critique angle, in contrast to traditional single-disciplinary perspectives and research methods. It also reflects on how to integrate art and technology to preserve and pass on the excellent genes of traditional art.

There are three levels of realisation of the cultural restoration pathway: (1) material protection, aimed at the restoration and protection of tangible cultural heritage;(2) cultural enrichment, aimed at promoting the excellent cultural genes within intangible cultural heritage, achieving aesthetic education through transformation; (3) value

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Table 6 Analytical results test

KMO & Bartlett's Test	KMO Measure of Sampling Adequacy						0.794	
	Bartlett's Test of Sphericity			Approximate Chi-Square			239.641	
				Degrees of Freedom			45	
				Significance			0	
Total analysis of variance		Extracted Sums of Squared Loadings				Rotated Sums of Squared Loadings		
	Component	Total	Percentage of Variance	Cumulative/%		Total	Percentage of Variance	Cumulative/%
	1	5.994	59.941	59.941		5.061	50.608	50.608
	2	1.448	14.475	74.416		1.958	19.584	70.192
	3	1.022	10.219	84.634		1.444	14.443	84.634
The rotated component matrix [a]	Adjective Pairs		Component 1	Component 2			Component 3	
	Happy-Unhappy		**0.918**	0.171			0.299	
	Excited-Calm		0.103	0.082			**0.904**	
	Relaxed-Tense		**0.953**	− 0.037			0.066	
	Interested-Monotonous		**0.784**	0.364			0.375	
	Inspiring-Depressed		0.403	0.635			**0.51**	
	Comfortable-Uncomfortable		**0.95**	0.163			0.126	
	Arousing-Tedious		0.032	**0.923**			0.198	
	Warm-Desolate		**0.897**	0.279			0.023	
	Harmonious-Inharmonious		**0.791**	0.289			− 0.043	
	Materialistic-Spiritual		− 0.432	**− 0.589**			0.273	

Extraction method: principal component analysis; rotation method: Kaiser normalization Varimax

[a] The rotation converged in 4 iterations
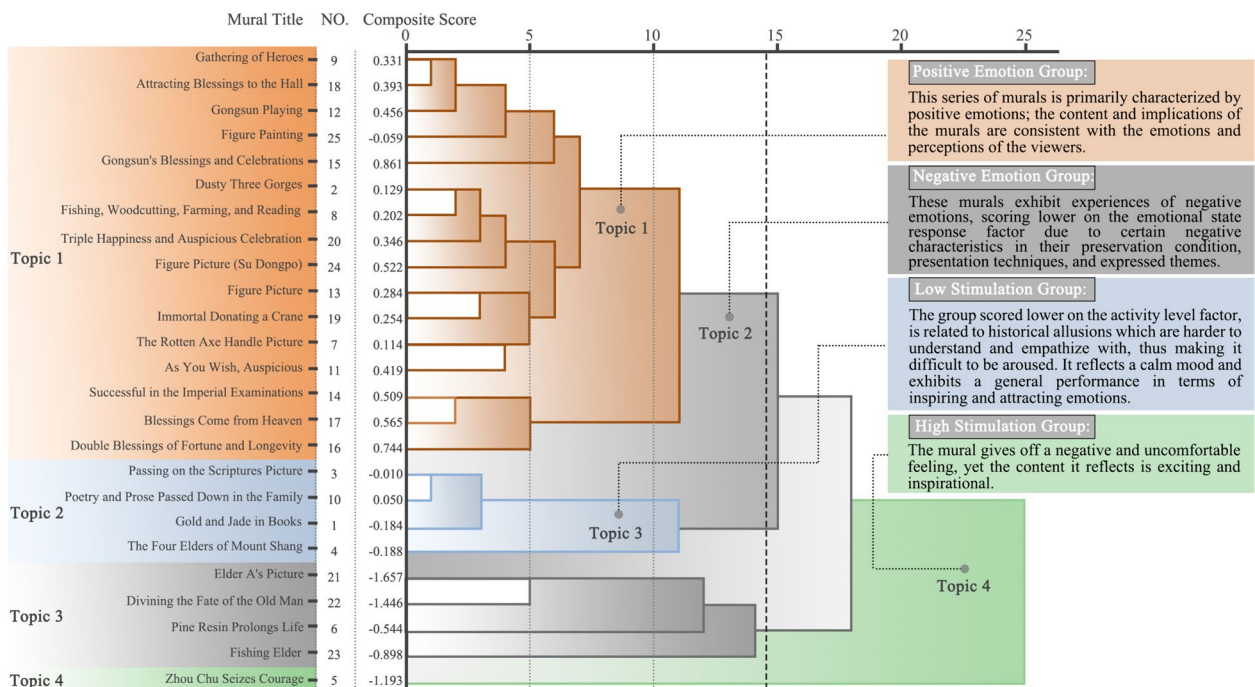
Fig. 5 Clustered spectrogram
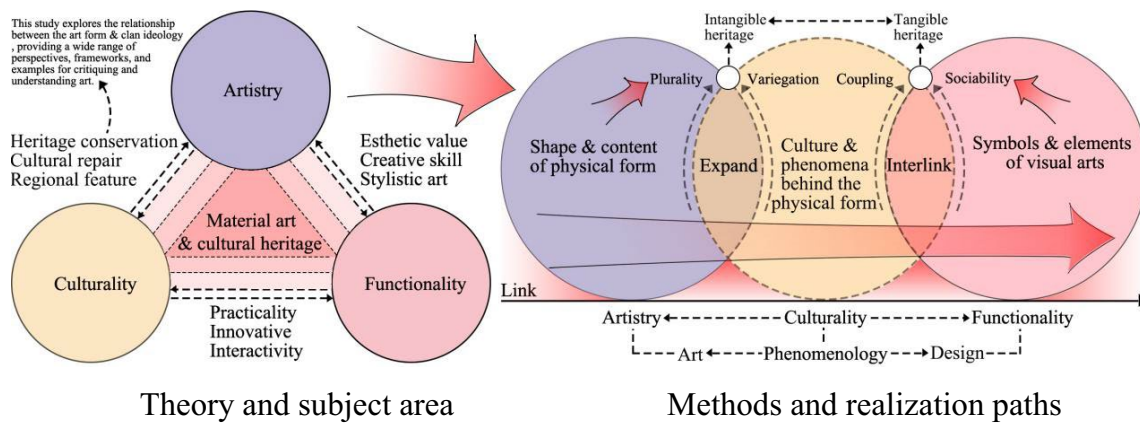
Fig. 6 Academic contribution map

empowerment, aimed at guiding the formation of correct social values, for example, by disseminating value aesthetics through art design. Previous research related to cultural restoration has primarily focused on the exploration of the first two levels, whereas this paper provides an implementation pathway for aesthetic education within the third level.

Based on intuitive visual observations, the initial phase of variable selection for this study identified the following characteristics in ancestral hall murals' colors: (1) the background colors are predominantly of low brightness, while a considerable use of primary colors such as green, white, yellow, and black is applied in character depiction; (2) compared to materialistic murals, spiritual murals prefer to use colors of higher brightness and saturation. However, research by Su et al. [46], Zhou and Taylor [47], Huang [48] seems to indicate a divergence between the color scheme of Guangzhou ancestral hall murals and the color system advocated in ancient Chinese folklore, leading to further intriguing questions: (1)What are the differences between the Guangzhou ancestral hall murals and the ancient Chinese folk color system; (2) Were the backgrounds and colors used for the figures in the Canton ancestral hall murals influenced by kinship culture? If so, in what ways.

A questionnaire survey involving 24 experts and encompassing 10 evaluation criteria (producing 240 data points per sample) was conducted. This implies that a dataset comprising 76,320 data points will be generated from the 318 mural samples, highlighting the importance of using sampling methods to reduce data processing load, improve analytical efficiency and quality, and ensure the scientific rigor and feasibility of the study [49]. Both random sampling and subjective selection have their respective advantages and disadvantages in statistical methodology. Complete random sampling may result

in uneven sample coverage [50], while subjective selection might introduce selection bias [51]. As a compromise, this study employed stratified sampling during the questionnaire design phase, selecting 25 mural samples for perceptual evaluation (totaling 6,000 data points).

The detailed sampling process provides a scientific basis for the results: (1) The 318 murals were categorized into five distinct themes based on imagery and descriptive content (first-level stratification); (2) Further stratification was based on story content (teaching, inspiration, seeking blessings, labor, reunion), decorative elements (mountains, rocks, plants, animals, furniture, books, figures), artists, color schemes, type of ancestral hall (public, family, clan), scale (large, medium, small), and the mural's placement within the hall (lintel, corridor, main hall, central hall); (3) An equal number of samples (5) were drawn from each stratum, ensuring that the selected samples represented the diversity, richness, uniqueness, and variety of the themes. Second, while questionnaire analysis based on a small sample size may have certain limitations [52], the combined use of the SD method, factor analysis, and cluster analysis helps mitigate these limitations and provides persuasive evidence for the validity of small-sample analysis [53]. Additionally, the 24 expert evaluators come from diverse fields within the arts and humanities, ensuring that the evaluation reflects a broad spectrum of perspectives.

Despite providing a rationale for the stratified sampling and combined analytical methods, it must be acknowledged that increasing and diversifying the sample size will enhance the quality of analysis. Increasing the sample size within each secondary stratum will improve the reliability of statistical analysis [54] and enable a more comprehensive explanation of the complexity of mural art. Furthermore, the scope of this work is limited by sample coverage. A total of 269 murals (51.6%) were placed at the

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entrances of ancestral halls, while the rest were located in worship halls and back halls. The content of the murals often correlates with their placement and spatial function, and the unequal sample coverage may introduce partial bias into the study results.

Recommendations for improvement: (1) Developing systematic stratified sampling standards, refining sampling methods, and ensuring the typicality and representativeness of selected samples; (2) Increasing the sample size within each secondary stratum to enhance the representativeness and reliability of statistical analysis; (3) Ensuring balanced coverage of murals from different decorative locations and spatial functions to reduce sample bias. Future experiments will consider these aspects in detail.

Conclusions

Findings: (1) the themes and implications of ancestral hall murals in Guangzhou are predominantly oriented towards positive and proactive value transmission. The content transitions from focusing on idealistic hermit life to realistic depictions of the lower strata of society, emphasizing human-centric values; (2) murals conveying positive emotions are mostly named after themes of longevity, auspiciousness, prosperity, and heroic deeds. In contrast, those depicting negative emotions primarily involve elderly male figures, reflecting a content preference related to character depiction; (3) murals with historical allusions have relatively complex content, which diminishes emotional resonance and arousal efficiency among viewers; (4) the content of incomplete murals increases negative emotions in perceivers, highlighting the impact of the preservation state of murals on emotional resonance; (5) murals with materialistic themes are usually related to wealth and are consistent with the results of factor analysis, reflecting the alignment between mural content, implications, and emotional responses; (6) some murals feature extroverted character images that contrast with the dignified and restrained etiquette of traditional rites. Meanwhile, the portrayal and facial expressions of certain characters demonstrate approachability, contrasting with traditional decorum.

As artworks imbued with clan hues, the development of clan painting and decorative arts exhibits kinship cultural attributes and is a concentrated expression of traditional ritualistic thought. The application of text mining and perceptual evaluation to heritage value research holds potential, and this paper provides empirical support. Future research by the team will focus on the relationship between the color palette of clan paintings and traditional color systems.

Declarations

Ethics approval and consent to participate
This study has been ethically approved by the Ethics Committee of the Department of Science and Technology Management at Zhejiang University of Finance and Economics Dongfang College (No. DFL20231230004), and informed consent was obtained from all participants.

Competing interests
The authors declare no competing interests.

Author details
[1]Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia. [2]School of Culture Communication & Design, Zhejiang University of Finance and Economics Dongfang College, Haining 314408, China. [3]School of Art and Design, Guangdong University of Finance and Economics, Guangzhou 510320, China. [4]School of Creativity and Design, Guangzhou Huashang College, Guangzhou 511399, China.

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Publisher's Note

Weicong Li   is a Ph.D candidate in Faculty of Built Environment and Surveying at Universiti Teknologi Malaysia, where he is also the Director of the Guangdong Quality Brand Research Talent Management Center and a trainer of space design technology at Guangzhou Meiheng Space Art Engineering Co. He specializes in cross-disciplinary theoretical integration and methodological innovation. His research interests include space syntax, history of urban planning, sustainable architecture and environmental design, architectural design and decorative arts, industrial cultural heritage, inclusive spatial design based on pathology adaptation, Belt and Road cultural communication, and design innovation.

Shangbing Ma   is a master student in Faculty of Built Environment and Surveying at Universiti Teknologi Malaysia. His research interests are in the fields of architecture and environmental arts, sustainable architecture and cultural heritage studies.

Wenwen Shi   is an associate professor at the School of Culture Communication & Design at Dongfang College, Zhejiang University of Finance and Economics. She is currently studying for a doctorate in architecture at Universiti Teknologi Malaysia. Her interests include spatial visualization and inclusive design, perceptual evaluation, environment and behavior, rehabilitative environments, decorative arts and cultural heritage studies.

Haopai Lin   is a student of Environmental Design at the School of Art and Design, Guangdong University of Finance and Economics. He specializes in health architecture and interior design and tangible cultural heritage research.

Yueling Liu   is an associate professor in the School of Creativity and Design at Guangzhou Huashang College. She teaches environmental design courses. Her research interests include the healing nature of art design for public environments and the study of material heritage art.

Yitong Cui   is a teacher at the School of Culture Communication & Design at Dongfang College, Zhejiang University of Finance and Economics. She specializes in public environments and art, inclusive design, visual perception and design empathy, and cultural heritage studies.

Jinghui Ao   is an associate professor and MA supervisor at the School of Art and Design, Guangdong University of Finance and Economics, and a visiting professor at Krirk University, Thailand. He is also the Managing Director of the Guangdong Industrial Design Association and a visiting scholar at Pace University, New York, USA. He focuses on the revitalization of tangible cultural heritage, the construction of cultural gene maps of artifacts in the Belt and Road, the creation of cultural IPs for industrial design brands in Guangdong, Hong Kong and Macao, the culture and spatial mobility of commerce and trade, the healing of digital products and the environment, and the perception and identity of Lingnan regional culture. Recently, he is focusing on the paradigm innovation of cultural heritage of artifacts and the design path research of using cultural elements.