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What are the differences in urban citizens' preferences for the colour of condominium building facades?

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The colour of a building facade is an important attribute that significantly influences consumers' purchasing intentions towards commodity buildings. This influence is often reflected in transaction prices, allowing researchers to extract consumers' colour preferences and analyse their psychological states. However, there is a significant lack of relevant research in this area. Therefore, this research is the first attempt to explore urban consumers' preferences for the colour of building facades using a housing price measurement system. It also conducts comparative analyses of the consumption psychology of different homebuying consumer groups. The innovative approach in this research can serve as a reference for exploring similar issues in other regions worldwide, and the empirical results of this research hold important professional value for fields such as social psychology and urban planning. Specifically, this research takes the city of Fuzhou, China, as an example, and it uses cross-sectional transaction data from second-hand residential communities in 2020 as its research reference. Through economic and geographical research methods, this study explores consumers' preference for colour among various consumer groups. The research reveals that the overall homebuying consumer groups in Fuzhou have specific preferences for the quantity and characteristics of facade colours. Furthermore, consumer preferences vary among different income levels and geographic locations of homebuying consumer groups. Finally, the research estimates the possible reasons for these preference differences.

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Background and introduction

In everyday life, consumption behaviour is a common occurrence, and colour factors constantly influence this behaviour. Palmer and Schloss (2010) discovered that the preferences of individuals are highly correlated with the colour of objects and thus reflect their psychological emotional responses. For instance, red expresses a passionate personality and a desire for festive activities, orange or yellow represents a healthy and delightfully vivacious state of mind, and green or white expresses a calm and contented inner state (Sable and Akcay, 2011). Therefore, colour has a significant impact on people's purchase decisions. As Raizada (2012) found through his research, red attracts the most attention and sells the best on the roadside or in the market in the research area. This finding is likely due to the local preference for the warm colour sensation. Even though consumers' consumption behaviours are influenced by their personal colour preferences, consumers' colour-based purchasing preferences are satisfiable only if the product is beneficial (Yu et al., 2021).

Moreover, groups share common preferences in terms of the influence of colour on consumer behaviour. According to Labrecque et al. (2013), the preference for or aversion to a particular colour that a society or culture has developed over time is group specific due to the similar psychological emotions of colour that people with a similar background culture share. Although this is a group characteristic, there are individual variances in how it is experienced. For example, Iris et al. (2015) showed that the colour preferences of people in Holland differ significantly between patterns, gender, age, educational levels, and personality. Considering that comprehending the psychology of public consumption is crucial to the market economy, it is essential to investigate a group's public consumption behaviour.

The colour of a commodity influences consumer behaviour, and the impact of this approach will also be reflected in the transaction price. In Turkey, for instance, Erdem and Şentürk (2009) observes that grey and black vehicles are more expensive than vehicles of other colours, and Hollister (2008) noted that identical white trainers are sold at a higher price than trainers of other colours. The reason may be that the colour of a product's exterior impacts consumers' views of its usefulness, quality, and usability (Creusen and Schoormans, 2010). More often, the reason is that the colour of a product's exterior becomes an essential consideration when buyers select products with comparable quality and content (Hsu, 2016). Therefore, based on this type of information on colour consumption preferences in terms of price, it is possible to investigate a group's public consumption psychology.

Similarly, the colour attributes of a condominium have a substantial impact on the popularity of the condominium itself. Building colour, which refers to a specific environmental colour formed by all the fixed surfaces of objects in a building area that are covered or have their own colours, is the sum of the colours of physical elements such as buildings, greenery, water bodies, roads, courtyards, facilities and vignettes (Liu and Guo, 2012). The colour characteristics of a building facade are frequently considered to be the most representative and indicative of the impact that colour attributes can have on a building's popularity, although the definition of architectural colour in previous research is quite complex. For example, Yoshizawa et al. (2007) examined how Japanese consumers select colours for building facades and discovered some trends and preferences. This phenomenon is also supported by the empirical research conducted by Gou and Wang (2017) in Changzhou, China, and by Motoki et al. (2019) in Golestan Province, Iran. Wan et al. (2020) examined Dujiangyan, China, and investigated a substantial association between residents' pleasure and access preferences and facade colour and spatial colour palette. Gou et al. (2021) investigated the urban building colour preferences of residents of

Shanghai, China, and their influencing factors based on the selection of colour samples. They discovered that citizens' most preferred urban building colours were red, high whiteness, and medium-low chroma. By researching the colour preferences for building facades in Fujian and Taiwan, China, Li et al. (2022) discovered that the majority of subjects preferred low and medium chroma and a bright colour palette, while high chroma building colours were less popular. In terms of harmony, architectural colour combinations with low chromaticity are more likely to inspire people's inner benevolence.

Although there have been discussions concerning the influence of building facade colours on popularity, previous research has not examined the impact of residential colour attributes on consumer purchasing behaviour, specifically the pricing impact of certain types of colour attributes related to group-wide perceptions of colour, thus investigating the status of the mental state of a public consumer group. In previous studies related to colour preferences, scholars often employed research methods such as experimental approaches (Cubukcu and Kahraman, 2008; Kaya and Crosby, 2010; Li et al., 2020) and questionnaire surveys (Tosca, 1994; Cubukcu and Kahraman, 2008; Gou and Wang, 2017; Li et al., 2020; Gou et al., 2021) to investigate relevant topics. This research introduces a novel research perspective by using price measurement as the evaluation criterion, providing researchers with a fresh approach to address these issues. Due to the wealth of feedback information contained within the pricing reference system, this approach allows for more precise and extensive analysis through regression analysis. Consequently, colour preference studies based on this approach hold significant experimental value. While some scholars have used regression analysis in previous studies, they primarily focused on categorising the colour characteristics of architectural facades without incorporating feedback information from residential users (Zhai et al., 2023), which is an important aspect that deserves further attention. While the differences in colour preference resulting from variations in the gender (Iheme et al., 2018), age (Lee et al., 2009), and educational attainment (Iris et al., 2015) of consumer groups have been briefly discussed in previous research (Gou et al., 2021), in the process of consumer behaviour, the variations resulting from differences in the affordability of consumer groups and the variations in their geographic distribution remain deficient.

In light of the limitations of prior research, through a combination of field research and computer analysis, this research is the first to innovatively explore the building facade colour preferences and consumer psychology of different consumer groups categorised by their purchasing power and spatial regions, with residential prices being used as a reference standard. This research fills a gap in research on the differences in colour aesthetics and psychology between various consumer groups. In urban society, understanding the colour preferences of home-buying consumer groups holds significant importance for the organised management of cities and the positive development of society (Howley et al., 2009). By gaining insights into the characteristics of different homebuying groups, formulating effective strategies, and maximising the satisfaction of a broader range of consumer needs, this study facilitates the efficient integration of societal resources. Thus, this research will serve as an essential resource for consumer purchasers, urban planners and managers, and academic researchers in the domains of social psychology, environmental health, architecture and urban planning.

Data and methodologies

Objectives. To investigate the common preferences for colours in the psychology of condominium consumer groups and to
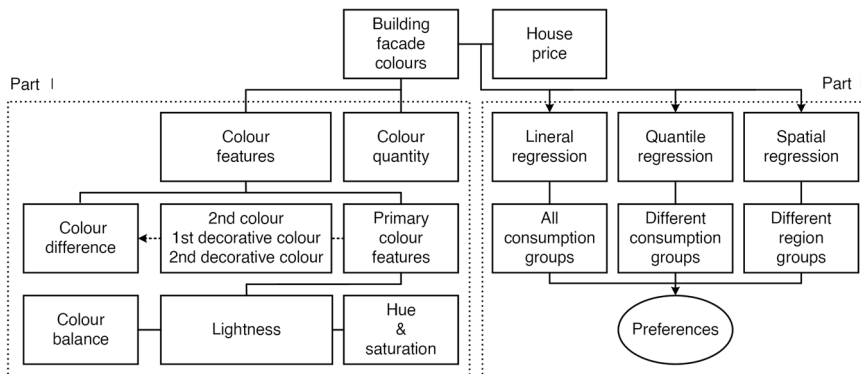
Fig. 1 Research framework. Figure demonstrates the core concept of the research as well as the research framework.

investigate the status of the mental state of public consumer groups, Fuzhou city (Fig. 1) in Fujian Province, China (longitude: 119.28 E, latitude: 26.08N), was chosen as the reference location for this research. Fuzhou is a well-known city on the southeast coast of China. It is also one of the primary hometowns for overseas Chinese in East Asia and even worldwide (Chiu, 2016), maintaining close connections with multiple countries and regions, including Malaysia, Japan, South Korea, Hong Kong, Taiwan, and others (Guldin, 1977; Zheng, 2019; Wen, 2021). Additionally, the city has a high volume of residential transactions and a large number of housing price reference samples, which can incorporate the consumer psychology of diverse groups and reflect the fluctuation in condominium transaction prices. Furthermore, due to the cultural similarities stemming from the Chinese cultural background (Paik et al., 1996), it is hoped that this research can provide reference points for regions with a significant influx of Chinese immigrants in East Asia and even globally to address similar issues.

Framework. The framework of this research is divided into two parts, with the particular procedure depicted in Fig. 1. Part I focuses on the development of the research variables of building facade colours. Part II analyses the preferences of consumption groups in relation to housing prices. The colour variables in Part I of the research are intended to visually and distinctively characterise the consumer groups' colour preferences. The colour variables in Part II of the research are analysed in relation to housing prices, and the consumer groups are divided into three research perspectives based on different features to explore their colour preferences: from the first research perspective, the preferences of all consumption groups are analysed based on composite linear regression analyses; from the second research perspective, the preferences of groups with different consumption abilities are analysed based on quantile regression analyses; and from the third research perspective, the preferences of groups with different geographic spatial locations are analysed based on spatial regression analyses. The selection of these three viewpoints can thoroughly research both the group distinctions and the general characteristics.

Data. To more precisely comprehend the prevalence of facade colour preferences among consumption groups, cross-sectional transaction information data from 906 sample communities in Fuzhou, China, in 2020 were selected as the research reference data. These specific data include the outcome variables of this research: the overall average transaction price of the residential sample; three types of control variables: the location environment variables, self-characteristics variables, and facility accessibility variables of the residential sample; and the research variables of

this research: the facade colour variables of the sample communities. In Table 1 below, specific variable information is displayed. Regarding the selection of residential communities for the research sample, the research considered the following five factors. First, to eliminate the impact of internal differences in housing types on the sample transaction prices, the selected residential communities in the research were all full-type communities (i.e., communities with a variety of non-villa housing types to accommodate different area requirements). This choice was made to reduce the influence of price variations caused by differences in housing type preferences among homebuying groups. Second, all the sample communities maintained consistent exterior architectural styles across all individual buildings within them. This criterion ensured that homebuying consumer groups purchasing within the same community would encounter consistent residential exterior appearances, eliminating potential price disturbances resulting from variations in individual building facades. Moreover, the residential communities selected for the research sample exclusively consisted of second-hand properties, thus excluding market pricing differences between new and resale properties. Simultaneously, all the residential communities chosen for the research had building facades with structures that could be measured using colour assessment instruments, allowing for the on-site extraction of colour numerical information. Finally, the selected residential community samples had a minimum of five complete transaction records for the given year, mitigating price disturbances caused by outliers or extreme customer behaviour.

To ensure that the residential community samples are representative of urban areas, the research selected residential samples from all administrative regions within the city of Fuzhou. In the Fuzhou region, the urban area comprises five administrative regions: Gulou, Cangshan, Taijiang, Jin'an, and Minhou. Therefore, the selected community samples for this research were all second-hand residential communities that met the five selection criteria within the geographic boundaries of these five major administrative regions, aiming to comprehensively reflect the colour preferences of homebuying groups in the Fuzhou area as much as possible (Fig. 2).

Control variables. The following are the primary content of the three types of control variables developed for this research. All of these variables have the potential to affect consumers' purchasing decisions, so they are all included in the research, ruling out the price effects they produce. The selection of these control variables was guided by previous relevant research. The control variables were location environment variables (whether the administrative region is directly subordinate to a higher-level government, whether the location is within the second ring road or the third

Table 1 Descriptive statistics of the variables (N = 906).

Variables	Description	Mean	Expect
Outcome Variable			
Pri	House price (ten-thousand yuan/m²)	2.790	/
Control Variables			
Variables of the Location Environment			
ADM	Dummy variable, 1 for the condominium inside the higher-level administrative region, 0 for else	/	+
LC1	Dummy variable, 1 for the condominium inside the second ring road, 0 for else	/	+
LC2	Dummy variable, 1 for the condominium inside the third ring road, 0 for else	/	+
POP	Quantity of population in March 2021 (ten thousand)	52.085	+
GDP	Per capita GDP in March 2021 (hundred million yuan)	118558.400	+
Variables of the Self-characteristics			
COM	Dummy variable, 1 for the condominium is pure commercial condominium, 0 for else	/	+
T500	Dummy variable, 1 for the developer is China's top 500, 0 for else	/	+
MIN	Dummy variable, 1 for the developer originated from Fujian province, 0 for else	/	+
PRI	Dummy variable, 1 for the condominium with high-quality primary school, 0 for else	/	+
MID	Dummy variable, 1 for the condominium with high-quality middle school, 0 for else	/	+
AGE	Dummy variable, 1 for the condominium built after 2000, 0 for else	/	+
DEN	Density of buildings (c)	2.356	-
GRER	Greening rate of community (c)	0.345	+
FEE	Monthly management fee (yuan/m²)	1.184	+
Variables of the Facility Accessibility			
RAI	Distance to the closest rail station (m)	1375.514	+
MAR	Distance to the closest market (m)	1098.150	+
HOS	Distance to the closest grade-A tertiary hospital (m)	1899.717	-
SCE	Distance to the closest scenic spot (m)	1080.911	+
GRE	Distance to the closest green space (m)	726.217	+
WAT	Distance to the closest main water source (m)	1135.450	+
FUN	Distance to the closest funeral facility (m)	3176.560	-
FAC	Distance to the closest factory (m)	1596.437	-
GAS	Distance to the closest gas station (m)	1180.834	-
DUM	Distance to the closest dump (m)	9617.311	-
Research Variables			
2 C	Dummy variable, 1 for residential building in 2 facade colours, 0 for else	/	+
3 C	Dummy variable, 1 for residential building in 3 facade colours, 0 for else	/	+
4 C	Dummy variable, 1 for residential building in 4 or more facade colours, 0 for else	/	+
M①	The first standard of the primary colour (lightness in LAB/LCH) (c)	/	+
M②	The second standard of the primary colour (red-green in LAB/saturation in LCH) (c)	/	+ (red-green) + (saturation)
M③	The third standard of the primary colour (yellow-blue in LAB/hue in LCH) (c)	/	- (yellow-blue) no sig. (Hue)
S①	Absolute value of the first standard colour deviation of the primary and secondary colours (c)	/	+
S②	Absolute value of the second standard colour deviation of the primary and secondary colours (c)	/	+
S③	Absolute value of the third standard colour deviation of the primary and secondary colours (c)	/	+
E1①	Absolute value of the first standard colour deviation of the primary and the primary decorative colours (c)	/	+
E1②	Absolute value of the second standard colour deviation of the primary and the primary decorative colours (c)	/	+
E1③	Absolute value of the third standard colour deviation of the primary and the primary decorative colours (c)	/	+
E2①	Absolute value of the first standard colour deviation of the primary and the secondary decorative colours (c)	/	+
E2②	Absolute value of the second standard colour deviation of the primary and the secondary decorative colours (c)	/	+
E2③	Absolute value of the third standard colour deviation of the primary and the secondary decorative colours (c)	/	+

ring road, population, per capita GDP) (Zhang and Yi, 2017), self-characteristic variables (pure commercial condominiums as a type, whether the developers are included in China's top 500, whether the developers originate from Fujian Province, whether the condominium is adjacent to a high-quality primary school or high-quality middle school, whether the condominium was built after 2000, the density of buildings, the greening rate of the community, the monthly management fee) (Goodman and Thibodeau, 1995; Lee, 2016; Wen et al., 2018) and facility accessibility variables (the distances to the closest rail station, market, grade-A tertiary hospital, green space, main water source,

scenic spot, factory, gas station, dump and funeral facilities) (Bourassa et al., 2004; Dziauddin, 2014; Evangelio et al., 2019; Zhang et al., 2020; Dou et al., 2023).

Research variables. The establishment of research variables was also based on previous relevant research (Table 2). To accurately and exhaustively position the characteristics of colour, this research precisely divides the colour research variables of facades into two categories: colour quantity variables and colour feature variables to accurately and exhaustively locate the colour
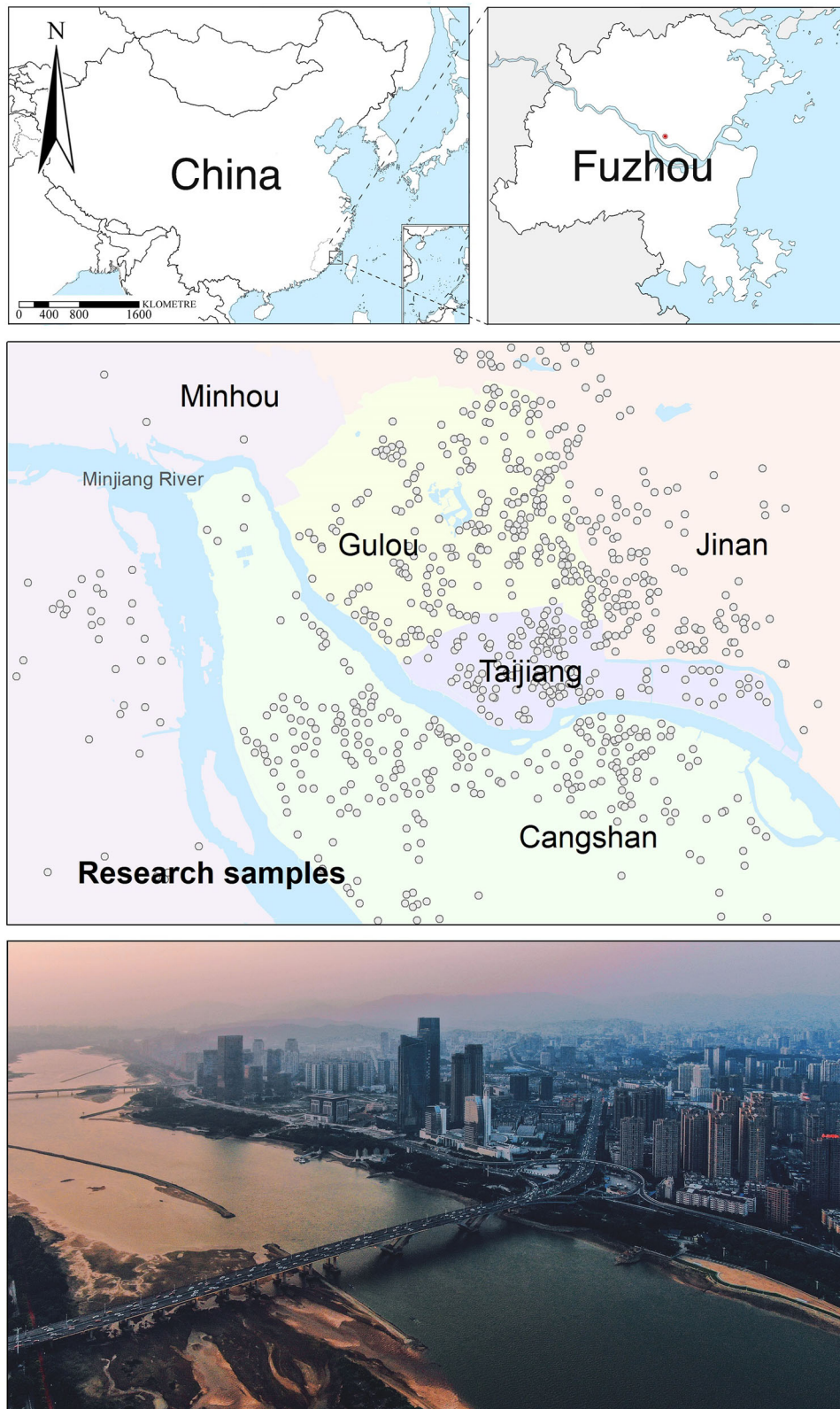
Fig. 2 The spatial distribution of research samples. Figure illustrates the geographical distribution characteristics of the research samples.

information features and gain an in-depth understanding of urban consumer groups' colour preferences for building facades. Colour quantity refers to the number of colours within a given range of representational differences, whereas colour features are quantitative descriptions of the constituent features of facade colours. In previous relevant research, some scholars attempted to explore people's colour preferences from the perspective of certain colour information features. These features included brightness (Gou and Wang, 2017), colour balance (Kaya and Crosby, 2010), and colour saturation (Cubukcu and Kahraman,

Table 2 Researches of the colour preferences on building facades.

| Content	Title	References	Research Area	Methods	Key Finding
Quantity of colours	Dreams of light for the city	Tosca (1994)	Thessaloniki, Greek	Questionnaire	The rejection of monochromacy by the subjects was unanimous. They all liked polychromacy, which peaked at trichromy for the individual house and at tetrachromy for the apartment and the public houses.
Lightness	Research on colour harmony of building façades	Li et al. (2020)	Taipei, Taiwan	Experimental Questionnaire	Prefer facades with a primary colour in high lightness level.
	Study of the colour characteristics of residential buildings in Shanghai	Wang et al. (2021)	Shanghai, China	Data Collection Statistical Analysis	The colours of residential buildings are mostly warm colours with high brightness.
	Hue, saturation, lightness, and building exterior preference: An empirical study in Turkey comparing architects' and nonarchitects' evaluative and cognitive judgments	Cubukcu and Kahraman (2008)	Izmir, Turkey	Experimental Questionnaire	For a building exterior, the brightest will not be the most preferred lightness levels.
	A comparison between wishes and status: Grey is not the preference for residents while the city shows neutral colours	Gou and Wang (2017)	Changzhou, China	Questionnaire	People are inclined to bright and light colour.
Red-green	Colour associations with different building types: an experimental study on American college students	Kaya and Crosby (2010)	Athens, USA	Experimental	Residences were mostly associated with the colour red.
	A comparison between wishes and status: Grey is not the preference for residents while the city shows neutral colours	Gou and Wang (2017)	Changzhou, China	Questionnaire	Better scores in residential building façade in green.
Yellow-blue	Colour associations with different building types: an experimental study on American college students	Kaya and Crosby (2010)	Athens, USA	Experimental	Residences were mostly associated with the colour blue.
	Hue, saturation, lightness, and building exterior preference: An empirical study in Turkey comparing architects' and nonarchitects' evaluative and cognitive judgments	Cubukcu and Kahraman (2008)	Izmir, Turkey	Experimental Questionnaire	Nonarchitects picked blue.
	A comparison between wishes and status: Grey is not the preference for residents while the city shows neutral colours	Gou and Wang (2017)	Changzhou, China	Questionnaire Site survey	colour in blue are welcome.
Saturation	Building façade colour distribution, colour harmony and diversity in relation to street functions: using street view images and deep learning	Zhai et al. (2023)	Shanghai, China	AWB Methods K-means Clusters Logistic Regression Model	Residential streets' saturation is overall higher than that of industrial streets.
	Hue, saturation, lightness, and building exterior preference: An empirical study in Turkey comparing architects' and nonarchitects' evaluative and cognitive judgments	Cubukcu and Kahraman (2008)	Izmir, Turkey	Experimental Questionnaire	For a building exterior, the most saturated colours will not be the most preferred saturation levels.
Hue	Hue, saturation, lightness, and building exterior preference: An empirical study in Turkey comparing architects' and nonarchitects' evaluative and cognitive judgments	Cubukcu and Kahraman (2008)	Izmir, Turkey	Experimental Questionnaire	Certain amount of agreement in judged pleasantness of hues.
	Colour preference and contributing factors of urban architecture based on the selection of colour samples —— Case study: Shanghai	Gou et al. (2021)	Shanghai, China	Questionnaire	At present, the colour distribution is associated with a full colour hue in Shanghai.
Difference in the primary and secondary colours	Research on colour harmony of building facades	Li et al. (2020)	Taipei, Taiwan	Experimental Questionnaire	Prefer facades with a a greater lightness difference between primary colour and the supplementary colour.

2008), among others. However, there has not been an attempt to establish a comprehensive colour system variable (comprising both colour quantity variables and colour feature variables). Therefore, based on the completion of a systematic set of colour variables, this research investigates consumers' colour preferences. Additionally, drawing from the conclusions of prior research, predictions of the analysis results for the established research variables were made and are presented in Table 1.

In this research, the data acquisition for colour variables was conducted as follows. Using computerised street image recognition techniques, this research commenced with the definition of the quantitative and compositional colour information of the facades of the sample communities within a certain range of colour tolerances (Fig. 3a). The first type of colour variable analysed was quantitative colour information obtained through

this process. This research divided the colour quantity variables into four groups: one colour, two colours, three colours, and four or more colours. Then, the facade colours were ranked based on the colour area size within the tolerance range, and the facade colours were categorised into four groups: the primary colour (area share between 1 and 100%, henceforth referred to as primary colour), secondary colour (0–49%), primary decorative colour (0–33%) and secondary decorative colour (0–24%) (Fig. 3b) (facade compositions with four or more colours are not specified). The features of each colour category were then extracted and used to define the colour feature variables of this research. The colour feature variables consisted of two parts, with the first part defining the feature information of the primary colour and the second part defining the differential feature information between the primary and secondary colours, as well
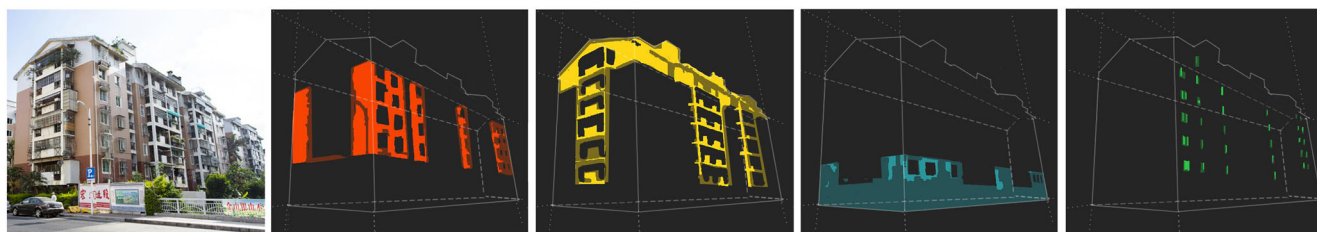
a. Elevation colour breakdown
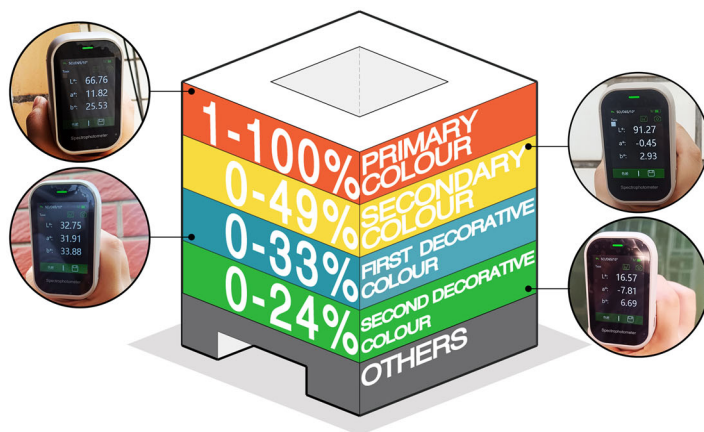
b. Proportion of facade colour
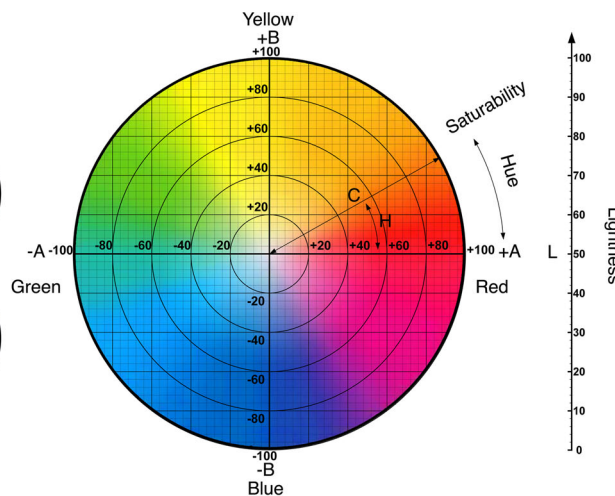
c. Schematic of colour feature

Fig. 3 Explanation of colour variables. Figure depicts the method of determining colour variables and the capture process. **a** The computer image recognition procedure used to assess the proportionality of the colour of the research sample's façade. **b** The Institute's colour-defining compositions and colour scale ranges, whereas the characteristic values of each colour composition are derived from field surveys. **c** The value ranges of the colour systems "LCH" and "LAB" as well as the corresponding relationships.

as the primary decorative and secondary decorative colours. When there were fewer than four or more colours in the building facades, this research determined the colour information features of the missing constituent colours based on the colour feature information comprising the lowest proportion of the current status area. When the facade colour was one, for instance, the primary colour, secondary colour, and primary and secondary decorative colours had the same colour feature data.

Compared to colour quantity information, colour feature information is relatively more complex to understand. Information about colour features typically includes a variety of indicators, such as lightness, saturation, colour tendency and hue. The colour feature information data of this research were extracted by field measurement through a colourimeter, and the density values of cyan, magenta and yellow in each component were measured and then converted into LAB and LCH colour standard values. The relationship between the two types of standards is shown in Fig. 3c. To ensure the accuracy of the feature values taken, three measurements were taken for each building facade in different areas of the same colour to take the average value as a reference.

In this research, the first part of the colour feature variables consisted of the characteristics of the primary colour, the lightness of the primary colour (i.e., "L" in "LAB" and "LCH"), saturation ("C" in "LCH"), colour tendency (i.e., "A" and "B" in "LAB"), and hue ("H" in "LCH"); these are descriptive variables of primary colour characteristics. The colour feature variables in this section reflect people's first impressions of the primary colours of building facades. Field research yielded the following spatial distribution of building primary colours and colour

quantities in the sample communities in Fuzhou, China (Fig. 4). There was no discernible pattern of clustering in the spatial distribution of condominium buildings with varying quantities of facade colours.

The second portion of the colour feature variables were the difference variables between the primary and the secondary colours, the primary decorative colours, and the secondary decorative colours, i.e., the absolute values between lightness, saturation, colour tendency and hue. These are descriptive variables that characterise the degree of difference between primary and secondary colours. These variables in this section complement and enhance the characterisation of facade colour features. The theoretical foundation originates from people first perceiving the primary colour of an object and then using the primary colour's features to establish the perceptual relationship between it and the secondary and decorative colours in the process of overall perception of multiple colour features (Li et al., 2020).

Methods

Hedonic price model. The hedonic price model is the predominant method in both domestic and international academic research for examining how residential variables influence house prices and for estimating the prices of these variables. It assumes that commodities are sold as a collection of their intrinsic attributes, thereby explaining commodity prices based on these properties. Lancaster and Rosen have laid a solid theoretical foundation for the Hedonic Price Model (Brown and Rosen, 1982; Herath and Maier, 2010). When applying the Hedonic Price Model to the real
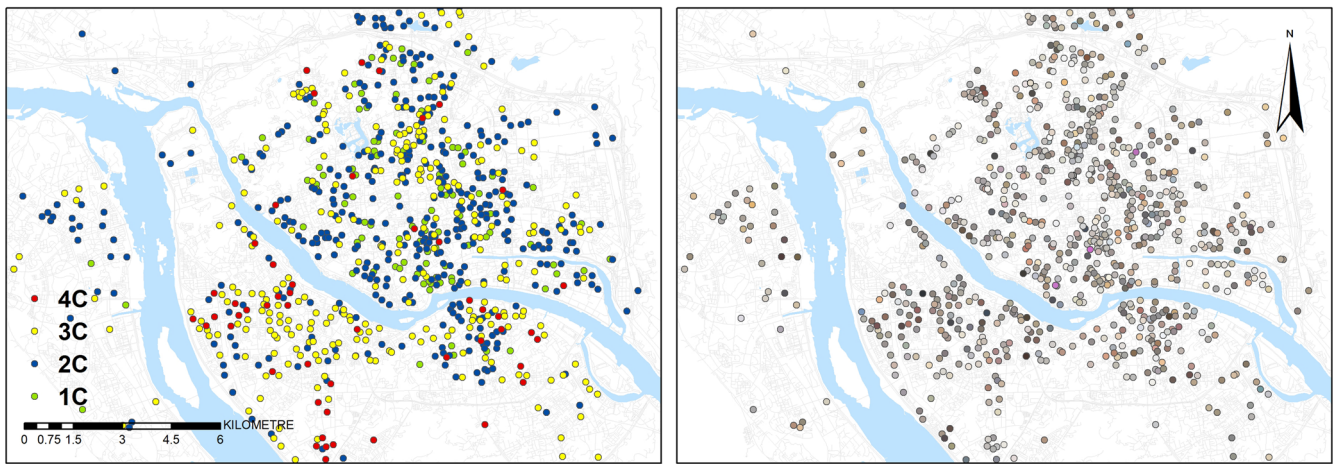
Fig. 4 The distribution of colour quantity and primary colour features of residential elevation samples. Figure represents the geospatial distribution of the sample of studied houses, as well as their corresponding facade primary colours and the number of facade colours. The the right figure "4C, 3C, 2C, 1C" represents, respectively, the number of colours on the facade of the houses with four or more colours, three colours, two colours, and one colour, while left figure expresses the primary colour profile of the facade.

estate market, three main aspects of property variables are considered: location environment variables, self-characteristics variables, and facility accessibility variables. Formula (1) is expressed as follows:

$$\ln P_i = \alpha + \sum_n \beta_n \ln X_{in} + \varepsilon_i \qquad (1)$$

Quantile regression analysiss. Quantile regression analysis is one of the techniques of regression analysis. Roger Koenker and Gilbert Bassett first proposed the idea in 1978 (Bassett and Koenker, 2017). Quantile regression examines the relationship between the independent variable and the conditional quantile of the dependent variable. In contrast to standard regression analysis, which reveals only the central tendency of the dependent variable, quantile regression can also deduce the conditional probability distribution of the dependent variable. Quantile regression is a non-parametric statistical method (Yang et al., 2020). The specific formula is given in Formula (2):

$$P_i = \beta_{0q} + \sum_{n=1}^{N} \beta_{nq} X_{in} + \varepsilon_i \qquad (2)$$

where β_{0q} is a constant, β_{nq} is the coefficient of the n-th hedonic variable associated with the q-th quantile, and all other variables are defined as stated previously. β_q (the vector with elements β_{nq}, $n = 0,1,\ldots,N$) is estimated as $\hat{\beta}_q$ by minimising the objective function shown as Formula (3):

$$\widehat{\beta}_q = \text{argmin}\left[\sum_{\epsilon_i \geq 0} 2q\varepsilon_i - \sum_{\varepsilon_i < 0}(2 - 2q)\varepsilon_i\right] \qquad (3)$$

Typically, asymmetrical weights are employed. Symmetrical weights are used only in median regression ($q = 0.5$). If $q = 0.5$, the above function is equivalent to Formula (4):

$$\hat{\beta}_q = \text{argmin}\sum|\varepsilon_i| \qquad (4)$$

Spatial autocorrelation analysis. The spatial autocorrelation test indicates that everything is spatially correlated, and the greater the spatial correlation is, the closer together the objects. In 1950, the Australian statistician Patrick Alfred Pierce Moran introduced Moran's I, which is commonly employed as a crucial metric for measuring spatial correlation (Carrijo and da Silva, 2017). The

formula is shown in Formula (5):

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \times \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \overline{y})(y_j - \overline{y})}{\sum_{i=1}^{n}(y_i - \overline{y})^2} \qquad (5)$$

where n is the total number of spatial units, y_i and y_j denote the attribute values of the i-th spatial unit and the j-th spatial unit, respectively, $\overline{y}$ is the mean value of the attribute values of all spatial units, and w_{ij} is the spatial weight value.

Geographically weighted regression. The geographical weighted regression (GWR) model was formally introduced by Professor A. Stewart Fotheringham of the University of St. Andrews, UK, in 1996 (Brunsdon et al., 1998). GWR is a local linear regression method based on modelling spatially variable relationships, which generates a regression model describing the local relationships at each location in the research area, thereby providing a good explanation of the local spatial relationships and spatial heterogeneity of variables (Yang et al., 2020). The specific formula is shown in Formula (6):

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{m} \beta_k(u_i, v_i)x_{ik} + \varepsilon_i \qquad (6)$$

where P_i is the value of the dependent variable at position i, which takes the logarithm of housing prices in this research; x_{ik} ($k = 1,2\cdots m$) represents the value of the independent variable at position i; (u_i, v_i) are the coordinates of the regression analysis point i; $\beta_0(u_i, v_i)$ is the intercept term; and $\beta_k(u_i, v_i)(\text{k} = 1,2\cdots m)$ is the regression analysis coefficient.

Analytical results
After regression analysis of the obtained data, the research yielded the following analytical results. The results are presented sequentially in three parts: linear regression, quantile regression, and spatial regression.

Linear regression and robustness test. In all the fitted results of linear regression (Table 3), the R-squared of all regression functions is greater than 0.76, the VIF values are less than 10, and the maximum deviation between the residual autocorrelation DW value and 2 is 1.87. These results show that the regression equations fit well and have good explanatory power. The research

Table 3 Coefficients of the linear regression analysis (N = 906).

Variables	Control	VIF	LAB	LAB Robustness Test	LCH	LCH Robustness Test
(Constant)	−2.894***	–	−2.881***	−2.066***	−2.833***	−2.782***
ADM	0.414***	3.096	0.388***	0.445***	0.393***	0.401***
LC1	0.112***	2.119	0.110***	0.122***	0.106***	0.103***
LC2	0.113***	3.208	0.117***	0.103***	0.116***	0.122***
POP	0.153***	1.858	0.128***	0.254***	0.128***	0.118***
GDP	0.157***	2.332	0.170***	–	0.165***	0.163***
COM	0.090***	1.458	0.091***	0.090***	0.088***	0.097***
T500	0.093***	1.381	0.096***	0.076***	0.092***	0.089***
MIN	0.049***	1.118	0.049***	0.044***	0.048***	0.047***
PRI	0.263***	1.165	0.261***	0.253***	0.263***	0.254***
MID	0.186***	1.564	0.179***	0.213***	0.184***	0.182***
AGE	0.063***	1.356	0.051***	0.037***	0.052***	–
DEN	0.020***	1.078	0.017***	0.016***	0.017***	0.017***
GRER	0.014***	1.234	0.015***	0.009	0.013**	–
FEE	0.127***	1.580	0.125***	0.128***	0.126***	0.132***
RAI	−0.036***	1.554	−0.036***	−0.024***	−0.036***	−0.037***
MAR	−0.022***	1.880	−0.023***	−0.033***	−0.022***	−0.022***
HOS	−0.036***	2.558	−0.036***	−0.047***	−0.035***	−0.035***
SCE	0.013***	1.755	.015***	–	0.013***	0.012***
GRE	−0.006**	2.142	−0.007***	−0.016***	−0.006**	–
WAT	−0.044***	1.308	−0.045***	−0.048***	−0.043***	−0.047***
FUN	0.035***	1.460	0.032***	0.078***	0.037***	0.036***
FAC	0.029***	1.598	0.024***	0.031***	0.027***	0.030***
GAS	0.018***	1.228	0.018***	–	0.015***	0.016***
DUM	0.110***	1.752	0.110***	0.174***	0.107***	0.107***
2 C	–	–	0.055***	0.039***	0.047***	0.061***
3 C	–	–	0.070***	0.043***	0.060***	0.076***
4 C	–	–	0.127***	0.094***	0.082***	0.103***
M①	–	–	0.000	0.000*	−0.000	−0.000
M②	–	–	0.005***	0.003***	0.000	0.000
M③	–	–	−0.001*	0.000	0.000	0.000
S①	–	–	−0.002***	−0.002***	−0.002***	−0.002***
S②	–	–	0.007***	0.007***	0.005***	0.004***
S③	–	–	−0.010***	−0.011***	0.000***	0.000***
E1①	–	–	0.000	−0.000	0.000*	0.000*
E1②	–	–	0.000	−0.001	0.002***	0.002***
E1③	–	–	−0.001	.000	−0.000	0.000
E2①	–	–	−0.000	−0.000	0.000	0.000
E2②	–	–	−0.004***	−0.002***	−0.003***	−0.003***
E2③	–	–	−0.001	0.000	0.000	0.000
Adj-R²	0.706		0.715	0.692	0.712	0.709
Dur-Wat	1.871		1.877	1.825	1.860	1.863

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

also conducts a robustness test for linear regression analysis, and the data analysis results are reliable and stable.

The control variables screened by the research are all pertinent and significant variables that have an effect on housing prices according to the results of the linear regression. Location environment variables (whether the administrative region is directly subordinate to a higher-level government, whether the location is within the second ring road or the third ring road, population, per capita GDP) and self-characteristic variables (pure commercial condominiums as a type, whether the developers are included in China's top 500, whether the developers originate from Fujian Province, whether the condominium is adjacent to a high-quality primary school or high-quality middle school, whether the condominium was built after 2000, the density of buildings, the greening rate of the community, the monthly management fee) have a positive correlation with housing prices (Yang et al., 2019). Among the self-characteristic variables, being adjacent to a high-quality primary and being adjacent to a high-quality middle school have

the most significant effects on the increase in housing price (Yang et al., 2018). Regarding the facility accessibility variables, the distance to the closest rail station (Yang et al., 2023), the distance to the closest market (Yang et al., 2022), and the distances to the closest grade-A tertiary hospital, green space and main water source provide a negative correlation with housing prices. In addition, the distances to the closest rail station, grade-A tertiary hospital and main water source provide the most significant effects on the decrease in housing prices. The distances to the closest scenic spot, factory, gas station, dump and funeral facilities have a positive correlation with housing prices. The results of the correlation data for the control variables are consistent with the results of previous approximate studies and are therefore not analysed in detail in the subsequent Discussion section.

Quantile regression. Quantile regressions are conducted for different percentiles (0.05, 0.25, 0.5, 0.75, 0.95) of housing

Table 4 Coefficients of the quantile regression analysis (N = 906).

Variables	LAB					LCH				
	q = 0.05	q = 0.25	q = 0.5	q = 0.75	q = 0.95	q = 0.05	q = 0.25	q = 0.5	q = 0.75	q = 0.95
(intercept)	−1.798***	−1.275***	−1.138***	−1.008***	−0.880***	−0.1676***	−1.221***	−1.054***	−0.911***	−0.664***
ADM[=0]	−0.588***	−0.425***	−0.334***	−0.294***	−0.297***	−597***	−0.424***	−0.341***	−0.290***	−0.303***
LCI[=0]	−0.099***	−0.098***	−0.096***	−0.108***	−0.114***	−0.117***	−0.093***	−0.093***	−0.100***	−0.121***
LC2[=0]	−0.064***	−0.106***	−0.100***	−0.122***	−0.167***	−0.074***	−0.108***	−0.097***	−0.116***	−0.139***
POP	0.120***	0.108***	0.093***	0.072***	0.105***	0.105***	0.118***	0.092***	0.062***	0.100***
GDP	0.150***	0.139***	0.177***	0.194***	0.185***	0.143***	0.136***	0.174***	0.192***	0.155***
COM[=0]	−0.077***	−0.082***	−0.088***	−0.085***	−0.105***	−0.084***	−0.088***	−0.088***	−0.080***	−0.097***
T500[=0]	−0.071***	−0.066***	−0.076***	−0.086***	−0.165***	−0.069***	−0.064***	−0.076***	−0.084***	−0.127***
MIN[=0]	−0.039***	−0.054***	−0.039***	−0.047***	−0.056***	−0.031***	−0.054***	−0.041***	−0.046***	−0.045***
PRI[=0]	−0.105***	−0.095***	−0.326***	−0.404***	−0.404***	−0.120***	−0.123***	−0.333***	−0.395***	−0.403***
MID[=0]	−0.106***	−0.171***	−0.167***	−0.4240***	−0.217***	−0.118***	−0.154***	−0.175***	−0.251***	−0.213***
AGE[=0]	−0.049***	−0.057***	−0.068***	−0.072***	−0.098***	−0.033***	−0.055***	−0.075***	−0.073***	−0.081***
DEN	−0.033***	0.013**	0.028***	0.035***	0.030***	−0.031***	0.024***	0.030***	0.030***	0.035***
GRER	0.001	0.010*	0.009*	0.013**	0.016*	−0.012*	0.012**	0.007	0.013**	0.004
FEE	0.058***	0.109***	0.138***	0.145***	0.143***	0.055***	0.104***	0.135***	0.151***	0.151***
RAI	−0.033***	−0.046***	−0.044***	−0.033***	−0.022***	−0.032***	−0.049***	−0.045***	−0.034***	−0.012**
MAR	−0.010***	−0.022***	−0.024***	−0.027***	−0.031***	0.003	−0.025***	−0.025***	−0.025***	−0.034***
HOS	−0.044***	−0.032***	−0.038***	−0.034***	−0.055***	−0.034***	−0.032***	−0.039***	−0.038***	−0.062***
SCE	−0.004	0.008**	0.013***	0.018***	0.023***	−0.007	0.005	0.013***	0.019***	0.031***
GRE	0.012***	−0.004*	−0.013***	−0.007***	−0.015***	0.016***	−0.004	−0.011***	−010***	−0.021***
WAT	−0.030***	−0.032***	−0.026***	−0.042***	−0.077***	−0.035***	−0.033***	−0.026***	−0.040***	−0.071***
FUN	0.062***	0.022***	0.027***	0.028***	0.045***	0.045***	0.026***	0.031***	0.034***	0.052***
FAC	0.014***	0.024***	0.022***	0.016***	0.033***	0.025***	0.026***	0.024***	0.019***	0.039***
GAS	0.025***	0.014***	0.015***	0.016***	0.012**	0.021***	0.011***	0.013***	0.016***	0.011
DUM	0.122***	0.133***	0.101***	0.096***	0.108***	0.120***	0.135***	0.095***	0.086***	0.108***
2C[=0]	−0.112***	−0.067***	−0.033***	−0.028***	0.011	−0.080***	−0.062***	−0.031***	−0.032***	−0.016***
3C[=0]	−0.114***	−0.082***	−0.052***	−0.050***	−0.017	−0.083***	−0.075***	−0.042***	−0.051***	−0.044***
4C[=0]	−0.246***	−0.129***	−0.084***	−0.048***	0.078**	−231***	−0.130***	−0.070***	−0.033	0.009
M①	0.001***	0.001***	0.000	0.000	−0.001***	0.000	0.000	0.000	0.000	−0.001**
M②	0.007***	0.006***	0.004***	0.003***	0.001	−0.002***	−0.001***	0.000	0.001**	0.002***
M③	−0.001**	−0.002***	−0.001***	0.000	0.001***	−0.000***	−0.000	0.000	0.000	0.000*
S①	−0.004***	−0.002***	−0.001**	0.000	0.002**	−0.008***	−0.002***	0.000	0.001	0.002**
S②	0.007***	0.004**	0.005***	−0.004**	0.001	0.008***	0.003**	0.001	0.002	0.000
S③	−0.015***	−0.003*	−0.005***	−0.004**	0.001	−0.001***	0.000***	0.000***	0.000**	0.000*
E1①	−0.001***	−0.001***	−0.000	0.000***	0.002***	−0.002***	−0.001***	0.000***	0.000**	0.002***
E1②	−0.005***	−0.001	−0.001**	0.001	0.004***	0.001	0.000	0.001***	0.003***	0.003***
E1③	0.001	−0.001*	0.001***	0.001***	0.000	−0.000	−0.000	0.000**	0.000	0.000**
E2①	0.000***	0.000	−0.000	0.000***	−0.001***	0.001***	0.000***	0.000***	−0.000	−0.002***
E2②	−0.001	−0.003***	−0.002***	−0.003***	−0.005***	−0.001	−0.001**	−0.003***	−0.004***	−0.006***
E2③	−0.003***	0.000	−0.002***	−0.001***	−0.003***	0.000	0.000	−0.000	0.000	0.000**
Pse R²	0.522	0.467	0.487	0.515	0.536	0.517	0.464	0.486	0.515	0.535
MAE	0.2584	0.1485	0.1201	0.1447	0.2713	0.2573	0.1483	0.1204	0.1446	0.2653

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

prices, and the results are obtained for the corresponding quantile (Table 4). The utility of different quantile regressions can be equivalent to the analysis of the colour preferences of different consumption ability groups. Additionally, to better describe the differences in colour preferences of distinct levels of consumer groups, this research selects colour variables that are significant for different levels of consumer groups and plots the coefficient trend changes of the quantile regressions (Fig. 5) to provide a more intuitive reference.

Spatial regression. Through geographically weighted regression analysis, this research obtained the following spatial regression coefficient results in Table 5 following spatial autocorrelation analysis. In the table of regression coefficient results, the adjusted R-square of the spatial regression models with different colour criteria is greater than 0.8, the AICc is less than −7898, and the BIC is less than −6712, indicating that the regression equations have a stronger fitting effect and model explanatory power. Furthermore, the coefficients of all research variables fluctuate within a certain range, indicating that there are spatial fluctuations in the degree of correlation of the research variables, i.e., there are significant geographic spatial differences in the degree of influence.

Discussion and conclusion
Discussion. Based on the results of the data analysis above, this research begins an empirical discussion on the common preferences for facade colours with reference to condominium consumer groups in the East Asian city of Fuzhou, China. The discussion is divided into three parts: the common preferences of all consumer groups, the preferences of consumer groups with different purchasing power and the preferences of different regional consumer groups. It also discusses the psychological state of public consumption as revealed by colour preferences, as well as the potential causes for the formation of these preferences.

First, for all consumer groups, the research reveals that the majority of condominium consumer groups share a number of preferences for building facade colours. These common preferences are reflected in both the quantity of facade colours and their features. The majority of consumers are obsessed with the quantity of colours, i.e., the greater the quantity of colours is, the greater the price increase of a condominium. There are two possible explanations for this phenomenon. The first is the quantity of facade materials implied by the quantity of facade colours, which tends to have a positive correlation with the construction cost of condominium buildings, such that higher construction costs result in higher housing prices (Mansur et al., 2016). Because all of the samples in this research are second-hand condominiums, it is likely
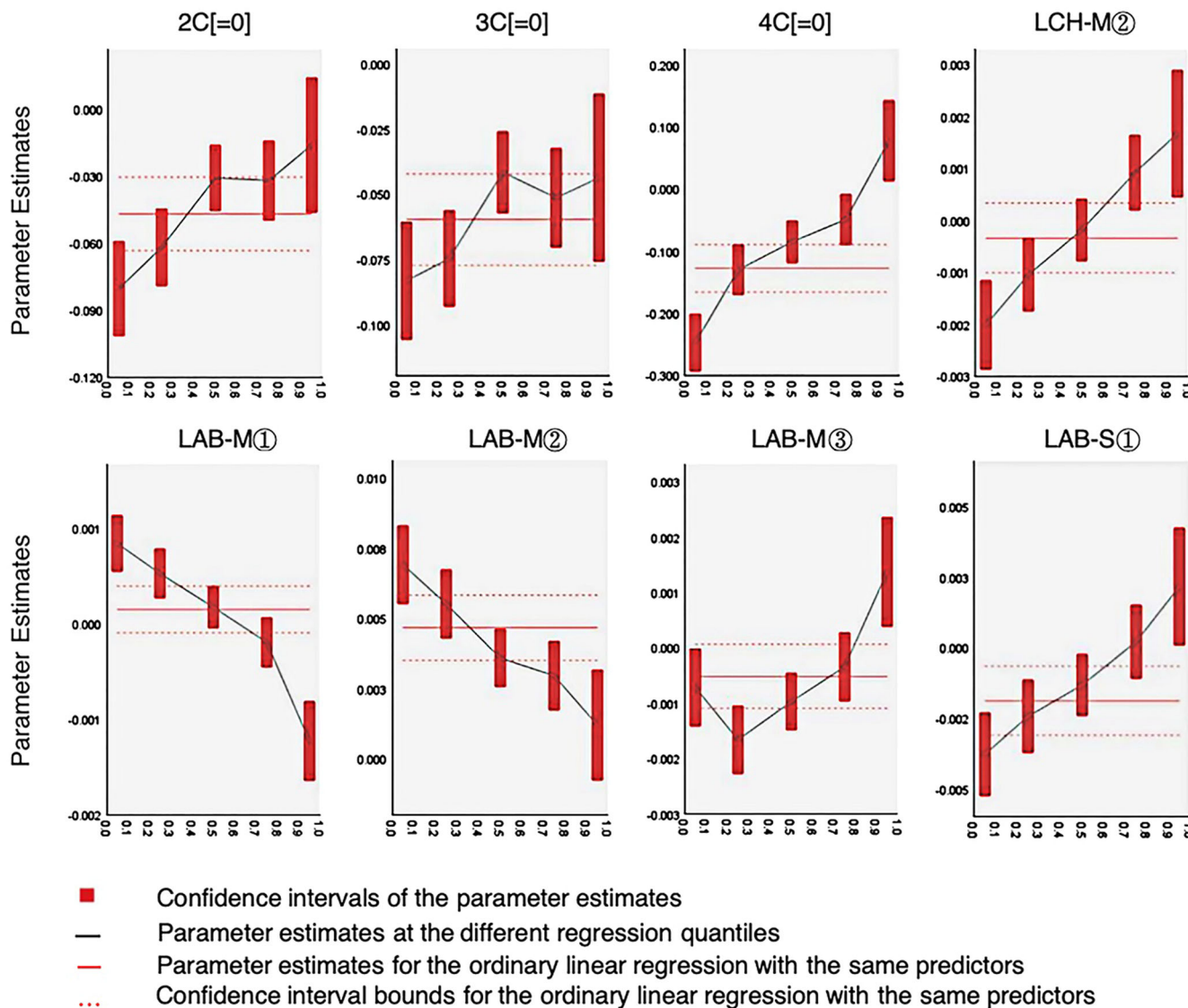
Fig. 5 Results of quantile coefficients. Figure expresses the differences in the coefficients of the specific research variables for groups with different levels of consumption. In this case, the horizontal coordinates represent the groups with different levels of consumption capacity, and the vertical coordinates represent the magnitude of the coefficient values of the corresponding research variables for their different groups.

that the construction costs of first-hand condominiums have little effect, as they are more likely to be due to a price premium resulting from the preferences of second-hand condominium consumer groups for the quantity of colours. The latter case also demonstrates that, for the entire group of condominium consumer groups, the more colourful the facade is, the more appealing it is to consumers. From an analysis of mental well-being, people's positive preference for colour quantity may be closely related to their inner sense of satisfaction. More diverse colours often tend to evoke a greater sense of satisfaction. This aligns with Tosca's (1994) conclusion that people exhibit a preference for four-colour combinations on the facades of apartment-type residences, showing a certain degree of consistency. Perhaps, for humans, an increase in the number of colours psychologically implies an elevation in value (Roediger III, 2005), and the joy brought by this increase in value is precisely the source of such satisfaction (Matzler et al., 2007). In terms of the primary colour features of the facade, all consumer groups prefer red and blue tendencies for the primary colour. This individual colour choice profile closely resembles the population preference profile discovered by Kaya

and Crosby (2010) in Athens, USA. This may imply that in people's psychological activities, people anticipate living in colourful environments that are warm and festive in red and that are serene and tranquil in blue, both in the Athens region of the United States and in the Fuzhou region of China. Colour's ability to evoke strong emotions in people might not vary by geographic location. Apart from the difference between primary and secondary colours exhibiting this consideration of colour brightness and saturation, the brightness and saturation of the primary colour on building facades in this research do not exhibit a group preference. This result is in contrast to the findings of Wang et al. (2021) in Shanghai, China. Nevertheless, this consideration of colour's lightness and saturation is reflected in the contrast between primary and secondary colours. From the contrast features of primary and secondary colours, all consumer groups prefer low contrast colour lightness and high contrast colour saturation, and the conclusion reached by Li et al. (2020) in Taipei, Taiwan, is not the same; people also prefer red–green contrast between primary and secondary colours but not yellow–blue contrast, and the degree of preference for red–green contrast difference is greater than the

Table 5 Coefficients of the spatial regression analysis (N = 906).

Variables	LAB		LCH	
	Min	Max	Min	Max
Intercept	−5.045	0.999	−5.034	0.493
ADM	0.006	0.749	0.026	0.806
LC1	−0.006	0.224	−0.001	0.208
LC2	0.001	0.446	0.011	0.399
POP	−0.009	0.626	−0.026	0.611
GDP	0.044	0.222	0.065	0.223
COM	−0.001	0.154	0.012	0.148
T500	−0.011	0.149	−0.013	0.145
MIN	−0.033	0.171	−0.032	0.164
PRI	0.106	0.358	0.116	0.369
MID	−0.033	0.322	−0.031	0.313
AGE	−0.023	0.115	−0.016	0.123
DEN	−0.034	0.077	−0.042	0.072
GRER	−0.030	0.095	−0.037	0.075
FEE	0.071	0.159	0.069	0.159
RAI	−0.106	0.068	−0.106	0.061
MAR	−0.064	0.015	−0.070	0.019
HOS	−0.056	0.044	−0.053	0.031
SCE	−0.045	0.038	−0.040	0.036
GRE	−0.033	0.032	−0.039	0.032
WAT	−0.110	−0.023	−0.109	−0.010
FUN	−0.071	0.145	−0.060	0.145
FAC	0.008	0.066	0.005	0.067
GAS	−0.017	0.066	−0.019	0.067
DUM	−0.405	0.352	−0.372	0.328
2C	−0.051	0.070	−0.038	0.090
3C	−0.028	0.118	−0.028	0.120
4C	−0.228	0.194	−0.049	0.284
M①	−0.007	0.006	−0.002	0.005
M②	−0.002	0.002	0.000	0.000
M③	−0.004	0.001	−0.002	0.001
S①	−0.018	0.006	−0.007	0.021
S②	0.000	0.002	−0.047	0.004
S③	−0.020	0.002	−0.012	0.003
E1①	−0.007	−0.002	−0.002	0.007
E1②	0.000	0.000	−0.005	0.002
E1③	0.000	0.001	−0.001	0.002
E2①	−0.003	0.019	−0.010	0.002
E2②	−0.002	0.000	−0.004	0.007
E2③	−0.002	0.021	−0.003	0.013
−2 log-likelihood	−8254.415		−8262.476	
CV	0.020		0.020	
R²	0.807		0.807	
Adj-R²	0.801		0.801	

the quantity of colours on the facade, whereas the higher the consumption level is, the less of a preference for the quantity of colours and even a degree of resistance to too many colours. The inverse relationship between the consumption level and colour quantity preferences is the most significant feature of facade colour quantity preferences among individuals with varying consumption abilities. This also partially explains why the majority of low-end residential communities have a facade with a greater quantity of colours, whereas high-end residential communities prefer an uncomplicated and uniform design scheme for the facades as a whole. This phenomenon demonstrates that, at the level of internal factors, the high-consumption group is not concerned with the quantity of the aesthetic perception of harmony (Burchett, 2002) and that their psychological perception of aesthetics differs from those of the middle- and low-consumption groups. From the features of the primary colour of the facade, the lightness of the primary colour exhibits the same degree of group preference variation as the quantity of colours. The low-consumption group prefers fundamental hues that are brighter and less saturated. The high-consumption group prefers the primary colour with reduced lightness and greater saturation. In the red-green colour tendency of the primary colour, the lower the consumption level of the condominium consumer groups is, the more persistent and profound the preference for red, as evidenced by the analysis of the data of the low- and middle-consumption categories. Low- and middle-consumption groups favour the blue tendency in the primary colour's yellow–blue colour tendency, whereas the high-consumption group prefers the yellow tendency. The high-consumption group prefers the primary colour of the facades to be dark and high-saturation yellow. The analysis above determines that there are two main categories of urban condominium consumer groups' preferences for the primary colour of facades: the low-saturation bright red style preferred by the low- and middle-consumption groups and the high-saturation dark yellow style preferred by the high-consumption group. Additionally, this may disclose the inner perception preferences of different consumer groups. The low- and middle-consumption groups prefer the open and festive atmosphere, whereas the high-consumption group prefers the wealthy and low-profile style (note: in the background culture of East Asia, the colour yellow has a symbolic meaning of wealth) (Getman, 2014). This indicates that the middle- and low-consumption groups are more concerned with the pursuit of a better existence, whereas the high-consumption group is more concerned with the fulfilment of their inner selves. Regarding the contrast features between the primary and secondary colours of the facade, the low- and middle-consumption groups prefer low contrast in lightness, with the degree of preferences being proportional to the consumption level, whereas the high-consumption group prefers high contrast in difference. Similar to the difference between the red-green colour tendency of primary and secondary colours and the yellow–blue colour tendency of primary and secondary colours, the distinction between the red-green colour tendency is more positive than the difference between the yellow–blue colour tendency. In addition, there is a significant preference difference between the low-consumption group and the high-consumption group regarding the distinction between primary and secondary colour saturation. In conclusion, the middle- and low-consumption groups prefer the green colour with the same lightness and different saturation as the secondary colour but not to the same degree as the low-consumption group, whereas high-consumption group only has a preference for the contrast in lightness between the primary and secondary colours and no preferences for differences in colour tendency and saturation. The analysis of the distinction between the primary and secondary

degree of aversion to yellow–blue contrast difference. In addition, there may be a degree of red–green preference differences between the primary and decorative colours, while the saturation difference may be irregular due to the coexistence of preference and tedium. This suggests that individuals are more interested in the sensory stimulation of colour and in obtaining satisfaction from differences in colour balance. Overall, when the primary colour is dark red and the secondary colour is dark green, condominiums with four or more facade colours that are near in lightness and contrast in saturation between primary and secondary colours are most likely to be favoured by the general public.

Second, the results of the data analysis corroborate that individuals with varying levels of spending power have distinct colour preferences for exteriors. This research organises the facade colour preferences of individuals with varying levels of purchasing power in Table 6 for clearer comprehension. The lower the consumption level is, the more insistent the group is on

Table 6 Colour preference of different consumption groups.

	Index	Low-consumption group	Middle-consumption group	High-consumption group
Quantity of colours	–	Preference order: 4 colours or more, 3 colours, 2 colours, 1 colour	Preference order: 4 colours or more, 3 colours, 2 colours, 1 colour, to a lesser extent than low-consumption group	May not prefer 4 colours or more, no preferecne in quantity of colours
Primary colour	Lightness	Minor preference high lightness	–	Minor preference low lightness
	Red-green	Prefer red, more favoured by lower consumption group	Prefer red, to a lesser extent than low-consumption group	–
	Yellow-blue	Prefer blue	Prefer blue	Prefer yellow
	Saturation	Prefer low saturation	–	Prefer high saturation
Difference in the primary and secondary colours	Lightness	Prefer minor differences, more favoured by lower consumption group	Prefer minor differences, to a lesser extent than low-consumption group	Prefer major differences
	Red-green	Prefer major differences, more favoured by lower consumption group	Prefer major differences, higher consumption group prefer minor differences	–
	Yellow-blue	Prefer minor differences	Prefer minor differences, to a lesser extent than low-consumption group	–
	Saturation	Prefer major differences, more favoured by lower consumption group	–	–
Difference in the primary and primary decorative colours	Lightness	Prefer minor differences	–	Prefer major differences
	Red-green	Prefer minor differences	Prefer minor differences, to a lesser extent than low-consumption group	Prefer major differences
	Yellow-blue	–	Prefer major differences	–
	Saturation	–	Prefer major differences, to a lesser extent than high-consumption group	Prefer major differences
Difference in the primary and secondary decorative colours	Lightness	–	–	Prefer minor differences
	Red-green	–	Prefer minor differences, to a lesser extent than high-consumption group	Prefer minor differences
	Yellow-blue	Prefer minor differences	Prefer major differences	Prefer minor differences
	Saturation	–	Prefer minor differences, to a lesser extent than high-consumption group	Prefer minor differences, more favoured by high-consumption group

Major denotes a significant preference distinction. Minor refers to a little preference distinction.

colours above demonstrates that the secondary colour psychology preferences of the low- and middle-consumption groups are more explicit and concrete, while those of the high-consumption group are more inclusive and diverse. Psychologically, it also infers that the aesthetics of the low- and middle-consumption groups are fixed and conformist, whereas the aesthetics of the high-consumption group are more distinctive. In terms of the contrasting features of the primary colour of facades and the primary decorative colour, the low-consumption group prefers a low difference in both the difference in lightness and the difference in red–green colour tendency; the middle-consumption group is consistent with the low-consumption group in the difference in red-green colour tendency, but the intensity is not as strong as the low-consumption group; and the high-consumption group prefers a high difference in lightness and red–green colour tendency. In the difference in the saturation of the primary decorative colour, both the middle- and high-consumption groups show a preference for the high difference. While in the difference of yellow–blue colour tendency, the middle-consumption group shows an exclusive preference for the high difference. Therefore, in psychological terms, the low-consumption group hopes that primary and secondary decorative colours and the primary colour can have unified coordination; the high-consumption group prefers a strong sense of colour contrast; and the middle-consumption group hopes that the primary decorative colour can favour the purple colour with a high difference in saturation with the primary colour. For the difference between the primary colour and the secondary

decorative colour, all consumer groups hope that the two can exhibit a certain degree of similarity rather than too many colour contrast differences. Thus, the primary decorative colour plays a design role, while the secondary decorative colour has a relatively weak meaning.

Finally, on the basis of the research variables, the differences in the colour preferences of different regional consumer categories are discussed. Since the research variables have various sample significance ratios and correlation levels for different geographic spatial regions, the spatial analysis section focuses on the variables with global regression significance. Before discussing the colour preferences of condominium consumer groups in different regions, it is helpful to refer to the sample distribution diagram (Fig. 6) of the research variables with global significance for a more intuitive understanding of the degree of differences in the colour preferences of different regional consumer groups under different research perspectives. Because prior research did not address the pertinent research subjects in this part, the presentation of this aspect of the research represents a novel and preliminary conclusion. The condominium consumer groups that are sensitive to the quantity of colours on the facades are broadly dispersed geospatially (Fig. 6a–c). Those with preferences for two and three colours are distributed similarly in terms of geospatial location, and those with preferences for four or more colours are located in the eastern portion of Fuzhou city. In psychological terms, those who are sensitive to the preferences for various colours are mainly concentrated in the eastern part of Fuzhou city on both sides of the Minjiang River, with the Taijiang District, the eastern part of the
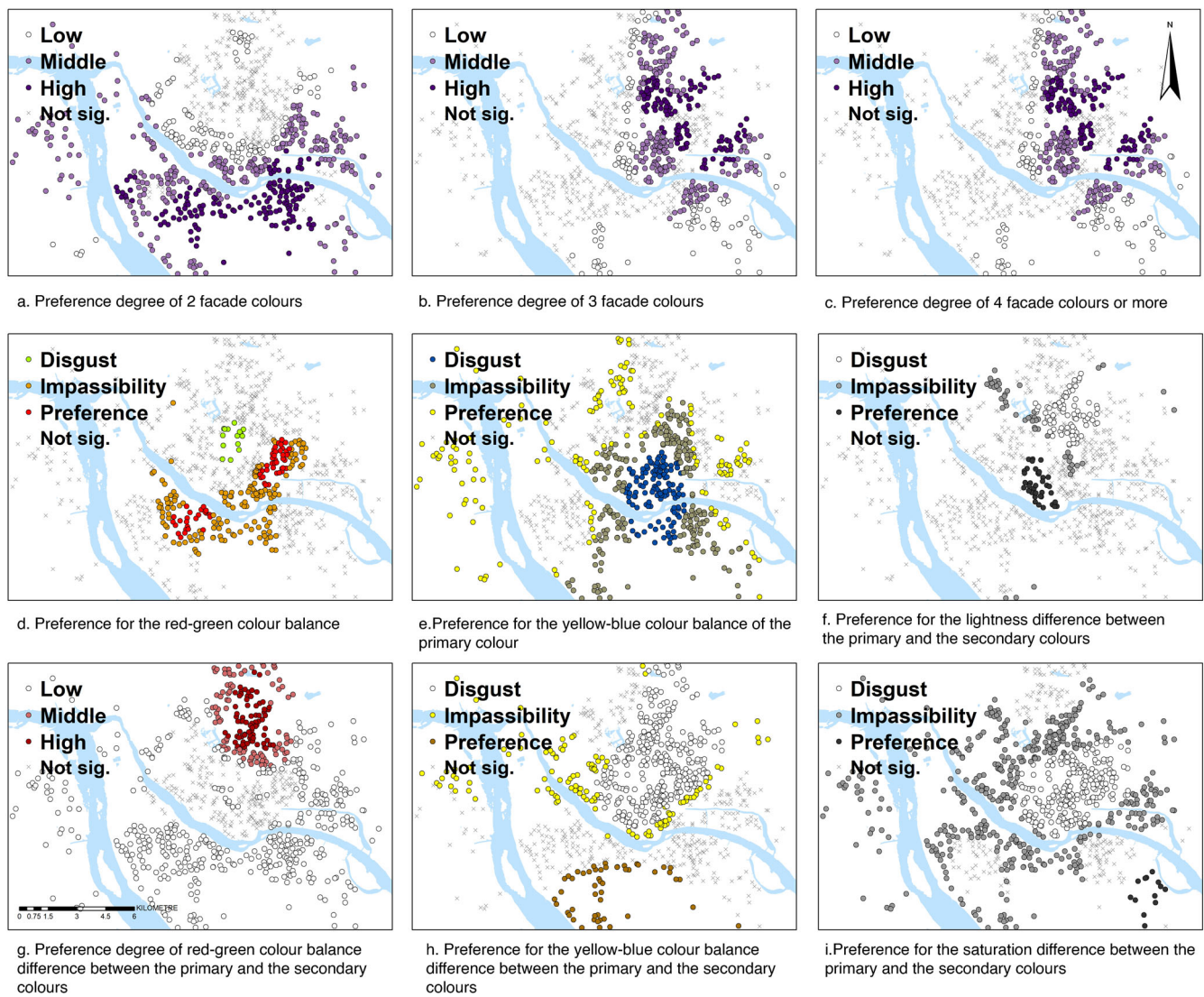
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Fig. 6 Colour preference of different consumption groups in space. Figure depicts the variability in colour preferences for building facades across different spatial subgroups of consumers. The legend in **a–i** expresses the differences in the preferences of different regional consumption groups for various colour balances (Disgust, Impassibility, PrefeR, Not sig.), as well as the strength of the preferences for colour brightness and colour saturation (Low, Middle, High, Not Sig.).

Cangshan District, and the northern part of the Jin'an District as the core gathering places; the majority of condominium consumer groups in the Taijiang District have a high preference for two, three, and four or more colours of facades; the majority of condominium consumer groups in the eastern part of the Cangshan District have a high preference for one colour of facades; in the northern portion of the Jin'an District, the condominium consumer groups favour three and four hues. In terms of the primary colour features of facades, the spatial concentration of condominium consumer groups with similar preferences follows a certain pattern. The groups with a preference for the red-green colour tendency of the facade's primary colour are concentrated at Wanda Plaza, Yantai Mountain, and Shida Pedestrian Street in the Cangshan District; Shangxia Hang, Chating, and Zhongting Street in the Taijiang District; Shiou Plaza in the Jin'an District; and Three Lanes and Seven Alleys in the Gulou District (Fig. 6d). There is a strong geographical correlation between the spatial distribution of consumer groups sensitive to the tendency of red-green colours and the city's active commercial districts. The regional condominium consumer groups, primarily in Wanda Plaza in the Cangshan District and Shiou Plaza in the Jin'an District, exhibit a strong preference for the colour red. The

condominium consumer groups with a preference for both commercial dominance and the red facade primary colour may be younger or more optimistic. The reason is that there is a correlation between the active nature implied by the consumer group's predilection for the colour red (Terada et al., 2012) and the vitality associated with the advertisement in the area. In contrast, the condominium consumer groups near Three Lanes and Seven Alleys in the Gulou District are fed up with the predominant red tendency. As the early urban origin of Fuzhou, Three Lanes and Seven Alleys is a famous historical and cultural location in Fuzhou, as well as one of the most expensive residential areas in Fuzhou. Therefore, the majority of condominium consumer groups in this area are wealthy individuals with an affinity for Oriental culture. Taking into account the external features of Three Lanes and Seven Alleys' white walls, the aesthetic psychology of the condominium consumer groups in this area should lean towards a simple and refined style. Although the condominium consumer groups in this area may also favour the commercial vitality of Three Lanes and Seven Alleys, their aesthetic preferences determine their opposition to the red colour of the surrounding buildings. There is a strong concentric urban spatial stratification of groups with various

preferences. Groups with sensitivity to the yellow-blue colour tendency are more widely distributed in Fuzhou. Figure 6e demonstrates that groups in the urban periphery have a strong preference for the prevalent colour yellow tendency, whereas groups in the downtown Taijiang and Cangshan Districts dislike the yellow tendency. This finding may be related to the inner demand of the condominium consumer groups, with the sensation of wealth represented by the yellow tendency becoming the group's greatest inner demand in this area. Due to their boredom with city life, consumer groups opposed to a yellow tendency exhibit an "idyllic mentality" (note: idyllic mentality indicates that people who have accumulated a certain quantity of wealth begin to focus on the concept of the living environment) (Swartz, 2008). This is reflected in the common features of the areas where the blue residential sample is concentrated: the highest house price in the city, the best views of the river, the most attractive surroundings and greenery, and the quality of cultural and educational resources. In terms of the distinctions between the primary and secondary colours of facades, the spatial distribution patterns of condominium consumer groups have similar preference differences. In terms of the difference in lightness preferences between primary and secondary colours (Fig. 6f), the sensitive groups are primarily localised in the central region of Fuzhou city, and the preferences for high lightness contrast are greatest in the region surrounding Shangxiahang in the Taijiang District. The condominium consumer groups that are sensitive to the difference in the colour tendency between primary and secondary colours are dispersed throughout the city (Fig. 6g), with the exception of a few downtown areas. The population as a whole has a clear preference for the difference in red-green colour tendency, with the strongest preference for those who buy condominiums in the northern part of the old city of Fuzhou (the northern part of the border between the Gulou District and the Jin'an District). In Fuzhou's relatively early downtown area (Gulou District, Taijiang District, Jin'an District) (Fig. 6h), the condominium consumer groups sensitive to the distinction between the primary and secondary colour yellow-blue tendency are primarily concentrated. While the condominium consumer groups who are sensitive to the difference in saturation between primary and secondary colours encompass the city as a whole (Fig. 6i), they are primarily concentrated in the suburbs. However, the group with significant differences in preferences for yellow-blue colour tendency and saturation preferences is found only in the southern Cangshan District's peripheral areas. In general, the condominium consumer groups that pay the most attention to the relationship between primary and secondary colours are primarily concentrated in the region between Fuzhou West Lake Park and Jinniushan Park. The condominium consumer groups in this region prefer larger differences in the red-green colour tendency between primary and secondary colours and smaller differences in lightness, saturation, and the yellow-blue colour tendency. This finding indicates that the condominium consumer groups in this area are conservative and consistent in terms of facade colour aesthetic psychology. This group prefers the red-green colour tendency between primary and secondary colours, except for a certain degree of difference, and other aspects of coordination and consistency are more respected between primary and secondary colours. Combining the colour preferences of this group with the aesthetic culture of East Asia, it can be presumed that the majority of condominium consumer groups in this area are middle-aged and elderly.

Conclusion. Based on empirical evidence of consumer behaviour in urban society, this research employs a combination of field research and computer analysis. It is the first to explore the colour preferences of different categories of homebuying consumer groups in Fuzhou, China, using the correlation between building

facade colour characteristics and housing transaction information as reference data. Additionally, this research performs estimations regarding consumer groups' potential psychological states. This research utilises methods from economics and geography to uncover commonalities in colour preferences among homebuying consumer groups, shedding light on the field of social psychology. Furthermore, this research represents an innovative attempt to introduce interdisciplinary modelling methods into social psychology research, using relatively precise measurement standards to investigate the colour preferences and psychological states of homebuying consumer groups. This research also includes some conclusions that are approximations of those from earlier research as well as more precise and thorough research results.

This research analyses a sample of condominiums in Fuzhou, China, and finds that the commonalities in facade colour preferences among urban condominium consumer groups in this region may be as follows. For all urban condominium consumer groups, there is a common preference for the quantity and features of facade colours. The overall preference is most likely for facades with four or more colours, with dark red as the primary colour and dark green as the secondary colour, while the lightness between primary and secondary colours is close and the contrast in saturation is strong. For condominium consumer groups with different consumption levels, there is a different preference for the quantity and features of facade colours. The colour preferences of the low- and middle-consumption groups tend to be conservative, robust, and conventional, whereas the high-consumption group prefers tendencies that are daring, avant-garde, diverse, and vibrant. For condominium consumer groups with different consumption levels, there is a unique commonality of colour preferences for different condominium consumer groups in different geographic spatial locations. For example, condominium consumer groups around the cultural area prefer basic and plain facade colours, whereas the condominium consumer groups around the commercial area prefer passionate and exuberant hues.

Additionally, by summarising building facade colour preferences, this research performs potential estimations regarding the psychological characteristics of various societal classification groups. This research is the first to reveal that different societal consumer groups distinguished by purchasing power or geographical location do not share the same psychological commonalities in colour preferences. It is estimated that these variations in shared understanding may stem from life experiences and cultural backgrounds. Therefore, from a social psychology perspective, the research findings on the psychological states of consumer groups may vary based on different reference standards within the social environment.

Implications. The insights of this research encompass both theoretical and practical aspects. The theoretical dimension pertains to the social science value provided for research scholars, while the practical dimension relates to the tangible utility for professionals engaged in social practice.

On the theoretical front, the social science value of this research can be further categorised into methodological and conclusion-oriented value. In terms of methodology, this research offers a fresh reference point for researchers in the field of social psychology. Scholars with similar research objectives in other regions can adopt the economic and geographical methods used in this research, with pricing as a reference, to explore the field of colour psychology. In terms of conclusion-oriented value, for other cities and regions with close cultural exchanges with Fuzhou in East Asia and globally, the findings of this research can be used as a reference to anticipate colour preferences for residential facades in the study area. This allows for cross-comparisons with research conclusions to derive more comprehensive generalisations. Additionally, based

on the conclusions of this research, scholars can employ psychological expertise to estimate the age, gender, and educational levels of different consumer groups. This, in turn, can facilitate empirical assessments of shared colour preferences for residential facades among consumer groups of different ages, genders, and educational levels.

On the practical front, this research holds professional utility for housing developers and government planning authorities. In the study area, Fuzhou, China, housing developers can use the analysis results to contemplate facade colour designs that cater to various target demographics and different community locations. Doing so will enable them to identify optimal colour design schemes that maximise commercial benefits by meeting the preferences of diverse consumer groups. Simultaneously, government planning authorities in the Fuzhou region can draw guidance from the analysis results of this research when proposing recommendations for facade colours in community areas during urban functional adjustments or designs. This contributes significantly to the city's image positioning and the coordination of its liveability environment.

Limitations. Although this research represents the first interdisciplinary attempt to derive sociopsychological implications from an empirical analysis of building facade colour preferences among homebuying consumer groups, yielding certain conclusions, there are some limitations. For instance, the facade colour preferences of condominium consumer groups discussed in this research reflect only the correlation between the quantity and features of facade colours and not other facade features, such as material, which are highly correlated with colour. On the other hand, the information composition of colour itself is very complex, and it is difficult to quantify all the information, such as the location of colour facades, shapes, and other related colour information, which is not accounted for in the research. Thus, future research will need to be conducted to add and enhance the relevant information. Similarly, for the results of the data on preference variability, this research analyses the psychological state of groups based on a summary of previous research and the researcher's life experience; however, there is no absolute uniformity. Finally, it is widely acknowledged that the preferences for things are influenced by cultural environments. Therefore, due to cultural differences and aesthetic variations between Fuzhou, China, and other regions worldwide, it is possible that the conclusions of this research may not be easily generalisable beyond East Asian cities where some Fuzhou diaspora communities are concentrated.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author contributions

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

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Additional information