

Investigation and analysis of public space in child-friendly community based on NCD color system—Taking Xianggangshan Community of Guangzhou as an example

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ABSTRACT

This study explores the application and impact of the NCD color system in designing child-friendly public spaces within the context of Guangzhou's Xianggangshan community. The aim is to enhance children's mental health, social development, and spatial attractiveness through color design. Using empirical research methods and the NCD's "Color Image Scale" tool, the study analyzes children's color preferences and their influence on the atmosphere of public spaces. Findings indicate that bright, warm colors positively impact children, while cluttered and dull color schemes are unwelcoming. Moreover, gender differences in color preferences are observed, with boys favoring high-purity, vibrant hues and girls preferring softer tones. Based on these findings, the study proposes scientific color schemes for Xianggangshan's public spaces, fostering a child-friendly and vibrant environment. This research not only offers color design guidance for the specific community but also provides valuable insights for future child-friendly community developments.

KEYWORDS

NCD color system; Child-friendly community; children public space design; color science

1 INTRODUCTION

The Convention on the Rights of the Child, issued in 1989, mandated that cities should be suitable for all, particularly children who represent the future of humanity, and advocated for considering children's rights as a core element in urban development. Subsequently, in 1996, the United Nations Children's Fund (UNICEF) and the United Nations Human Settlements Programme (UN-Habitat) jointly formulated and advocated the "Child-Friendly Cities Initiative (CFCI)." UNICEF projects that by 2050, 70% of children will be living in urban areas (United Nations Children's Fund, 2012). In China, the "Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through the Year 2035" has set clear goals and contents for child-friendliness, emphasizing "optimizing the environment for children's development and effectively safeguarding their rights to survival, development, protection, and participation." Thus, building "child-friendly cities" has gradually emerged as a significant issue that cannot be overlooked.

Currently, research on child-friendly community street spaces primarily focuses on the following aspects: firstly, spatial planning studies, where Riggio analyzed the characteristics of "child-friendly cities" and proposed corresponding planning measures (Riggio, E, 2002); secondly, children's play

and interaction patterns (Abu-Ghazze, T. M, 1998), which emphasized the importance of street environments for children's development and social interaction, advocating for balancing the needs of children and traffic in community street planning; and thirdly, research on facility layout and environmental safety in child-friendly communities (Zhong Yanfen, 2018). However, there is a need for deeper exploration into the "softer" aspects such as children's psychological needs and the multifaceted factors influencing their development.

In terms of urban color design, Galen Minah believes that color can clarify and define the form and structure of space, playing a crucial role in architectural and urban design processes. As a core element of visual art, color profoundly influences children's cognition, emotions, and behaviors. Integrating color theory into the study of child-friendly community street spaces not only enhances the visual appeal of these spaces but also promotes children's physical, mental, and social well-being through strategic color usage. Common color application systems used in architectural space design include the Practical Color-ordinate System (PCCS) and the Nippon Color Development (NCD) color system. PCCS is suitable for comprehensive analysis of color attributes and styles, while NCD excels in expressing emotional semantics of color. Combining psychology and semantic analysis, NCD systematizes color image scales, integrating color, color matching, language, environment, and human factors. It establishes the "Color combination Image Scale" and "Adjective Image Scale" coordinate systems, transforming color from a mere visual element into a multifaceted linguistic tool capable of conveying emotions.

Therefore, this study, based on the color system theory of the Nippon Color Development Institute (NCD), takes the Xianggangshan Community in Guangzhou as an example to explore the potential impact of different color schemes on children's behavior and mental health in the design of public spaces in child-friendly communities.

This empirical research reveals the potential value of color in the design of public spaces in child-friendly communities. Leveraging the NCD color system, we can quantify and systematically analyze children's emotional preferences for color, providing scientific color schemes for the design of Xianggangshan Community and other public spaces. Looking ahead, we anticipate more researchers delving into the application of color science in the construction of child-friendly communities, creating richer, more vibrant, and nurturing environments for children's growth.

2 METHODOLOGY

2.1 NCD color system and psychological relationship

In 1915, Munsell introduced the Munsell Color system, which gained widespread adoption in the industrial world due to its user-friendly nature. Building upon Munsell's research system, Shigeobu Kobayashi of the Japan Color Research and Design Institute developed the NCD (Natural Color System - Nippon Color) by referencing the ISCC-NBS color naming method. The NCD color system successfully represents the entire spectrum of colors using 130 carefully selected hues, aiming to align with human visual perception by categorizing colors into fundamental groups based on brightness, saturation, and other perceptual levels. This classification method aims to provide designers and artists with a more accurate selection of colors that cater to different emotional needs. An essential tool within this system is the "Color Image Scale," which arranges and classifies these 130 colors on a two-dimensional plane according to tone and hue before mapping them onto three axes: warm-cool, soft-hard, clear-gray. By integrating psychology and semantic discrimination principles, this comprehensive approach combines color theory with language comprehension while considering environmental factors as well as human preferences. (Figure 1)

Therefore, with the help of the "Color combination Image Scale" and "Adjective Image Scale" of

NCD color system and the particularity of the users of the site, This paper evaluates the color of the public space of Xianggangshan community, explores the color tendency of the child-friendly space of Xianggangshan community, introduces child-friendly ideas to stimulate and guide the design, and explores the possibility of connecting the construction of old urban blocks with the child-friendly concept.

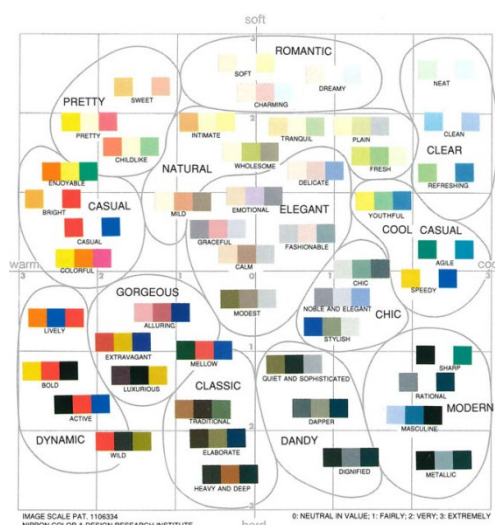


Figure 1 Color Combination Image Scale (three colors).Source: NIPPON COLOR & RESEARCH INSITUTE

2.2 Current Status of Xianggangshan Site and Collection of Children's Color Preferences

Overview of Xianggangshan Community

Xianggangshan Community, situated in Liurong Street, Yuexiu District, Guangzhou City, Guangdong Province, China, lies along the eastern flank of Jiefang North Road, with the Nanyue King Museum to its north and Dongfeng West Road Primary School to its southwest. The community is built along the hillside, climbing upwards with the terrain, creating a series of terraced steps and layered streets that give rise to numerous spaces and plazas of varying sizes.

Within the community, there are four sizable open areas designated for rest and conversation, three of which are equipped with children's playground facilities, while one features a bamboo pavilion for adults to engage in leisure activities such as chess and cards. The primary playground is situated along the main thoroughfare of Xianggangshan, while the other two, located in more secluded areas, have been appropriated for storing miscellaneous items. Given the proximity of two primary schools, children constitute a significant portion of the community's population, yet only one child-friendly facility remains functional. Due to the topographical constraints of the community's buildings and streets, which limit available space, altering architectural forms and facilities proves challenging. Consequently, this study proposes exploring the relationship between public space and children's behavior from the "color" perspective of the original site, adopting color as the leading design concept and fully considering children's emotional needs and comfort within these spaces (Figure 2).

The construction of public spaces in Xianggangshan Community mirrors that of traditional Chinese communities, prioritizing functionality over other aspects, thereby neglecting children's psychological needs for color during their development. Furthermore, as the community evolves, spontaneous organization and occupation of public areas by residents often lead to the encroachment of private belongings and facilities into planned public spaces. This phenomenon not

only reduces children's play areas but also clutters the community's color palette, resulting in a "gray," "busy," or "vulgar" visual impression. Therefore, rejuvenating these spaces through color design represents one of the starting points of this study, aiming to enhance their vitality.



Figure 2 Map of Xianggangshan community and its facility distribution. Source: the author of self-painting, self-photography

2.3 Site Color Collection and Questionnaire Survey

To establish an initial understanding of the color characteristics of the original site and explore the extent of the surrounding environment's influence on community colors, the colors of the public space environment within the community were extracted and analyzed. Focusing on creating a child-friendly color scheme for community public spaces, this study specifically targeted a small plaza equipped with three children's play facilities for color extraction. This encompassed the colors of facilities, paving, vegetation, and background buildings, which were then plotted on an NCD hue and tone chart as well as a "Color Image Scale." Additionally, firsthand interviews with children and parents in Xianggangshan were conducted to gather their initial impressions of the colors in public areas, thereby assessing the overall color trend in the community's public spaces.

Furthermore, to investigate the usage patterns of public spaces in this community and the color preferences of children, a "Color Image Scale"-based approach was employed. Through four rounds of field research, conducted on Friday and Sunday afternoons and evenings, interviews and questionnaires were administered to children and their parents in Xianggangshan. The questionnaire comprised two main sections: firstly, children were shown images of public spaces from various communities and asked to rate the richness, harmony, and satisfaction level of the colors depicted on a scale of 1 to 5. These images were then analyzed using software to extract color blocks, forming a foundational color spectrum. Secondly, to delve deeper into children's color preferences for community environments, pictures and color cards were used to guide children in expressing their preferences for different color combinations, allowing them to select their six favorite and least favorite colors.

Ultimately, 38 paper questionnaires were collected, with 36 deemed valid, while 43 electronic questionnaires were received, of which 35 were valid, totaling 71 valid questionnaires. By collecting and analyzing these responses, the color preferences of children in Xianggangshan Community

were plotted on the NCD "Color Image Scale" and matched with the "Color Combination Image Scale" and "Linguistic Image Scale" to identify suitable color schemes for the community.

3 RESULTS AND DISCUSSIONS

3.1 Color Matching and Emotional Semantics of Public Spaces in Xianggangshan Community

Through color processing of on-site photographs, it can be concluded that yellow, brown, green, and achromatic colors constitute the primary hues. The ground paving predominantly features low-brightness, low-saturation yellows and achromatic tones, while play facilities exhibit higher brightness and saturation, with bright yellows, reds, and blues serving as accents within the overall color palette. All three plaza spaces suffer from a lack of uniformity in color theming, and children's color needs are primarily reflected in play facilities. Simple coloring has resulted in a stark contrast between these equipment colors and the surrounding environment, leading to a discontinuity and disharmony between points and planes within these spaces. Additionally, from a child-friendly perspective, public facilities other than play equipment, such as benches and guardrails, tend towards dull tones (DI), making it difficult for children to distinguish play area boundaries and hindering their interest in exploring areas beyond the equipment (Figure 3).

Field interviews also revealed that most children expressed satisfaction with the colors of play equipment in the plazas. At Site 1, they described the equipment as "looking very new" and "beautiful, like the color of the sun." However, they expressed dissatisfaction with the cluttered colors of the surrounding environment, commenting that "it looks dusty and dirty around here." Meanwhile, equipment at Sites 2 and 3, due to years of neglect and accumulated dust, appeared faded and "not clean, not liked." This underscores how the temperature and saturation of equipment colors directly influence children's visual and psychological perceptions (Figure 4).

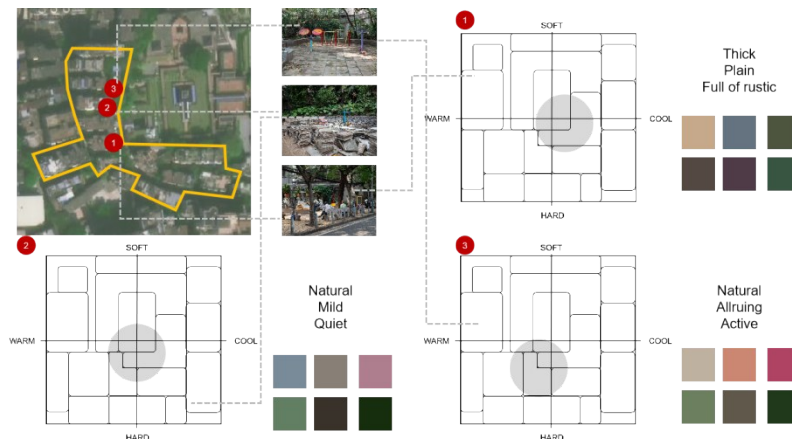


Figure 3 Overall color perception map of Xianggangshan Community public space. Source: the author of self-painting, self-photography

3.4 Color Preferences of Children in Xianggangshan

After evaluating the richness, harmony, and satisfaction levels of photographs from various community public spaces, we further analyzed the images of children's play facilities from the questionnaires by converting them into color block combinations and placing them within the NCD

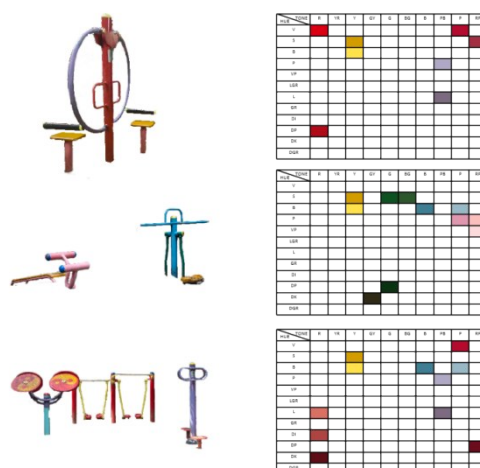


Figure 4 Color and color distribution of amusement equipment. Source: the author of self-painting, self-photography

color coordinate system. Images with predominantly cool tones and high color hardness received lower scores, with the lowest being the satisfaction score of merely 2.91. These images were associated with emotional descriptors such as "plain, primeval, coarse" on the "Color Combination Image Scale," which children interviewed offline expressed clear dislike for. Conversely, images featuring warm tones consistently scored above 4.0, encompassing both soft and hard colors, mostly belonging to the P (pale tone), v (vivid tone), and b (bright tone) categories. This indicates that the hardness of colors has minimal impact on children's preference for community colors. Notably, the image with the highest richness score (4.21) featured contrasting colors of yellow and blue, which, due to their vivid tones and strong contrast, evoked a sense of excitement and novelty among children. This combination ensured that the contrasting colors did not appear jarring, contributing to a high harmony score as well. Meanwhile, images with the highest harmony scores predominantly featured hues in the G and GY hue regions, while the second-highest harmony score belonged to an image dominated by Y hues. Interestingly, an image with a satisfaction score of 4.0 only received a harmony score of 3.64 due to uneven distribution of hues, including Y, R, G, and B, all with high brightness and purity in vivid tones, leading to an overall high score despite the lack of harmony.

Therefore, in designing child-friendly community public spaces, the use of cool and hard tones may diminish children's satisfaction and engagement, whereas warm tones are more likely to captivate their interest and affection. Additionally, the richness and contrast of colors significantly influence children's visual and emotional experiences. High-contrast color combinations, like yellow and blue, enhance the space's richness by stimulating and refreshing children. On the other hand, harmonious color combinations contribute to the overall aesthetic appeal and children's comfort, with adjacent hues from the NCD system being ideal for such compositions.

The analysis of the questionnaire according to the gender influence factor found a significant difference in the choice of "six favorite colors" between boys and girls in Xiangangshan children. Boys prefer to high purity and bright colors in color selection, especially like high purity yellow. In addition, boys also prefer high purity blue and green, and also show a preference for high purity red and yellow of bright tone. These colors are characterized by scattered color phase, high color purity, and a strong sense of stimulation, which may reflect their pursuit of more vivid and exciting feelings in the visual experience. Girls show completely different preferences in color choice. They mainly prefer pale tone, which are concentrated in purple red, purple and a small amount of blue phase. Their colors are characterized by elegant and softness, low purity and small impact. These choices

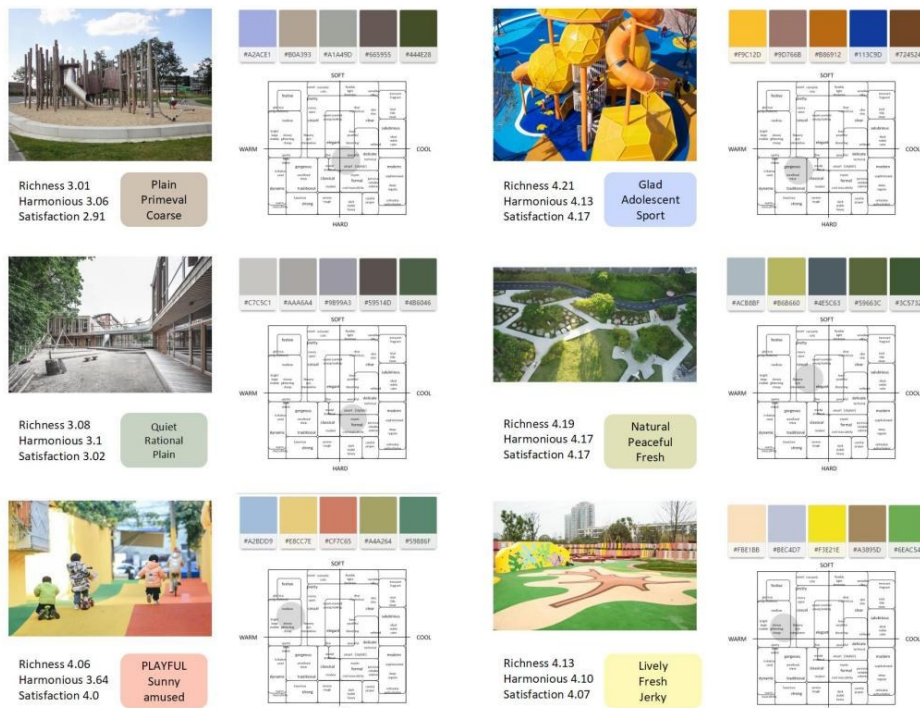


Figure 5 Xianggangshan children rated the public space of different communities. Source: the author of self-painting, self-photography

may reflect the girls' preference for gentle and harmonious colors in the visual experience, and the pursuit of visual comfort and tranquility. In the "six colors that I don't like", most boys choose dark tone purple color and dark grayish tone purple red color, while girls choose dgr color purple color. These undesirable colors are basically concentrated in deep tone and dark grayish tone. These color characteristics are generally low lightness, giving people a dull and depressed feeling. The rejection of these colors by boys and girls may reflect their shared pursuit of brighter and pleasant colors in visual experience.

Despite clear differences in color preferences between boys and girls, they showed consistency in the disliked colors. This consistency can provide a benchmark for color design, by Try using lighter and more lively colors, while avoiding low-lightness colors that can easily cause negative emotions. Moreover, the gender differences and common points of this color selection also provide new ideas for the zoning design of the community public space. According to the function of different areas and the use of people, we can use different color collocation. For example, in the sports and game areas, high purity and bright colors can be used to stimulate their vitality and adventure spirit, while in the leisure and communication areas, soft and warm colors can be used to create a comfortable and harmonious atmosphere. At the same time, in the public mixed use areas, low-lightness, dull colors should be avoided to ensure that all children can feel positive and pleasant emotions in these spaces.

4 CONCLUSION

The study revealed numerous issues with the current color status of the public spaces in Xianggangshan Community, primarily manifested in the lack of a unified color theme, chaotic color schemes, and the dominance of low-brightness colors. These issues not only impacted children's

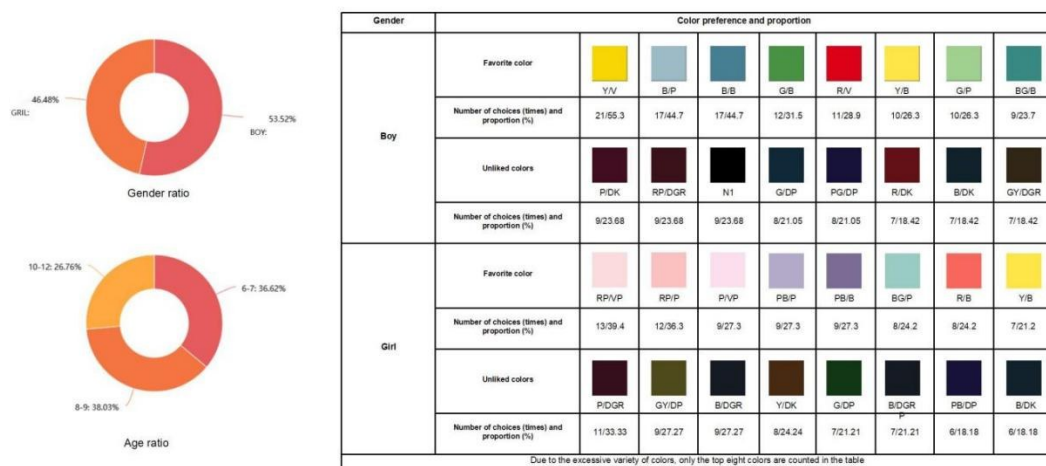


Figure 5 The ratio of gender to color preference. Source: the author of self-painting, self-photography

Table 1 Analysis of color and hue choice favored by boys

Tone	V	S	B	P	VP	Lgr	L	Gr	DI	DK	Dgr	W
Ratio(%)	21.05	5.26	33.33	17.98	7.89	3.95	5.26	0.44	0.44	0	1.31	2.19
Hue	R	YR	Y	GY	G	BG	B	PB	P	RP	Achromatic Colors	
Ratio(%)	11.4	10.96	16.67	5.7	13.6	7.46	20.61	3.07	3.51	4.82	2.19	

Table 2 Analysis of color and hue choice favored by girls.

Tone	V	S	B	P	VP	Lgr	L	Gr	DI	DK	Dgr	W
Ratio(%)	7.58	0.51	24.75	27.27	25.26	1.01	0.51	0	0.51	27.27	0	0.2
Hue	R	YR	Y	GY	G	BG	B	PB	P	RP	Achromatic Colors	
Ratio(%)	15.66	5.05	11.11	3.54	7.58	9.6	859	13.64	7.58	15.66	0.2	

visual perception but also diminished their activity motivation and psychological comfort to a certain extent. Consequently, enhancing the visual environment of public spaces through rational color design can effectively elevate children's experiences within these spaces.

The questionnaire survey results demonstrated a notable difference in children's preferences for various colors. Male children favored high-purity, vibrant hues such as yellow, blue, and green within the vivid tone range, whereas female children preferred lower-brightness, soft colors like mauve and blue within the pale tone spectrum. This discovery provides crucial reference points for color design in community public spaces. In design, tailored color combinations can be selected based on gender preferences to enhance the attractiveness and utilization of spaces. Additionally, the study found that children generally disliked low-brightness colors, perceiving them as dull and oppressive. This consensus sets a benchmark for color design in public spaces, advocating the avoidance of dark tones, deep tones, and dark grayish tones, particularly in children's activity areas. Instead, bright and lively hues should be employed to foster a joyful and invigorating atmosphere.

In leisure areas such as seats, pavilions, and pathways, warm tones (e.g., bright yellow, orange, and light red) can be utilized. These colors not only create a warm and harmonious ambiance but also echo the brownish-red hues, fostering visual unity. For major public plazas and activity zones, contrasting colors like yellow and blue from the vivid or bright tone categories can be employed. These colors amplify the visual appeal of spaces while stimulating children's senses and fostering their interest in activities. Color contrasts can be achieved through ground coatings, landscape accents, and recreational facilities. Green tones can be extensively used in walkways, fences, and leisure areas, blending seamlessly with vegetation to create a natural and harmonious landscape

that imparts psychological comfort and relaxation. The brightness and saturation of green tones can be adjusted based on the functions of specific areas, e.g., using soft light green in leisure zones and vibrant dark green in sports areas.

To elevate the overall aesthetic of Xianggangshan Community's public spaces while integrating local cultural features, the brownish-red hues inspired by the nearby Nanyue King Tomb can be incorporated. This not only resonates with the surrounding culture but also endows the community with a unique historical ambiance. Brownish-red tones can be applied to major buildings, ground paving, and large-scale landscape elements to establish a consistent color palette.

Concurrently, to ensure the longevity of the revamped color effects, regular maintenance and cleaning of public facilities and ground coatings are essential, preventing color fading and soiling. This is particularly crucial in children's playgrounds and main public areas, where vibrant and clean colors enhance children's visual experiences.

These color design strategies can refine the visual and cultural identity of Xianggangshan Community's public spaces, fostering a vibrant, friendly, and alluring environment that elevates the quality of life for residents, particularly children. Future research could delve deeper into the long-term impacts of these color interventions on community engagement and children's wellbeing, offering continuous insights for optimizing public space design.

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