

Article

Multi-Sensory Experience and Preferences for Children in an Urban Forest Park: A Case Study of Maofeng Mountain Forest Park in Guangzhou, China

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Abstract: This study developed an analysis based on children's multi-sensory experiences and preferences in urban forest park to make practical suggestions for the design of children's activity areas. Taking Maofeng Mountain Forest Park in Guangzhou, Guangdong province as a case study, based on a face-to-face survey and online questionnaire survey, this study analyzed children's multi-sensory landscape preferences in the park and explored the influence of multi-sensory experiences on children's behavioral experience by establishing a structural equation model. The results reveal that visual, auditory, tactile and olfactory sensations were significantly correlated with children's behavioral experiences. In terms of landscape preference, children preferred landscapes in blue-green tones, original building materials and challenging entertainment programs. Based on these analysis results, the design recommendations for children's activity areas in urban forest parks are discussed.

Keywords: urban forest park; children; multi-sensory experience; preference research



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1. Introduction

The urban forest park is based on the ecological landscape of the forest near the city, equipped with appropriate artificial facilities and landscape buildings to meet the demand of urban residents for outdoor activities to return to natural ecology and have leisure vacations [1]. As an important part of the urban green space system, urban forest parks are built following the basic principles of the forest ecosystem and have the functions of recreation, science and education, culture, etc., bringing ecological, economic, social and educational benefits to the city and its residents [2]. Compared with urban parks, urban forest parks focus on forest ecosystems and showcase ecological diversity, presenting a kind of natural and rustic look that is different from artificial urban parks [3]. With the recent concern for urban ecological environment protection, research on the new concept of urban forest parks has increasingly shown its value and potential.

To better realize the various functions of urban forest parks, the multi-sensory experience of park visitors is particularly significant. According to Edward T. Hall, an American anthropologist, human receptors are divided into distance receptors and direct receptors, which form a variety of perceptual sensations such as vision, hearing, smell, touch and taste [4]. These receptors also have different tasks and ranges. The interconnection and cooperation between multiple receptors can realize the complete perception of things and the world [5], and then obtain a more comprehensive and enjoyable personal experience. As a new perspective of experience and cognition, certain theoretical and practical achievements have been developed in the field of multi-sensory research. On the theoretical side,

international research focuses on three main directions: health care, multi-sensory landscape construction and sensory experience tourism [6]. There is also an increasing number of studies on audiovisual perceptions such as the “soundscape” [7]. On the practical side, sensory parks designed for specific groups of people or medical purposes are emerging [8], with world-renowned examples of multi-sensory applications such as the Osaka Garden in Japan and the Frosinone Sensory Park in Italy. With the continuous development of theories and practices, multi-sensory ideas continue to permeate innovations in landscape design [9]. As the key point of future urban green infrastructure construction, urban forest parks should be designed and innovated around people’s multi-sensory experience to bring all-around green experiences and enjoyment to urban residents.

Increasing attention has been paid to natural activities in child development during the past decade, since children’s lack of activities has become a global public health problem [10]. Urban forest parks are some of the most accessible public places for children in terms of natural activities. They play an important role in effectively improving the amount of children’s extracurricular activities and promoting children’s all-round growth [11]. The positive effects of activities in forest parks on human health have been well documented in the past [12]. However, the best way of maximizing the function of urban forest parks to serve children and improve their multi-sensory experience remains an open question [13]. In 2018, the proportion of domestic tourists aged 18 and below in China reached 12.80% [14], indicating that underage tourists have become more prominent in the total tourist population [15]. At present, the research objects in the field of visitor perception in urban forest parks are more concentrated on adults, not children [16,17]. Moreover, some urban forest parks have no activity areas designed for children, and other forest parks with children’s amusement places also make fewer considerations for problems such as children’s physical and psychological characteristics [10]. A children’s activity area is a special area in an urban outdoor space for children to play, rest, interact, etc. [18]. In some Western cities, children are moving away from outdoor public areas [19], which leads to many problems, such as some children becoming avoidant, timid and lacking in concentration [20,21], which has drawn increasing attention to the importance of children’s activity areas for their healthy development [22]. Some scholars have pointed out the need for exclusive children’s activity areas in urban forest parks [20]. Based on this, many scholars have used gender differences, differences in household income levels, and ethnic differences as variables to explore children’s behaviors and preferences within children’s activity areas in urban forest parks [23,24]. Simultaneously, some studies focus on children’s health needs and the design of activity areas. Solomon suggested that the design of activity areas should take into account children’s physical and mental characteristics, rather than a “McDonald’s” type of simple stacking [25]. Cumbo et al. found that children’s rich imagination allows them to make full use of the resources in the forest park. A suitable environment for children’s fantasies in the forest park is conducive to the dynamics of communication and the realization of imagination, allowing children to have pleasant sensory experiences [26]. To date, there is a paucity of research that explores the needs of child visitors in urban forest parks from a multi-sensory experience perspective. Montessori, a renowned educator, has stated that children grow up experiencing the natural environment primarily through the five senses, which lead to memory, imagination, and thinking [27]. Sensory experiences are a basic way for children to know the external world and play an important role in their growth and development [18]. Compared with adults, children are more sensitive to external sensory stimuli. In addition to seeing and listening, the aroma and touch of urban forest parks can also have a huge impact on children’s senses [28]. However, many existing studies mainly focus on the visual and auditory fields, and other sensory effects are often ignored [7]. Previous research results show that tourists have less demand for taste experiences [29], and the olfactory experience is mainly reflected in tourists’ eating activities [30], which has a low correlation with forest parks. Accordingly, this study will mainly examine four aspects: vision, hearing, smell and touch. As an exclusive place for

children in urban forest parks, the development of children's activity areas should pay more attention to children's sensory experience and participation.

Therefore, under the current situation, in which the lack of movement in the process of children's growth is becoming increasingly prominent and the proportion of child tourists in urban forest parks is gradually increasing, the research of this article has practical and theoretical significance. On one hand, by investigating children's landscape preferences in urban forest parks, this paper puts forward some suggestions for the design of children's activity areas in urban forest parks, hoping to meet children's entertainment needs, so that children can actively participate in extracurricular activities with a greater probability and grow up healthily. On the other hand, at present, there are few studies in the field of urban forest parks that focus on children's groups and multi-sensory experiences. With the gradual liberalization of China's fertility policy and the improvement in people's attention to the growth of children, children's groups are becoming an important topic that cannot be ignored. Based on the summary and utilization of existing research results, this article can make up for the lack of children's sensory experience research to a certain extent and further enrich the research on children's visitor groups in urban forest parks. It also has certain characteristics that can help urban forest park managers to understand the needs of children customers and the common problems existing in the operation of the park, and finally provide a reference for the future strategic development of urban forest parks.

2. Methods

2.1. Case Selection and Data Collection

As shown in Figure 1, Maofeng mountain forest park is located in the northeast of Baiyun District, Guangzhou, Guangdong Province, China, with a total area of 69.72 square kilometers. This park covers the central city of Guangzhou and the new Baiyun International Airport within 20 km, providing an accessible urban green space for families with superior locational conditions [31]. It has a humid southern subtropical climate, with temperatures generally 2–5 °C lower than in the city center. It is dominated by broadleaf and coniferous forests, with a forest cover of 77.63%, while there are several reservoirs and mountain ponds within the park, with a total water area of 2.80 km². This park has good forest ecological landscape resources and superior conditions for developing forest tourism, and it was included in the list of provincial forest parks in 2001, being represented as an urban forest park with universal significance for studying children's visiting behavior [32].

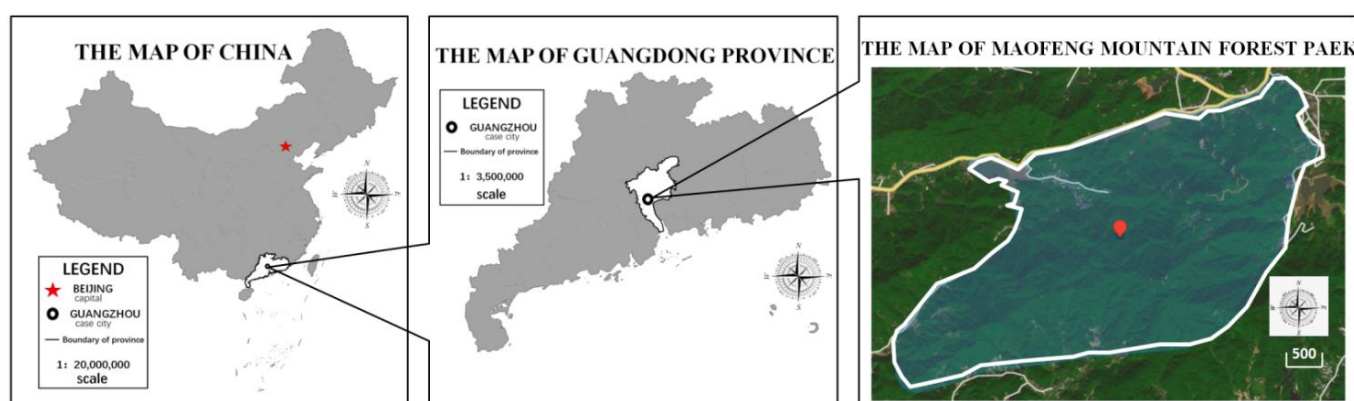


Figure 1. Geographical location of Maofeng Mountain Forest Park in Guangzhou.

Prior to the start of the large-scale questionnaire, this study conducted a pre-study with 10 school-age child volunteers of different ages to ensure that the children in the selected age group could understand the questionnaire questions in a basic way, and could complete the questionnaire in an average of 4 min 53 s (min = 3'28'', max = 9'28''). Moreover, investigators tested the children's intelligence level with simple general knowledge questions prior to the interview. Meanwhile, to ensure that the children fully understood the questionnaire,

the survey team members and the parents of children assisted as support staff throughout the interview. However, they were not allowed to interfere with or intentionally guide the children's true thoughts. After completing the questionnaire, each child who successfully completed the whole task received a gift, which attracted more children and stimulated sharing among the children's group.

This study conducted a multi-sensory experience questionnaire survey of child visitors aged 6–14 years in Maofeng Mountain Forest Park during clear daylight hours (9 a.m.–5 p.m.) from January 25 to 21 February 2022, a time when the weather in Guangzhou was more comfortable than average (5–24 °C); therefore, residents were more willing to travel. Furthermore, it was the Chinese New Year period with a high probability of parent-child travel, which was suitable for this study. In terms of research methods, the research respondents were children aged 6–14 years old, who received elementary school education and had a certain level of literacy [33]. Moreover, the sample size required for this study was large, such that the data collection of the questionnaire survey was divided into two modes: an on-site face-to-face survey and an online survey. The on-site survey used a random sampling method by observing and questioning children of appropriate age at four different locations (Jinguo Forest, Tianhu Lake, Maofeng Qinyuan and Ancient Temple) in Maofeng Mountain Forest Park. As for the online survey, the online questionnaire was distributed to age-appropriate children who had been to Maofeng Mountain Forest Park after obtaining the permission of their guardians. Furthermore, an online video was used to assist children in real time in order to avoid excessive parental intervention in the process of children's texts.

In the end, the team members interviewed 157 children at the park site, excluding respondents who were not of the right age and were unwilling to cooperate, finally collecting a total of 126 on-site questionnaires. The online survey placed more emphasis on the authenticity of the subjects, and a total of 224 online questionnaires were collected. Excluding inconsistencies and incomplete answers, there were 336 valid questionnaires left online and offline, with an effective rate of 96%.

2.2. Questionnaire Design

This study used the definition of children in the relevant Chinese laws [34], and defined the interviewed group as children aged 6–14 years. The study first summarized the role of urban forest parks in children's growth and the importance of multi-sensory design in children's activity areas. Then, the article investigated the multi-sensory experience and preferences of children tourists and analyzed the collected questionnaire data quantitatively, followed by suggestions for the design of children's activity areas based on the analysis results. Finally, limitations and directions for future research were given at the end of the article.

This study applied a questionnaire survey method and collected 336 valid questionnaires. These questionnaires used a five-point Likert scale to examine the relationship between multi-sensory perceptions and children's multi-sensory behavioral experiences. The Likert scale can quickly and intuitively obtain the degree of recognition of a subject and quantify it, and has the characteristics of strong operability and analysis [35]. In this study, children's multi-sensory perceptual situation, the sense of behavioral experience and sensory attention were categorized into five levels: very good (2), better (1), neutral (0), bad (−1) and very bad (−2). Due to the limited cognitive level of the children group, the questionnaire was designed to have simple and friendly textual expression, so that children could better understand the content. There were also colorful pictures associated with questions in the questionnaire to give children a more visualized and vivid presentation. In addition, the questionnaire was divided into several parts. In every questionnaire distributed, each section was randomly arranged and combined in order to avoid order effects. The following dimensions were adopted to design the questionnaire in this study.

2.2.1. Multi-Sensory Perception and Behavioral Experience Dimensions

The multi-sensory perception section of the questionnaire drew on Zhang et al.'s scale on the influence of multi-sensory perception on the restoration effect of urban green spaces [8], and the behavioral experience section drew on Cui et al.'s study on user experience evaluation methods [36], finally designed to investigate children's multi-sensory behavioral experiences along four dimensions (visual sensation, auditory sensation, tactile sensation and olfactory sensation). Additionally, this study investigated children's perceptual preferences for the above four senses, collecting the senses that children paid the most and least attention to.

2.2.2. Landscape Preferences and Design Dimensions for Children's Activity Areas

Children's visitation environment settings are divided into three aspects: contact with nature, aesthetic appearance and opportunities for recreation and play [37]. Accordingly, this study also investigated children's design preferences regarding children's activity areas in terms of five aspects: (1) color; (2) building types; (3) vegetation types; (4) landscape types; and (5) activity types. Specifically, regarding the fifth item, "activity types", in addition to the conventional amusement programs and quality-development programs, this study also set up outdoor learning activities about knowledge of the natural environment with reference to the findings of Labintah and Shinozaki [38]. Through the setting of the above questionnaire questions, this study can, to a certain extent, find what children expect of the children's activity areas in urban forest parks.

2.2.3. Individual Relevance Dimension

Socio-demographic characteristics and visiting habits were investigated as relevant factors, specifically: gender, age, frequency and duration of visits and periods of visits [8]. This study investigated the potential influence of these individual factors on children's multi-sensory experiences and preferences in forest parks.

2.3. Technology Roadmap

As shown in Figure 2, this paper assumes that there is a dependency between children's multi-sensory perceptions, landscape preferences, and children's behavior in the forest park, and applies it to our questionnaire design. Visual sensation, auditory sensation, tactile sensation and olfactory sensation together influence children's landscape preferences and behavioral experience, and children's multi-sensory perception and landscape preferences together influence their behavior. There is a close relationship between multi-sensory perception, behavioral experience and landscape preference, which makes it possible to formulate guidelines on how to design children's activity areas. After completing the questionnaire design, this paper validated the conjectures through a series of data analyses. The first was a reliability and validity analysis to establish that the questionnaire data collected were reliable and internally consistent. Secondly, the results obtained from the collected questionnaire data were briefly described through descriptive analysis, which was used to analyze children's overall preference for urban forest park landscapes. Finally, by building structural equation models, this paper explored the correlation between children's multi-sensory perceptions and children's behavioral experiences in urban forest parks.

2.4. Reliability and Validity Analysis of Respondents Sample

The data samples were tested for reliability and validity using the SPSS reliability test with IBM SPSS Statistics 26. As shown in Table 1, the Cronbach's alpha value of the total variables of the scale was 0.804, and the Cronbach's alpha values of the five latent variables were all in the range of 0.637 to 0.903. The combined reliability (CR) was also higher than 0.60, indicating that the observed variables of each latent variable of the scale were reasonably designed, and the internal stability of the sample data was good.

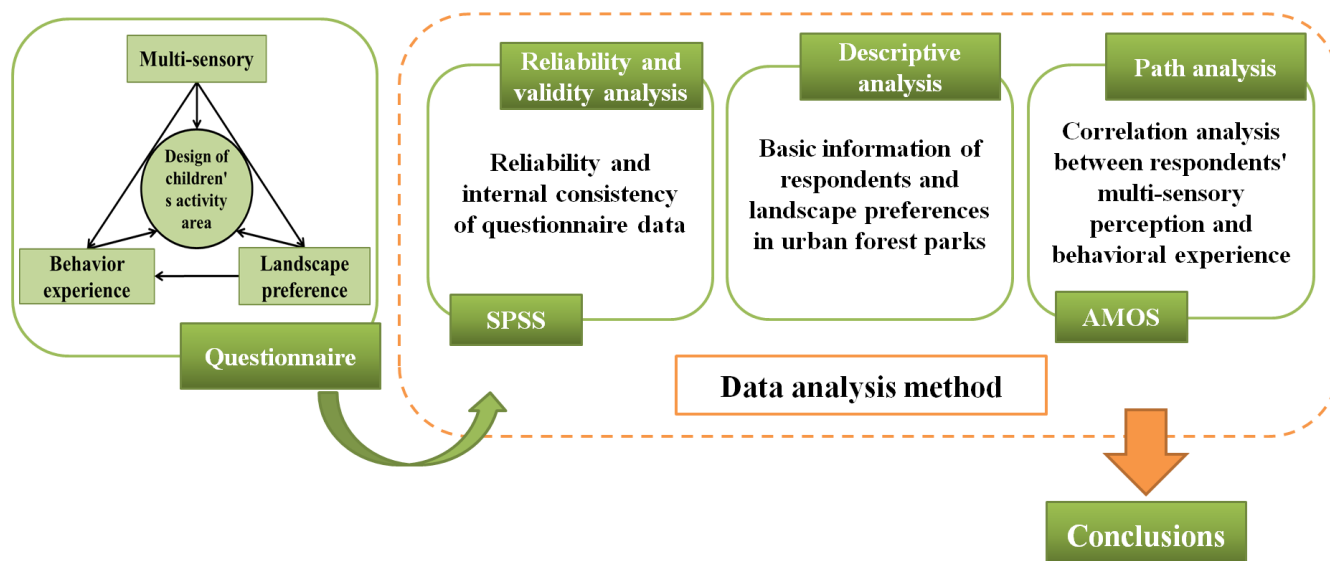


Figure 2. Research framework.

Table 1. Reliability and validity analysis.

Latent Variable	Observation Variable	α	KMO	<i>p</i> Value
Visual sensation	8	0.796		
Auditory sensation	6	0.738		
Tactile sensation	7	0.903		
Olfactory sensation	5	0.637		
General behavior experience	5	0.682		
Total	31	0.804	0.822	0.000

In terms of validity, the KMO value was 0.822, which was greater than 0.6. The *p* value (0.000) was less than 0.001, indicating that the validity of the measurement model was high and the selected observed variables had a certain correlation and validity.

2.5. Path Analysis of Respondents Sample

This study used IBM SPSS Amos 26 Graphics to construct a structural equation model for the data obtained from the questionnaire. In this study, the specific questions about multi-sensory perception in the questionnaire are listed as observation variables, and the children's multi-sensory perception experience and general behavioral experience, which are the variable that the research wants to explore, are listed as potential variables, as shown in Figure 3.

The fit indices of the structural equation models for all observed variables are shown in Table 2. The fitting index test is an important link to evaluate the effectiveness of the structural equation model [39]. The fitting index is the consistency between the hypothetical theoretical model and the actual data. The higher the value of the fitting index, the better the consistency between the theoretical model and the actual data. From the first index, TLI, proposed by Tucker and Lewis [40] in 1973, to NTLI, proposed by Marsh and Balla [41] in 1996, there are more than 40 named fitting indexes officially published in the literature. At present, the RMSEA (root mean square error of approval), AGFI (adjusted good fit index), TLI (Tucker–Lewis index), CFI (comparative fit index), SRMR (standardized root mean square residual) and other popular fitting indexes are recommended in academic circles [42]. This paper referred to the commonly used fitting indexes in academia and the selection of fitting indexes in the study of multi sensory restoration effect of urban green space by Zhang et al. [8], and finally chose Chi-square/df, RMSEA, GFI, AGFI, TLI and CFI

as the fitting indexes for the study. The chi-square/df and RMSEA in the model reached the desired values. The values of GFI, AGFI, TLI, and CFI in the model were slightly lower than the ideal values, but the overall fitting degree is acceptable for these data [8,30,43]. The results suggest that all scales used in this study formed adequate measurement models, and the construct validity of the measures was confirmed.

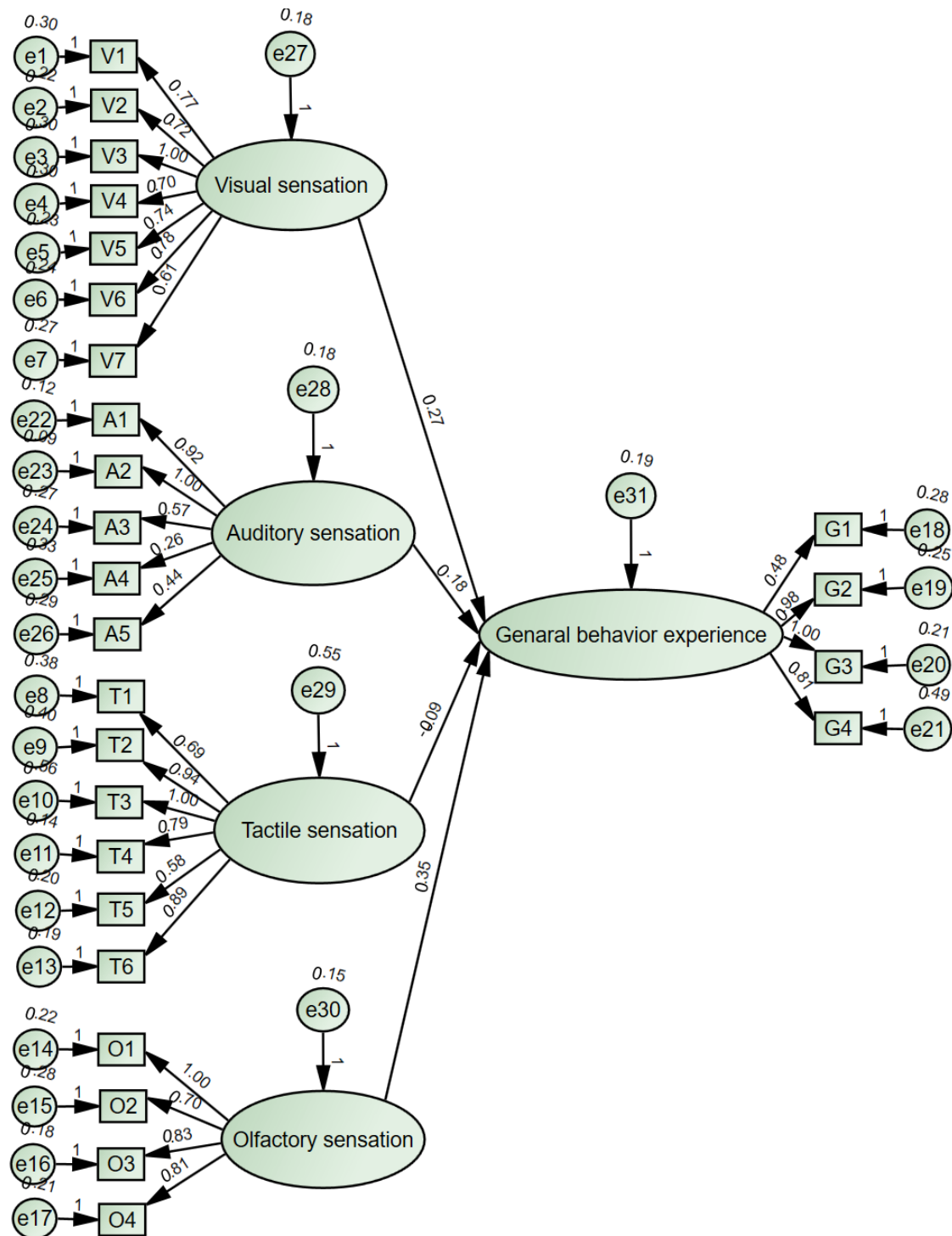


Figure 3. Structural equation model regression coefficients.

The standardized regulation weights of the structural equation model are used to describe the relationship between elements in the model. When the weight is greater than zero, it indicates that the two elements are positively correlated. When the weight is less

than zero, it indicates that the two elements are negatively correlated. The higher the value, the greater the correlation.

Table 2. Tests of structural equation model fit indices.

Fitting Index	Ideal Value	Acceptable Value	Model Predictive Value	Whether Passes Test
Chi-square/df	1–2	1–3	1.839	Pass
GFI	>0.9	>0.7	0.892	Pass
AGFI	>0.9	>0.7	0.871	Pass
RMSEA	<0.08	<0.09	0.050	Pass
TLI	>0.9	>0.7	0.874	Pass
CFI	>0.9	>0.7	0.885	Pass

3. Results

3.1. Descriptive Analysis

The descriptive statistics of the sample are presented in Figure 4. In terms of socio-demographic characteristics, regarding gender structure, the proportion of male and female respondents was relatively balanced (Figure 4a). In terms of age, the largest proportion of respondents (57.13%), more than half, were between 10 and 12 years old (Figure 4b). Regarding the average frequency of park visits, the majority of children (45.50%) visited the forest park once a month, with slightly fewer choosing “Once a week or more” and “Semiannual or less” (Figure 4c). In terms of the personal duration of park visits, more than half of the children (56.25%) stayed between one hour and three hours, while nearly one-third (28.57%) stayed between half an hour and one hour (Figure 4d). As for the period of visits, nearly half of the respondents (43.75%) chose to visit the park in the morning, and more than one-third (35.71%) chose to visit in the afternoon (Figure 4e).

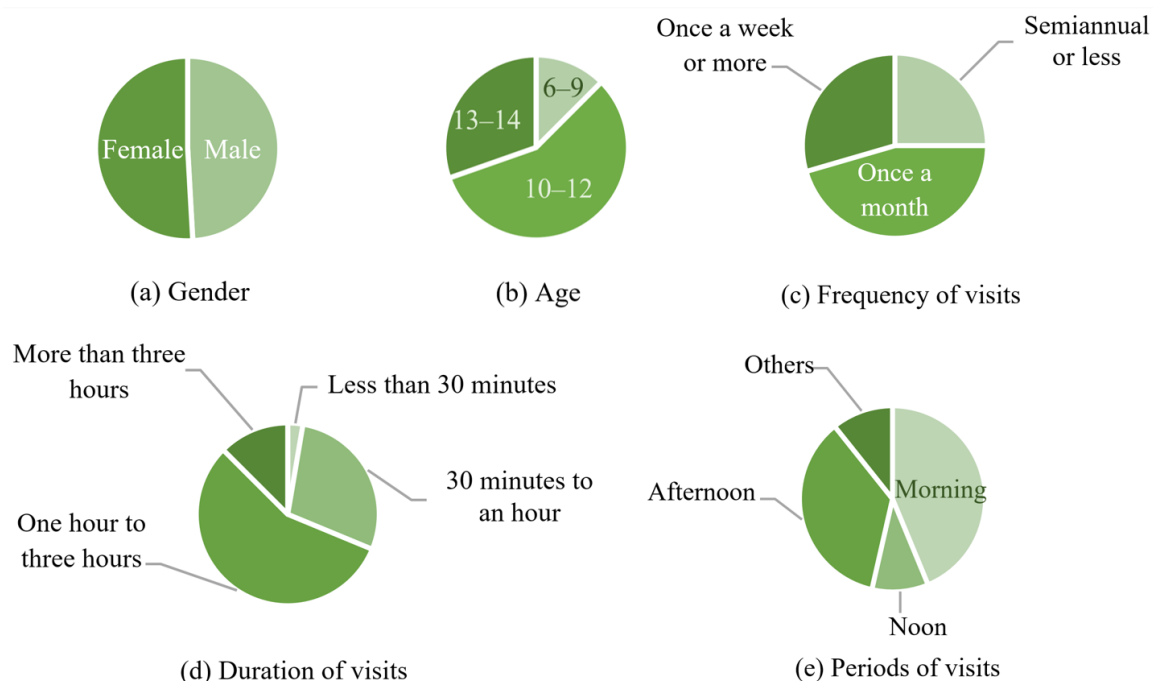


Figure 4. Description of surveyed children’s basic characteristics and activities in the urban forest park. (a) Gender; (b) age; (c) frequency of visits; (d) duration of visits; and (e) periods of visits. All items were set as single-choice questions.

As shown in Figure 5, in terms of personal color preference, nearly two-thirds of the respondents preferred green (69.64%) and blue (16.96%) (Figure 5a). As for the landscape color combination preference, more than half of the respondents preferred a combination of

blue and green water and wood landscapes (65.18%), 42.86% of the respondents preferred planted landscapes with various colors, and only 9.82% of the respondents preferred large-scale planted landscapes with high contrast (Figure 5b).

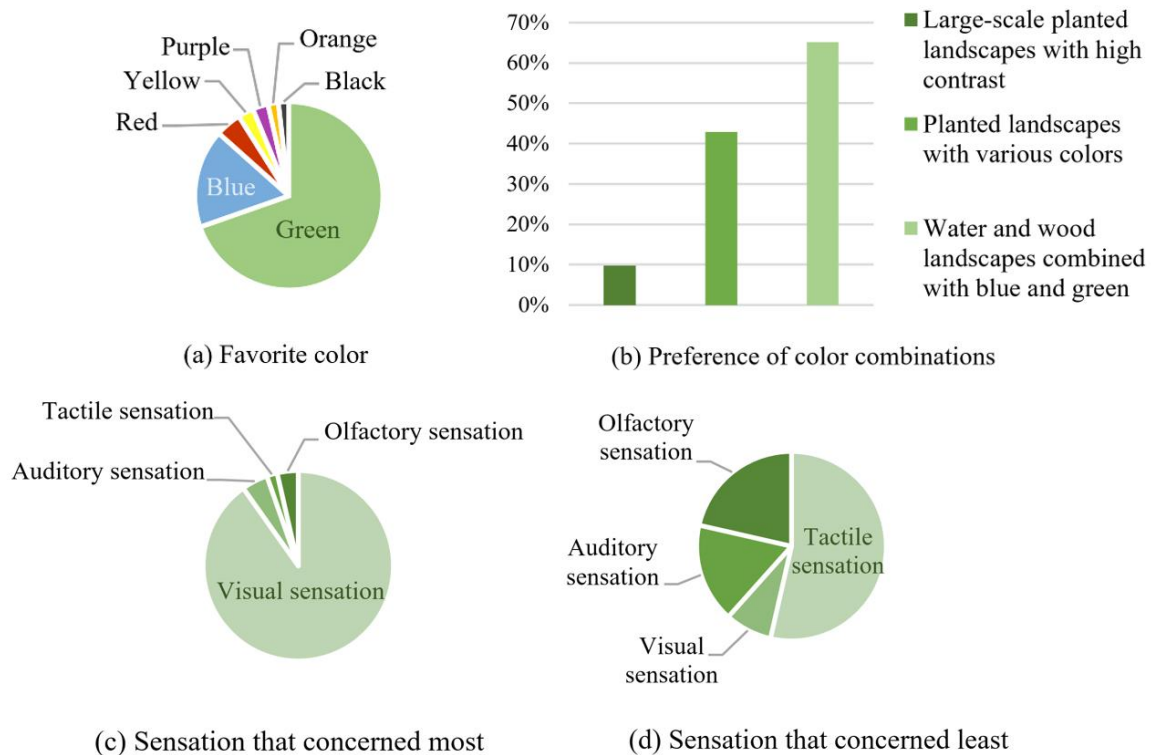


Figure 5. Description of surveyed children's perceived preferences in the urban forest park. (a) Favorite color; (b) preference of color combination; (c) sensation that concerned them the most; and (d) sensation that concerned them the least. Items (a,c,d) were set as single-choice questions, while item (b) was set as a multiple-choice question.

For the overall perception of children's sensations in the forest park, visual sensations (90.18%) were those that children paid the most attention to in the forest park, and tactile sensations (53.57%) were those that the children were least concerned with (Figure 5c,d).

Regarding the children's landscape preferences in urban forest parks, as shown in Figure 6, in terms of the choice of building materials, original ecological materials such as wood (61.61%) were the most popular ones. Elastic materials such as rubber (42.86%) and soft materials such as cotton (41.96%) followed. Rough-texture materials such as hemp rope (25.00%) and light and durable materials such as plastics (16.96%) were chosen by fewer people, while only 9.82% of the respondents chose smooth and hard materials such as steel (Figure 6a).

In terms of the type of vegetation designed, there was no significant difference in preference between different vegetation types. The largest number of children preferred lawn (62.50%), followed by flowering plants (56.25%). In contrast, the preference for forest vegetation was relatively low (41.96%–44.64%), but the differences presented between the three different types of tree species were not significant (Figure 6b). It could be seen that children expressed a certain preference for the rich and diverse types of forest park vegetation. The comparison of people choosing lawn vegetation versus forest vegetation also showed that children's preference for taller forest vegetation was lower than for lawn vegetation.

The same small difference was also seen in the preference for landscape types, where the largest number of children chose comfortable rest areas made with gallery frames (66.07%) and feature amusement facilities (60.71%); wide squares or open spaces (62.50%) and beautiful natural landscapes (50.00%) were next in number. Novel artificial ornaments

were chosen by the least children (43.75%) (Figure 6c). It was clear that feature amusement facilities, plazas or open spaces for free movement, and beautiful natural landscapes were preferred, being endorsed by half or more of the children surveyed. In addition, comfortable rest areas were the most popular form of landscape for the children surveyed, which emphasizes the need for children to rest after activities and sightseeing, showing that the construction of rest areas for children should not be neglected in forest parks.

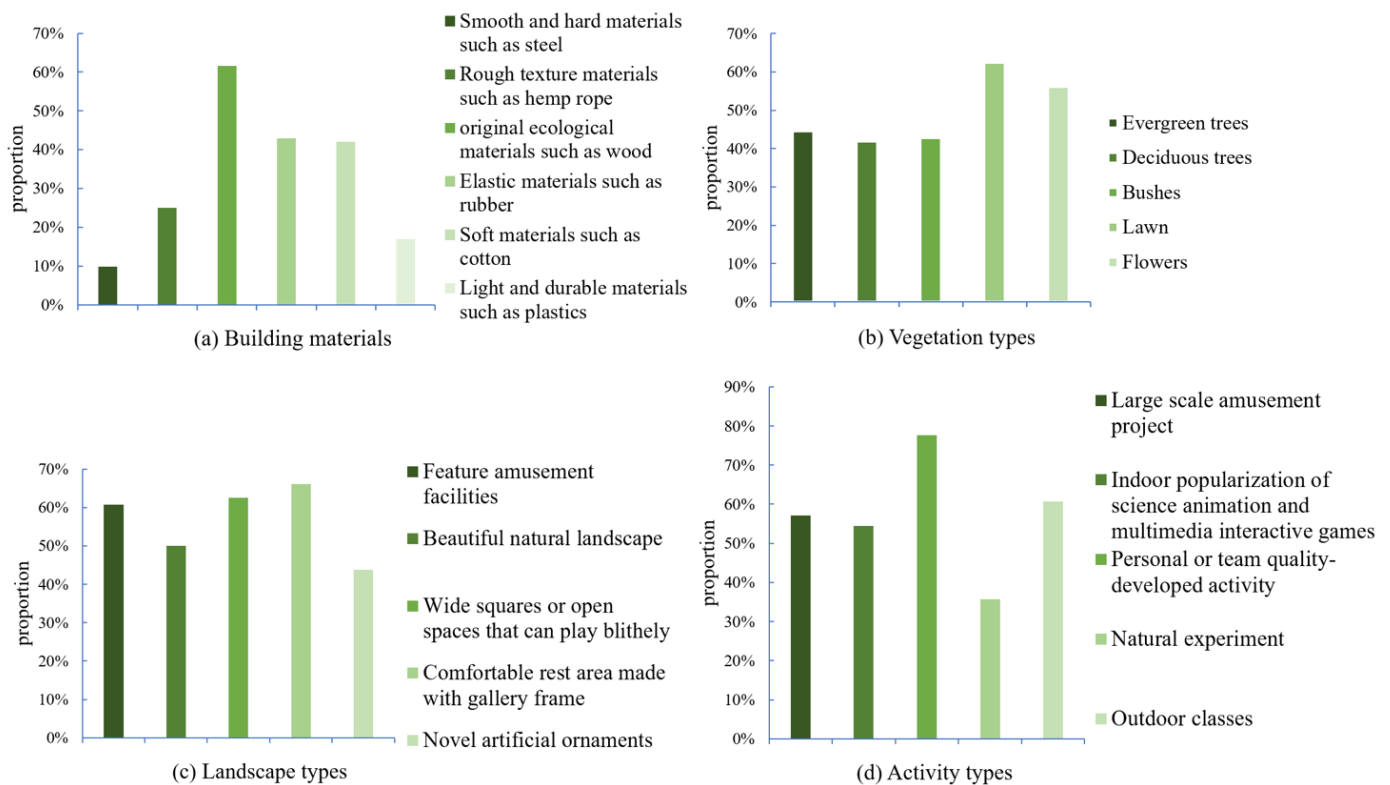


Figure 6. Children's preference for children's activity areas in urban forest parks. (a) Building materials; (b) vegetation types; (c) landscape types; and (d) activity types. All items were set as multiple-choice questions.

Focusing on the types of activities in the children's area, the results show that the highest number of people chose personal or team quality-developed activities (77.68%), more than half of the respondents also chose outdoor classes (60.71%), large-scale amusement projects (57.14%), and the indoor use of science animation and multimedia interactive games (54.46%), and the smallest number of respondents chose nature experiments (35.71%) (Figure 6d). It could be seen that personal or team quality-developed programs, such as rock climbing and canoeing, which were hands-on and challenging, were the most interesting activities for children. Amusement programs, on the other hand, still received majority support as traditional children's recreational activities.

In terms of visual perception, the mean values of "V2 Lush vegetation" "V7 Rich colors" were all at a high level, being greater than 1.4 (1.43–1.57), and only the value for "V1 Regular landscape" (1.38) was slightly lower than the other six items, indicating that the children interviewed had a high perception of most of the visual experience variables in the forest park. In terms of auditory perception, the mean values of all potential variables were higher than 1 point, indicating that children showed strong agreement in terms of the perception of each auditory experience. In particular, the children perceived beautiful natural sounds such as "A1 Natural sounds" and "A2 Animal sounds" more favorably than comfortable artificial sounds such as "A3 Background music", "A4 No traffic noise" and "A5 Others' sounds of activities". As for tactile perception, the differences between latent variables were larger. As can be seen from Figure 7, the means of "T1 Suitable apparent temperature",

“T2 Suitable somatosensory wind speed”, and “T3 Paved road” were all below 1 (0.89–0.93), which were between the levels of general to relatively agreeable attitudes. The means of the last three, “T4 Natural landscapes touch”, “T5 Artificial landscapes touch”, and “T6 Safety perception of artificial landscape”, were relatively high (1.08–1.38), indicating that children paid slightly less attention to the dimensions related to physical sensation and road leveling. However, for natural or artificial specific landscapes, the degree of tactile perception was higher. In terms of olfactory perception, the children showed a stronger agreement (1.33–1.61), ranging from agreeing to strongly agreeing, in all four experience perception subdivisions, especially for “O3 Fragrant natural beings” (1.61). Regarding the overall sensory experience of the forest park, “G1 mood” received the highest perceptual agreement (1.74), while “G4 Content attraction” presented a slightly lower perception (1.15) compared to the other three. However, in general, the mean scores of “G1 Mood”–“G4 Content attraction” dimensions were higher than 1, showing positive attitudes ranging from agreeing to strongly agreeing, indicating that respondents had a better overall behavioral experience in the forest park and tended to have a pleasant experience of activity in the park (Table 3 and Figure 7).

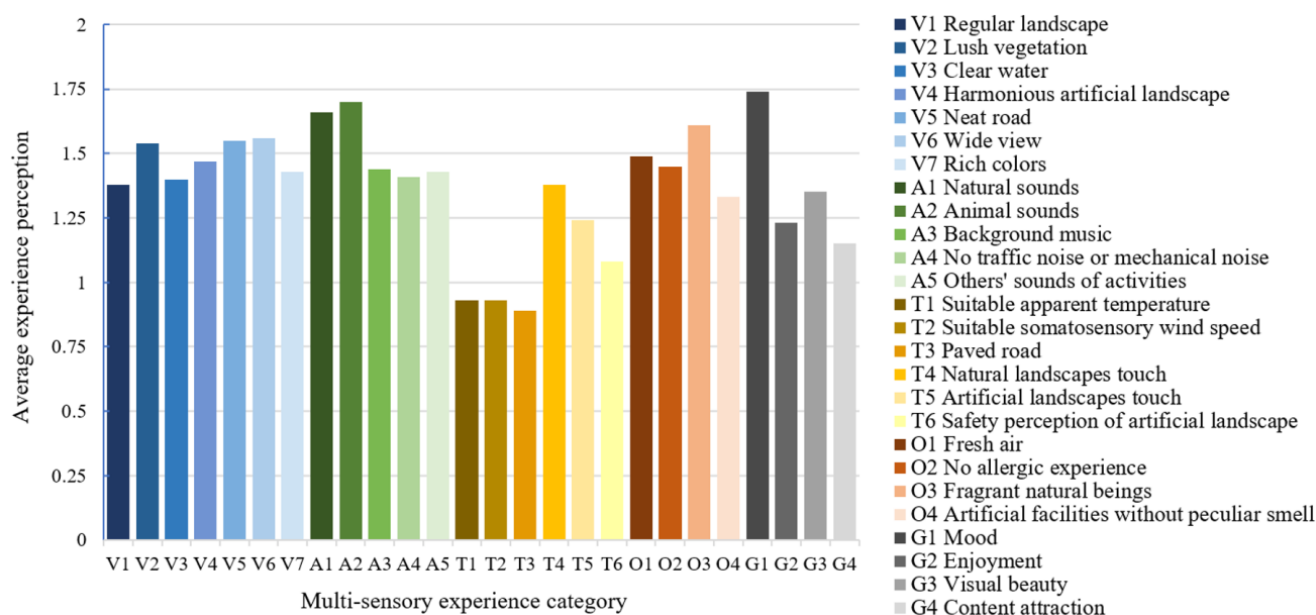


Figure 7. Bar chart of perceived mean values of children’s multi-sensory experiences in an urban forest park (more details of items are shown in Table 3).

In this study, an in-depth investigation of the “O1 Fresh air” and “O3 Fragrant natural beings” was conducted. In “O1 Fresh air”, the reasons that children thought the air in urban forest parks was not fresh were presented. A few respondents who expressed bad and completely bad attitudes toward the air cleanliness considered that the air quality in the park had decreased due to dust or garbage (Figure 8). In “O3 Fragrant natural beings”, the study also investigated children’s perceptual descriptions of flowers, trees and soil in urban forest parks. Most respondents described this item with words such as “fresh” and “fragrant”, indicating that children’s olfactory perception of air, natural plants and trees was relatively good (Figure 9).

3.2. Path Analysis of Multi-Sensory Perception

The standardized regression weights of the structural equation model are shown in Table 4. In terms of visual sensation, the most influential indicator was V3 clear water (0.613), followed by V6 wide view (0.564), V5 neat road (0.554) and V2 lush vegetation (0.542). From this conclusion, it could be seen that children paid more attention to simple and accessible visual experiences than to the more complex criteria such as landscape

regularity and colorfulness. Therefore, the design of children's activity areas needed to focus on the positive influence of natural scenery on their willingness to experience things. For auditory sensation, the standardized regression weights were larger for A1 natural sounds (0.752) and A2 animal sounds (0.821), and smaller for A4 no traffic noise (0.186) and A5 other sounds of activities (0.327). This meant that children were more sensitive to and were fond of natural sounds and animal sounds, and more repulsed by traffic noise and noisy human sounds. Accordingly, the design of children's activity areas should avoid areas in the park that are close to downtown areas and factories, and should be close to areas with more vegetation and animals.

Table 3. Descriptive analysis of the perception of multi-sensory experiences in the urban forest park ($n = 336$).

Code	Items	Mean	Standard Deviation
V	Visual sensation		
V1	Regular landscape	1.38	0.64
V2	Lush vegetation	1.54	0.56
V3	Clear water	1.40	0.69
V4	Harmonious artificial landscape	1.47	0.63
V5	Neat road	1.55	0.57
V6	Wide view	1.56	0.59
V7	Rich colors	1.43	0.58
A	Auditory sensation		
A1	Natural sounds (the sounds of water flow, wind blowing leaves, etc.)	1.66	0.52
A2	Animal sounds (the sounds of birds and insect, etc.)	1.70	0.52
A3	Background music (broadcast music, live music, etc.)	1.44	0.57
A4	No traffic noise (car whistle, etc.) or mechanical noise (sounds from factories and lawn mowers, etc.)	1.41	0.59
A5	Others' sounds of activities (the sounds of conversation, whistle, footsteps, singing, large-scale activities, etc.)	1.43	0.57
T	Tactile sensation		
T1	Suitable apparent temperature	0.93	0.80
T2	Suitable somatosensory wind speed	0.93	0.94
T3	Paved road	0.89	1.06
T4	Natural landscapes touch (water flow, plants, land, etc.)	1.38	0.70
T5	Artificial landscapes touch (amusement facilities, rest seats, etc.)	1.24	0.63
T6	Safety perception of artificial landscape	1.08	0.80
O	Olfactory sensation		
O1	Fresh air	1.49	0.61
O2	No allergic experience	1.45	0.60
O3	Fragrant natural beings (trees, flowers, soil, etc.)	1.61	0.53
O4	Artificial facilities without peculiar smell (buildings, amusement facilities, etc.)	1.33	0.55
G	General behavior experience		
G1	Mood	1.74	0.58
G2	Enjoyment	1.23	0.69
G3	Visual beauty	1.35	0.67
G4	Content attraction	1.15	0.81

In terms of tactile sensation, T4 natural landscape touch (0.842) and T6 safety perception of artificial landscape (0.833) had high correlations, indicating that children had clear perceptions of the touch of natural objects that they could directly come into contact with and the safety of the artificial landscape, while they were not sensitive to the perception of external temperature and wind speed. In terms of olfactory sensation, its correlation with O1 fresh air (0.632) was stronger than other variables, indicating that children paid more

attention to air odor in terms of olfactory sensation compared with the odor of natural and artificial landscapes, and it was especially important to keep the air in the children's activity area clean and fresh. In terms of general behavioral experience, the standardized regression weights for mood, enjoyment, visual beauty, and content attraction were 0.402, 0.689, 0.720, and 0.483, indicating that children paid more attention to G3 visual beauty (0.720) and G2 enjoyment (0.689) in their general behavioral experience.

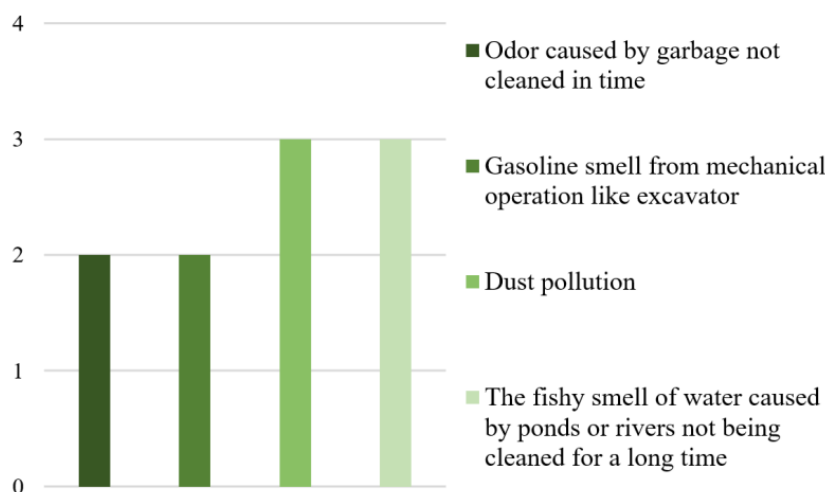


Figure 8. The reasons that children thought the air in urban forest parks was not fresh ($n = 4$).

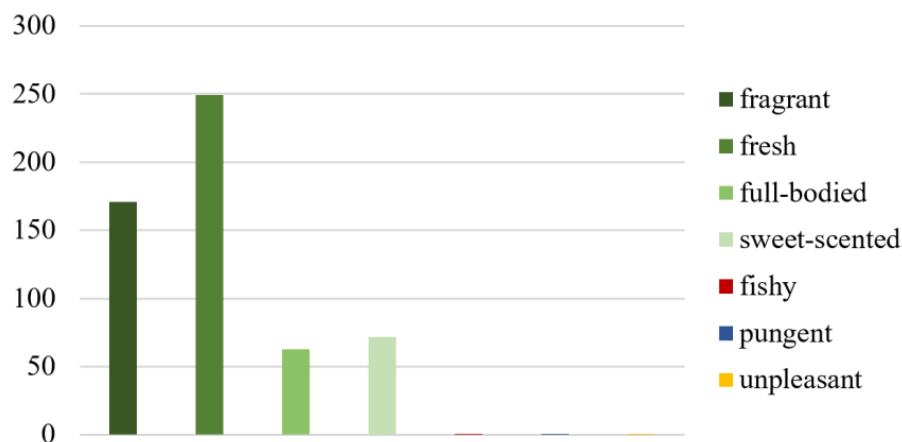


Figure 9. Children's perceptual descriptions of flowers, trees and soil in the urban forest parks ($n = 334$).

Standardized weights and their statistical significance obtained from the structural equation model are presented in Table 5. Visual, auditory, tactile and olfactory sensations all had p -values < 0.05 and were positively and significantly associated with general behavioral experience [8]. In addition, the standardized weights for visual, auditory, tactile, and olfactory sensations were 0.268, 0.176, -0.085 , and 0.348, which implied that olfactory sensation had the greatest influence on children's behavioral experiences, followed by visual and auditory sensation, and tactile sensation had the least influence on children's behavioral experiences. Meanwhile, visual, auditory and olfactory sensations were positively correlated with behavioral experience, and tactile sensation was negatively correlated with behavioral experience.

Table 4. Structural equation model standardized regression weights of observed variables.

Items	Standardized Regression Weights
Visual sensation	
V1 Regular landscape	0.510
V2 Lush vegetation	0.542
V3 Clear water	0.613
V4 Harmonious artificial landscape	0.476
V5 Neat road	0.554
V6 Wide view	0.564
V7 Rich colors	0.450
Auditory sensation	
A1 Natural sounds (the sounds of water flow, wind blowing leaves, etc.)	0.752
A2 Animal sounds (the sounds of birds and insect, etc.)	0.821
A3 Background music (broadcast music, live music, etc.)	0.424
A4 No traffic noise (car whistle, etc.) or mechanical noise (sounds from factories and lawn mowers, etc.)	0.186
A5 Others' sounds of activities (the sounds of conversation, whistle, footsteps, singing, large-scale activities, etc.)	0.327
Tactile sensation	
T1 Suitable apparent temperature	0.639
T2 Suitable somatosensory wind speed	0.741
T3 Paved road	0.707
T4 Natural landscapes touch (water flow, plants, land, etc.)	0.842
T5 Artificial landscapes touch (amusement facilities, rest seats, etc.)	0.696
T6 Safety perception of artificial landscape	0.833
Olfactory sensation	
O1 Fresh air	0.632
O2 No allergic experience	0.451
O3 Fragrant natural beings (trees, flowers, soil, etc.)	0.605
O4 Artificial facilities without peculiar smell (buildings, amusement facilities, etc.)	0.560
General behavior experience	
G1 Mood	0.402
G2 Enjoyment	0.689
G3 Visual beauty	0.720
G4 Content attraction	0.483

Table 5. Results of path analysis: standardized estimates ($n = 336$).

Hypothesis	Estimate	S.E.	C.R.	<i>p</i>
General behavior experience← Visual sensation	0.268	0.086	3.121	0.002 *
General behavior experience← Auditory sensation	0.176	0.080	2.186	0.029 *
General behavior experience← Tactile sensation	−0.085	0.043	−1.998	0.046 *
General behavior experience← Olfactory sensation	0.348	0.103	3.381	***

Note: * means $p < 0.05$, *** means $p < 0.001$, S.E. means standard error, C. R. equivalent to the value of T in statistics.

4. Discussion

Although the previous literature has attempted to explore the relationship between sensory perceptions and behavioral experiences of crowds in urban parks [16], few scholars have analyzed this from children's perspective by combining four different senses. In this study, the subjective evaluation method was used to explore the relationships among multi-sensory perception, children's behavioral experiences and landscape preferences based on the questionnaire data of children in Maofeng Mountain Forest Park in Guangzhou, and the following conclusions were obtained. Specifically, this study confirmed the direct link

between visual, auditory, tactile and olfactory multi-sensory perceptions on children's behavioral experiences, indirectly revealed the relationship between multi-sensory perception and children's landscape preferences, and finally integrated multi-sensory perception, behavioral experiences, and landscape preferences into a whole, providing a comprehensive exploration of children's behavior and psychology in urban forest parks from a multi-sensory perspective. Therefore, this study could enrich the evidence of the multi-sensory perception and behavioral psychology of children to some extent.

4.1. General Behavioral Experience Findings of Children in Urban Forest Parks

4.1.1. The Sensory Perception with the Highest Level of Children's Self-Attention Was Visual and with the Lowest Level of Attention Was Tactile

In terms of general sensory perception in the forest park, vision was the sensation that the interviewed children paid the most attention to in the forest park (90.18%) and touch was the sensation that the interviewed children paid the least attention to (53.57%).

This finding further validates the conclusion of Lyu and Zhang (2021), that eyes are the most basic tools for children to perceive external information, and that children understand and perceive objects through the world as seen by the eyes, which makes children pay more attention to and favor visual inputs in the development of their senses. In terms of tactile sensations, this study presents further exploration of and reflection on Lyu and Zhang's (2021) findings through an empirical approach. It has been argued that the sense of touch is the most intuitive process that children experience [44]; however, this study found that vision is the sensation that the interviewed children paid the least attention to in the forest park of all four sensations, which suggests that the extent of children's tactile perception needs to be assessed from the children's own perspective and based on the actual situation.

4.1.2. Visual, Auditory, Tactile and Olfactory Sensations Were Significantly Correlated with Children's Behavioral Experiences

The results of the operational tests of the structural equation model show that visual, auditory, tactile and olfactory sensations were all significantly correlated with children's general behavioral experience in the urban forest park, indicating that visual, auditory, tactile and olfactory sensations all influence children's overall sense of experience in the forest park. This finding is consistent with existing research by Yaswinda (2016), which suggest that children's direct and authentic experiences require multiple senses to deepen their perception and understanding of what they see, hear, smell and touch [45].

4.1.3. Olfactory Sensation Has the Greatest Influence on Children's Behavioral Experiences, Followed by Visual and Auditory Sensations, and Tactile Sensation Has the Least Influence on Behavioral Experiences

Among children's behavioral experiences in urban forest parks, the most influential is the need for olfactory sensation (0.348), which indicates that good olfactory sensation can improve the satisfaction of potential child visitors to a greater extent, with the odors of O1 fresh air (0.632) and O3 fragrant natural beings (0.605) having the greatest impact on children's overall olfactory sensation. This conclusion is different from previous scholars' view that vision is the most influential of all senses on behavioral experience [46], probably because the improvement of the overall urban environment and landscape in recent years has led to better visual sensation in forest parks in general. Coupled with the lack of social experiences of children compared to adults, which makes the amount of park contrast insufficient, the impact of visual sensation on experience satisfaction is relatively lower. More empirical research is needed to support the effects of olfactory sensation on children's behavioral experiences and their causes. In addition, unpleasant odors directly stimulate children's respiratory tracts, causing children to produce behavioral feedback such as using body language and voice language to express resistance, while visual sensations do not have such obvious feedback. The effects of visual and auditory sensations on behavioral experience were 0.268 and 0.176, and the visual sensation of air freshness and natural landscape in urban forest parks had positive effects in enhancing children's behavioral

experience dimensions. Comfortable auditory sensations generated in urban forest parks, including natural soundscapes and pleasant artificial soundscapes, can enhance children's experience in forest parks and regulate their behavior. Traffic noise and noisy people have a low impact on enhancing the experience. The absolute value of the standardized coefficient of tactile sensation is 0.085, which has a low impact on children's behavioral experience.

4.1.4. Olfactory Sensation Was Negatively Correlated with Children's Behavioral Experience

Olfactory sensation was negatively correlated with children's behavioral experience (-0.085), which shows that lower somatosensory, landscape tactile sensations result in a higher general experience. The reasons for this may be due to some error in the results due to less consideration of tactile factors in the setting of children's general behavioral experience variables, which needs further research and investigation. Moreover, it may be due to the individual differences in perceptual preferences during childhood. Previous studies have confirmed that children enjoy activities and challenges involving risk, speed, excitement, stimulation, and uncertainty [47]. To some extent, uneven surfaces, lower physical sensations and landscape tactile sensations can stimulate children's sense of adventure and challenge, and enhance their experience satisfaction.

4.2. General Landscape Preferences for Children in Urban Forest Parks

4.2.1. Children Prefer Blue and Green Tones in Urban Forest Parks

In terms of visual color preference, this study consistently ascertains that blue and green received higher support from the children surveyed in both single color preference and color combination preference statistics. This is in line with the findings of Child et al. (1968), who found that children and adolescents from 6 to 18 years of age preferred cooler colors and that blue and green were favorite colors for all age groups. In addition, children's preference for highly saturated colors generally diminishes with age [48]. Furthermore, blue and green landscapes (water and wood landscapes, etc.), as the main components and basic elements of forest parks, fit better with children's perceived impressions of forest parks; thus, these two colors in forest parks give children a better sense of connection and intimacy [49].

4.2.2. Children Prefer Soft and Original Ecological Building Materials in Urban Forest Parks

In terms of building tactile preferences, children's more delicate skin than that of adults makes them prefer soft and comfortable tactile sensations. Wood, cotton and rubber are the preferred building materials for children, while the rough, cold and hard touches of materials such as twine, steel and plastic are resisted by them. This finding echoes the established knowledge by Friso et al. (2015) that natural materials such as wood and fiber are usually associated with comfort. Additionally, the degree of elasticity and softness that these natural materials have usually bring better comfort and pleasure to children and offer them the sense of security [50].

4.2.3. There Is Little Difference between Children's Perceived Preferences for Vegetation and Landscape Types in Urban Forest Parks

Focusing on the vegetation types in urban forest parks, lawns, flowers, and trees are all preferred by children. However, in general, vegetation types such as lawn and flowers with a low field of view are preferred over vegetation types such as trees with a higher field of view, which may be due to children's high demand for social activities in the forest park and the fact that children's perception of the size, positive recreational use and shade capacity of forest vegetation is not as strong as that of adults [51]. In contrast, the situation regarding floristic plants, which were chosen by more than half of the children, is consistent with the findings of Talal and Santelmann (2021), indicating that most people of all ages have some preference for floristic plants with color [51].

Regarding the landscape types, most children show preferences for recreational facilities, squares, natural landscapes, and rest areas. Among them, feature amusement facilities, plazas or open spaces for free movement, and beautiful natural landscapes were strongly endorsed by the children surveyed, which reflects the same finding as previous studies, that the most important influences that attract children to parks are active recreational facilities and natural landscapes [52]. In addition, comfortable rest areas were the most popular form of landscape for the children surveyed, which emphasizes the need for children to rest after activities and sightseeing, showing that the construction of rest areas for children should not be neglected in urban forest parks. The importance of rest areas in relation to children's outdoor activities deserves further research and attention in the future.

4.2.4. Children Prefer Quality-Development Programs That Are Somewhat Hands-On and Challenging in Urban Forest Parks

Childhood is a time in life when people are more imaginative, curious, and adventurous than in other periods [47]. In terms of activity programs, children generally show more interest in and a preference for personal or team quality-development programs that are hands-on and challenging, such as rock climbing and canoeing. This result is also consistent with the effectiveness of the "Adventure Obstacle Course" derived from the study by Labintah and Shinozaki. When children participate in this kind of adventure course, such as going through the mudflats, they have the opportunity to use their sensory and tactile skills and gain more immersion and enjoyment [38].

Children also prefer science animations and interactive games that reveal the mysteries of nature, etc., indicating that the introduction of activity programs about nature science knowledge in forest parks is equally attractive and relevant.

4.3. Design Recommendations of Children's Activity Areas in Urban Forest Parks

Children are the participants of their own activity areas. However, at present or in the past, designers have tended to ignore children's own feelings and needs, and to be too subjective during the design process [53]. Thus, based on the above findings on children's multi-sensory experiences and landscape preferences in forest parks of this study, the following recommendations are made for the design of children's activity areas in urban forest parks.

4.3.1. Overall Design

Many previous studies have investigated and designed children's learning and therapeutic environments from a multi-sensory perspective to better facilitate children's interaction and the learning experience [54,55]. As a place for children to rest, play, learn and interact, children's activity areas should pay more attention to children's perceptions and preferences for landscapes, and meet the needs of children's unique group experiences. As the basic window for children to perceive and understand the world, multi-sensory perception is an important reference for the design of children's activity areas. It is suggested that the design and construction of children's activity areas in urban forest parks should fully consider the multi-sensory experience of children, and bring better experiences and natural perceptions to children through the interplay of sight, sound, touch and smell. Secondly, it is also important to optimize the functional zoning and activity design of children's activity areas to better meet children's preferences and enhance their experience and interest.

4.3.2. Visual Design

Vision is the sensory perception that receives the most attention from children in forest parks (Figure 5), accounting for approximately 80% of all human perceptual activities, and is critical to the visual landscape design of children's activity areas. In terms of color, influenced by the main color palette of the park, the interviewed children, aged 6–14 years old, had significantly more favorable perceptions and stronger preferences for green and blue in the forest park. In terms of landscape color combinations, more than

half of the respondents expressed a preference for water and wood landscapes with a combination of blue and green colors, while less than half of the children chose planted landscapes with richer and brighter colors. This is mainly because the color perception of children aged 6–14 years old is gradually becoming similar to adults', and the high purity of colors is likely to cause visual fatigue, so they begin to pay attention to and prefer less pure colors [28]. Therefore, in the color arrangement of children's activity areas, it is recommended to focus on the perceptions and preferences of children of different ages for colors, and to reasonably match colors of different purity to reduce the visual fatigue of children in environments with high-purity colors for a long time. Moreover, the color characteristics of the forest park should be appropriately integrated to make the color of the activity area more harmonious with the surrounding landscape, which can also effectively reduce children's cognitive dissonance with landscape colors in urban forest parks. In terms of vegetation, the interviewed children had the highest preference for lawn vegetation, followed by floral plants, and a lower preference for forest trees (evergreen trees, deciduous trees and shrubs). The main reason is that forest vegetation is less ornamental and less palpable, and most of the trees are tall, such that children are affected by their height and easily feel alienated from these large-scale landscapes. Consequently, when designing children's activity areas, it is recommended that designers focus on the scale of the landscape, so that the spatial distances and the size of objects in the activity areas are closer to the perceptual habits and standards of children, which is in line with "the accessibility and safety principles" of Ding et al. (2019), suggesting that children's line of sight and height should be specially considered when designing the equipment of urban residential areas [53].

4.3.3. Auditory Design

Hearing is a perceptual pathway second only to vision, and a good auditory environment can make children happy and relaxed and has certain physiological health functions [28]. In this study, it was found that the interviewed children had some positive emotions toward natural sounds, animal sounds, and beautiful background music, while they had negative emotions toward traffic and mechanical noises, and the sounds of other people's activities. Accordingly, it is suggested that the auditory design of children's activity areas focuses on creating a natural sound environment where natural sounds (water, wind, etc.) and animal sounds (insects, birds, etc.) are coordinated with each other, such as musical fountains, small zoos, etc., and supplemented with beautiful radio music or live music performances. This approach can create a comfortable and harmonious sound atmosphere to enrich children's aesthetic perception of the activity area. This suggestion echoes the established theory of positive soundscape design, and can bring people a better experience of the sound environment through the organic superposition of various sound elements [56]. Simultaneously, paying attention to attenuating artificial noises such as traffic and machinery to soothe the mood also allows children in the activity area to better immerse themselves in the natural atmosphere.

4.3.4. Tactile Design

Tactile sensation refers to direct contact, and is the most intuitive sensory activity for children to perceive the world. However, this study found that more than half of the respondents felt that touch was the least relevant to their sensory experience in forest parks (Figure 5), and that there is an urgent need to improve tactile perception. For the choice of construction materials, the interviewed children preferred natural, soft, and textured materials such as wood, rubber, and cotton, and had poorer tactile experiences with hard and rough materials such as steel and twine. Therefore, this study suggests that the tactile design of urban forest parks should strengthen the materials and textures of landscapes, as well as the facilities and equipment in activity areas. The landscape quality of natural objects such as water flow and trees in the activity area should be improved through timely pruning and cleaning, and using soft and smooth construction materials to build facilities.

A tactile experience walking path is also an infrastructure worth considering, by integrating a variety of different materials. As Ding's (2019) research showed, children can better understand the different shapes and textures through different ground materials and then enrich their tactile experience and intuitive sensory feelings, finally creating psychological resonance [53].

4.3.5. Olfactory Design

Past studies have shown that human olfactory ability decreases with age, and children's perception of smell is more sensitive than that of adults [28]. In this study, children's olfactory perception of natural landscapes such as air, natural plants and trees was relatively good. However, a very small number of respondents reported that dust and garbage influenced their perception of air quality in the park. As for artificial buildings and amusement facilities, the perceptions varied widely among subjects, with nearly one-quarter of children perceiving artificial buildings in the park to have a certain pungent odor. Consequently, it is recommended to increase the odor cooperation between different natural objects in the process of activity area olfactory design, reduce the discordant odor factors in the olfactory environment, and also strengthen the environmental management and odor inspection to create a fresh and natural olfactory environment. In turn, this can deepen children's experience and impression of spatial places and the landscape environment, and a good olfactory environment can promote their physical and mental health [57].

4.3.6. Functional Partitioning and Activity Design

With regard to the functional partitioning and activities of children's activity areas, the survey data of this study showed that the interviewed children had some recognition of areas with specific functions such as resting, playing and viewing. Among these areas, children pay most attention to the comfortable corridor rest areas, while they are relatively less interested in the novel artificial decorations. In terms of activities, this study also provided the interviewed children with options for activities such as amusement facilities, quality-development activities, and outdoor classes with reference to the contents of nature experience and education [58]. The results show that all of the nature activity programs, except for the nature experiments, were supported and preferred by more than half of the children, with the largest number choosing individual or team quality-development programs, nearly 4/5 of the total number. Accordingly, this study suggests that children's activity areas can also be enhanced by strengthening the construction of various functional zones and introducing various kinds of rich nature activities to improve children's overall experience in the activity areas, so as to promote children's physical and mental health while enhancing their perception of nature and cognitive ability.

5. Conclusions

This study explored children's behavioral experiences and landscapes preference from a multi-sensory perspective and provided some suggestions for the construction of children's activity areas in urban forest parks. Focusing on children's behavioral experiences, a direct association was ascertained between visual, auditory, tactile, and olfactory sensations and children's behavioral experiences. In comparison, it was found that olfactory sensation had the greatest influence and tactile sensation had the least on children's behavioral experiences. In addition, olfactory sensation was negatively correlated with children's behavioral experiences, calling for further explanation in future studies. Children's landscape preferences in urban forest parks were investigated and summarized under a multi-sensory perspective, which further strengthened the interconnection between multi-sensory perception and children's landscape preferences. This study took a more comprehensive look at children's landscape preferences from five main perspectives: color tones, building materials, vegetation types, landscape types and activity types. Operationally, multi-sensory perceptions and preferences should be seriously considered when

designing children's activity areas in urban forest parks, particularly the integration of the above findings regarding children's behavioral experiences and landscape preferences.

This study reveals a potential link between multi-sensory perception, children's behavioral experiences and landscape preferences in urban forest parks, which provides a new way of thinking about how to create appropriate activity areas for children. Nevertheless, the limitations of this study should be admitted: the taste variable is more difficult to consider in urban forest parks; thus, the interaction and influence of children's five senses (visual, auditory, tactile, olfactory and taste) in forest parks cannot be completely analyzed. Additionally, this study specifically found that olfactory sensation had a greater impact on children's behavioral experiences than the other three senses, and that there was a negative correlation between tactile sensation and children's behavioral experiences, all of which need to be further explored and explained in detail in future studies. Children's multi-sensory perceptions in forest parks are an area worth exploring, and more in-depth additional research is needed, achieved through increased research time, more case sites, and greater sample sizes.

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