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PEDESTRIANS' AND CYCLISTS' PREFERENCES FOR STREET GREENSCAPE DESIGNS

ABSTRACT

In recent years, the public's interaction with street green spaces has been increasing, leading to much more concern about its design. By using stated preference data from a discrete choice experiment and the multinomial logit model, this study investigates pedestrians' and cyclists' landscape preference regarding street green space through an online survey based on a virtual street environment. The results show that trees are the most suitable to be planted symmetrically between the cycle track and sidewalk. Large size trees with large crown width and tall height are more preferred than common size trees. There are considerable differences in preferences for locations of shrubs, hedges, flowers, and grass between cyclists and pedestrians. Cyclists prefer grass by the cycle track the most and grass by the sidewalk the least. But for pedestrians, flowers, hedges, and grass by the sidewalk are positively significant. Buildings with green plants in their front yards are preferred over a monotonous facade or coffee seats. This study enriches the understanding of the public's landscape preferences for streets sharing non-motorised lanes. The results also play a guiding role in people-oriented street green space designs of landscape architects and governments.

KEYWORDS

living street; planting preferences; planting locations; discrete choice experiment.

1. INTRODUCTION

The high-density development of urban areas has produced a series of urban issues, among which traffic congestion has a wide range of impacts and plagues the lives of residents. Consequently, walking, cycling, and public transportation have been advocated by many cities and countries worldwide. Walking more, cycling more, and using public transport more can not only ease traffic congestion, reduce travel costs, decrease air and noise pollution but also promote physical activities and public health [1, 2]. Compared with vehicle travel modes, walking and cycling make residents interact with street greenscape better. Besides, fast urbanisation leads to unfair distribution of green space, and the rapid pace of people's life and work results in a decline in the frequency of contact with ample public green space. As an essential part of the urban green infrastructure system, green space in living streets makes it easier and more frequent to interact with greenscape and gain health benefits such as stress reduction and mental fatigue relief [3]. Therefore, it is urgent to design a living street space that can effectively promote walking and cycling for residents to live a healthier and happier life.

Previous studies have shown that the street environmental design greatly affects the perception of pedestrians and cyclists and then affects their route choices [4]. Among these environmental factors, street greenscape design is an important factor affecting route preferences both for pedestrians and cyclists [5]. For pedestrians, green elements have been shown to increase walkability in urban streetscapes [6]. In terms of each green element, roadside trees primarily affect pedestrians' preferences [7]. In addition to trees, brightly coloured flowers are also preferred by pedestrians [8, 9]. Configuration of green elements is a common way of planting design in living streets. Todorova et al. concluded that pedestrians preferred various vegetation types instead of a uniform seed mixture [9]. Weber et al. further demonstrated that pedestrians preferred symmetrical and uniform arrangement of vegetation [10]. Regarding the locations of green elements in the street, Sarkar et al. pointed out that people preferred walking along the streets lined with trees on both sides [11]. For cyclists, a beautiful street environment would make them enjoy riding more [12], and street greenscape or natural environment is an important factor [13]. In some studies on cyclists' street design preferences, the existence and quantity of street greenscape affected their use of streets. It showed that cyclists were willing to cycle longer if the route had green surroundings [14]. For transportation cycling, Mertens et al. found that vegetation had a positive impact [15]. For recreational cycling, it was found that passing through well designed streets with green landscape was preferred [16]. Specifically, street greenscape designs of elements and locations have a significant impact on preferences. Research showed that street trees positively influenced preferred streets for cycling [17–20]. Evans-Cowley et al. revealed that trees set back from the street were positively associated with the public's preferences [21]. Nawrath et al. showed that the shadow of street trees could help improve riding comfort [20]. Other than street trees, vegetated tree pits, vertical greening, and possibly other green elements can also increase the attractiveness of cycling. Street greenscape also affects cyclists' sense of security. Wang showed that different locations and arrangement of trees and grass had a positive impact on riding safety [22].

Several studies on preferences for street configuration did not distinguish between pedestrians and cyclists. The intensities of elements and the configuration were found to be significant to preference in [23]. Ng et al. found that the public preferred trees planted on both sides of the street over trees planted in the street's centre [24]. However, few studies explore the similarities and differences between pedestrians' and cyclists' landscape preferences. Lusk et al. surveyed five cycle tracks in Boston, asking pedestrians and cyclists whether trees should be planted or not and their preferred locations [25]. They concluded that pedestrians and cyclists preferred trees and trees with bushes between the cycle track and vehicle lane compared with no trees or trees on the sidewalk. The study also found that pedestrians indicated a higher preference for trees between the sidewalk and the cycle track than cyclists. *Table 1* summarises the above studies on elements and locations of street greenscape designs.

Table 1 – Studies on elements and locations of street greenscape designs

Authors (year)	Elements considered	Locations considered	Main conclusions
Akbar KF, Hale WHG, Headley AD (2003) [8]	trees, grass, flowering herbs	tidy, intensively mown grass sward with tidy appearance, less intensively mown grass sward with colourful flowering herbs, grass swards with occasional clumps of trees, grass swards with flowering herbs near road and trees further away	Grass swards with flowering herbs near the road and trees further away were the most preferred combination of plant types for the re-vegetation of road edges.
Evans-Cowley JS, Akar G (2014) [21]	trees	along the street, set back from roadway, densely planted	Trees set back from the street were positively associated with respondents' preferences.
Wang KL, Akar G (2018) [22]	trees, grass	grass borders with trees along the road, grass borders along the road, as well as trees behind the sidewalk, trees both on and behind the sidewalk, heavy set of trees	Grass borders with trees along the road, as well as trees behind the sidewalk, have the highest impacts on individuals' safety perceptions.
Ng WY, Chau CK, Powell G, Leung TM (2015) [24]	trees	on both sides of the street, at the centre of the street	Trees planted on both sides of the street were preferred to trees planted at the centre of the street.
Lusk AC, da Silva DF, Dobbert L (2020) [25]	trees, bushes	trees between the sidewalk and the cycle track, trees between the cycle track and the street/parked cars, trees and bushes between the cycle track and the street/parked cars, trees between parked cars	The surveyed pedestrians and cyclists preferred trees and trees with bushes between the cycle track and the street compared with no trees or trees on the sidewalk.

The earlier studies about the perception and preference of street greening were mainly questionnaire surveys [8, 9]. A few questions are asked to respondents to reflect the attitudes and preferences of the specific samples. The surveys include on-site responses and web-based surveys [23, 25]. Web-based surveys have gradually become more common in recent years. With the development of technology, the questionnaires are no longer text description questions. Street view pictures or real scenes with different types of street greening are widely used [26]. Generally, one picture represents one semantic, and the respondents can score it. While the disadvantages of real scenes are the interference from other environmental factors and complex combinations of green elements, reducing the controllability of street green variables. In terms of control variables, virtual images have more advantages over real images. In some studies, manipulated photos were used to control and edit the physical environment factors (e.g. street background, eye-level viewpoint, street greening elements) to effectively control variables to conduct relative studies [15, 18]. Adobe Photoshop and SketchUp are often used in the process.

With further research of street greenery preferences, descriptive statistical analysis methods are no longer suitable for the complex street elements, and the combinations of various elements have a greater impact on preferences. Which factor has the most significant impact, and to what extent? Therefore, studies began to adopt a discrete choice model to solve the above problems [23, 24, 27]. The discrete choice model is based on the random utility theory, which assumes that the decision makers' preference for alternatives can be measured by the utility index [28]. The Logit models are used to explain the discrete choice [29]. Moreover, the application of a virtual environment and discrete choice model can better understand road users' preferences.

In summary, most existing studies only focus on the public's preferences assuming they are walking or cycling. Since green space in living streets is shared by pedestrians and cyclists, landscape architects need more opinions from different perspectives of street users. In addition, sidewalk seats, planted flowers, and building interfaces are also part of street greenscape, besides trees, shrubs, and flowers, and the former are missing from previous studies. Consequently, they are also considered in this study. Therefore, in order to encourage walking and cycling in living streets, this study applies a virtual environment and discrete choice experiment to investigate pedestrians and cyclists, to (1) identify the preferences of each element (including trees, shrubs, hedges, flowers, grass, and other elements) separately; (2) figure out preferred planting locations beside cycle path and sidewalk; (3) compare the preferences of pedestrians and cyclists, respectively.

2. METHODOLOGY

2.1 Attribute selection

Based on previous research and existing literature on street greenery [18, 21, 25, 30], the key factors for public preferences on street greenery and their possible locations could be determined. We selected five factors that might influence greenery preferences by pedestrians or cyclists in the living streets: trees, bushes, seats, hues, and interfaces of buildings. In addition, two environmental factors should be considered in a complete living street: segregation between cycle path and motorised traffic and segregation between cycle path and sidewalk [15] (*Figure 1*). Since the possible locations of street greenery are complex, the greenery could be present or absent in the segregation infrastructures or along the front areas of buildings.

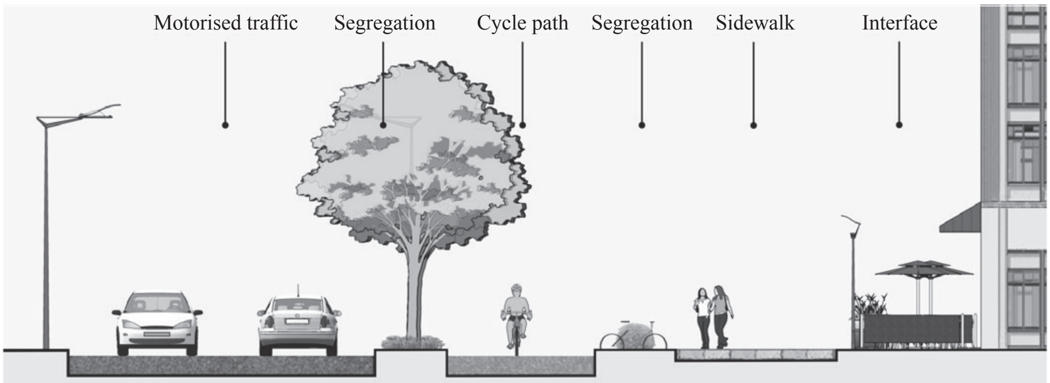

Figure 1 – Street section

Table 2 – Selected attributes and levels for pedestrians and cyclists

Attributes	Levels	Codes
Trees	1. Absence	T0
	2. Large size trees by the cycle track	Tll
	3. Large size trees by the sidewalk	Tlr
	4. Large size trees by the cycle track and sidewalk	Tl2
	5. Common size trees by the cycle track	Tcl
	6. Common size trees by the sidewalk	Tcr
	7. Common size trees by the cycle track and sidewalk	Tc2
Bushes by the cycle track	1. Absence	V0
	2. Shrubs by the cycle track	Vs
	3. Hedges by the cycle track	Vh
	4. Flowers by the cycle track	Vf
	5. Grass by the cycle track	Vg
Bushes by the sidewalk	1. Absence	B0
	2. Shrubs by the sidewalk	Bs
	3. Hedges by the sidewalk	Bh
	4. Flowers by the sidewalk	Bf
	5. Grass by the sidewalk	Bg
Seats on the sidewalk	1. Absence	S0
	2. On the sidewalk	S1
Planting hues	1. Bright	Br
	2. Gray	Gr
Interfaces of buildings	1. Buildings	Bu
	2. Coffee seats in front of buildings	Co
	3. Plantings in front of buildings	Pl

Moreover, trees could be large size, common size, or absent. They could be linearly planted in the separation between cycle path and motorised traffic, in the separation between cycle path and sidewalk, or symmetrically planted in both. Undergrowth plantings could be shrubs, hedges, flowers, grass, or absent. Similarly, they could be linearly planted in one of the separations or symmetrically planted in both. Interfaces of buildings consisted of plantings, coffee seats, or none. Seats could be on the sidewalk or absent. Planting hues could be bright or grey. Bright represented the colour-leafed woody plants and conspicuous flowers, while grey represented dark green woody plants and flowers with grey blooms. Each type of element contained 2–7 levels, as shown in *Table 2*.

The virtual models of a living street environment were built using SketchUp and further developed using Adobe Photoshop. According to the *Code for Urban Pedestrian and Bicycle Transport System Planning and Design* made by the Ministry of Housing and Urban-Rural Development of the PRC [31], and the common situation of Chinese living streets, we set the sizes of the virtual environment. The large size trees were approximately 13 m tall, and the common size trees were approximately 8 m tall. The width of the sidewalk was 2 m. The width of the cycle path was 4 m. The segregation was 2 m wide, and there were two motorised lanes. The front area of the buildings was 2 m wide. We did not specify the greening species. The photos were extracted at the eye level of an adult (approximately 1.6 m).

2.2 Experiment design

A stated choice experiment was used to calculate attribute levels’ parameters that affect the utility of participants’ choices. In this paper, 2–7 levels were contained in 6 attributes, which resulted in 7×5×5× 2×2×3=2100 different profiles in a complete factorial design. The orthogonal fractional factorial was selected to reduce this number. 36 attribute profiles were created, and 18 choice sets were created by combining 36 profiles. Profiles with obvious selection tendencies were removed. In addition, to reduce the burden on respondents to make choices more efficient, respondents were to be presented

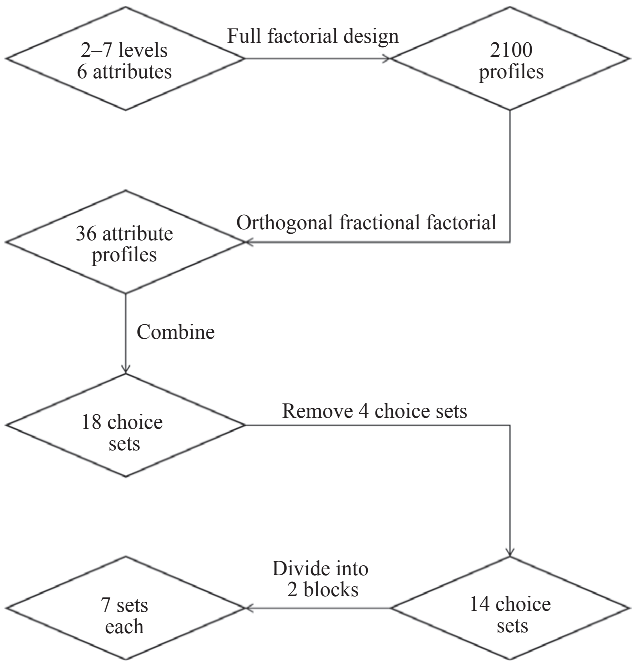

Figure 2 – Framework of experiment design

A B A B

a) An example of a stated choice set for pedestrians *b) An example of a stated choice set for cyclists*

Figure 3 – Examples of the stated choice sets

with no more than 8 choice sets. Afterward, 4 choice sets were removed, and the remaining 14 choice sets were divided into 2 blocks, each of which contained 7 sets. Perspectives of pedestrians and cyclists were contained in each block. The framework of the experiment design can be seen in *Figure 2*.

The respondents would receive a random block with 7 sets of streetscapes. They would choose each set for walking or cycling, respectively. We sketched a virtual street environment to present the profiles above, and each choice set comprised two pictures in the view of a pedestrian and a cyclist. The pictures in each set were randomly presented on the left or right to avoid the order of pictures influencing the choice. An example of a choice set is shown in *Figure 3*, where *Figure 3a* is a set for pedestrians and *Figure 3b* for cyclists.

2.3 Data collection

The questionnaire included three parts: (1) the sociodemographic information of respondents, (2) ranking of the benefits of street greening, and (3) seven stated choice questions. Respondents answered the questionnaire randomly from cycling or walking perspectives.

The sociodemographic variables included gender, age, income, and education level. We also asked respondents to rank several benefits of street greening, including feeling cooler, improved air quality, plant diversity, feeling safe, more relaxed, and reduced noise. In addition, the subjective attitudes of respondents towards characteristics of green plantings in the streets were also studied, including shading, seasonality, flowering shrubs, herbaceous flowers, and pruning. For the choice sets, the respondents would see the following description: *The weather is sunny and the temperature is moderate. The road is in good condition. You are on your way to or from work. Which street do you choose to walk/cycle through? (The road condition is the same other than the attributes above.)*

At the beginning of the questionnaire, we stated that we would like commuting respondents whose daily travel included walking and cycling to answer it. Data were collected in July 2020, considering that cyclists were the most likely to choose to commute by cycling in that season. Through the online platform of Wenjuanxing (https://www.wjx.cn/), 520 respondents fully finished the questionnaires, of which 496 were valid (247 pedestrians and 249 cyclists, respectively), and 6944 choices were made and remained in the further analysis.

2.4 Model estimation

The stated choice experiment is based on the random utility theory that an individual's utility of a good is assumed to consist of the sum of a deterministic part and a random unobservable term [28]. For a choice set, the participant measures the individual utility in different profiles and selects the choice to bring the maximum utility level. Therefore, we used stated choices in this study to compute a set of parameters for independent variables to predict the choices made in reality. The multinomial logit (MNL) model is the basis of the whole stated choice model system, and it is also the most commonly used in practice. The MNL model is relatively simple and requires a small sample size. However, it is a mature model, with high robustness and universality, high data utilisation, and low model error rate [32]. Therefore, its position is crucial in discrete selection experiments, and it is selected for the subsequent calculation. According to the requirements of the model, this study followed the IID (independent and identically distributed) assumption in the experiment design. Ideally, all choices made by respondents are random and independent, and all choices follow the identical distribution in the stated choice experiment.

The approach was used for the data from pedestrians' and cyclists' perspectives and the sum of two groups. Street environmental attributes were dummy coded and used for 6 attributes. It meant that these attributes with 2–7 levels were dummy variables encoded as 0 or 1. The level presented was coded as 1 and 0 for not presented. Since there were 6 street environmental attributes with 2–7 levels (24 variables) and 11 sociodemographic variables, a total of 35 parameters had to be estimated. We established whether the parameters were significant ($p<0.10$). McFadden's pseudo R-square was estimated to measure the goodness-of-fit of the estimated models. The model was estimated using the statistical software STATA/IC 16.1 (StataCorp LLC., TX, USA).

3. RESULTS

3.1 Sample characteristics

The sociodemographic characteristics are shown in *Table 3*. The sample has a bit more females than males, and a majority of them are under 64 years of age. 48% have bachelor's degree while 40% have master's degree. Most respondents belong to low and middle-income groups.

3.2 Subjective attitudes

According to the respondents' scores of the benefits of street green space, 'feeling cooler' ranks first, followed by 'improved air quality', 'plant diversity', 'feeling safe' and 'more relaxed', while 'reduced noise' ranks last (*Figure 4*). There is no significant difference between cyclists and pedestrians on the preference trend of benefits brought by greenscape. Cyclists claim that green plantings make them feel safer, the score of which is much higher than for pedestrians. Also, pedestrians have a higher preference for the diversity of landscape than cyclists.

The results of respondents' preference for green plantings show that trees with big crowns are the most preferred for providing more shade, followed by trees with seasonal changes. The scores of 'flowering shrubs' and 'herbaceous flowers' are close and

Table 3 – Social-demographic characteristics

<table>
<tr><th colspan="2"></th><th>Number</th><th>Percentage</th><th colspan="2"></th><th>Number</th><th>Percentage</th></tr>
<tr><td rowspan="3">Income (CNY)</td><td>0–3000</td><td>207</td><td>42%</td><td rowspan="2">Gender</td><td>Male</td><td>211</td><td>43%</td></tr>
<tr><td>3001–12000</td><td>249</td><td>50%</td><td>Female</td><td>285</td><td>57%</td></tr>
<tr><td>12001 or more</td><td>40</td><td>8%</td><td rowspan="4">Education</td><td rowspan="2">High school/
Technical school</td><td rowspan="2">57</td><td rowspan="2">12%</td></tr>
<tr><td rowspan="3">Age</td><td>18–44 years</td><td>338</td><td>68%</td></tr>
<tr><td>45–64 years</td><td>154</td><td>31%</td><td>Bachelor</td><td>239</td><td>48%</td></tr>
<tr><td>65–70 years</td><td>4</td><td>1%</td><td>Master</td><td>200</td><td>40%</td></tr>
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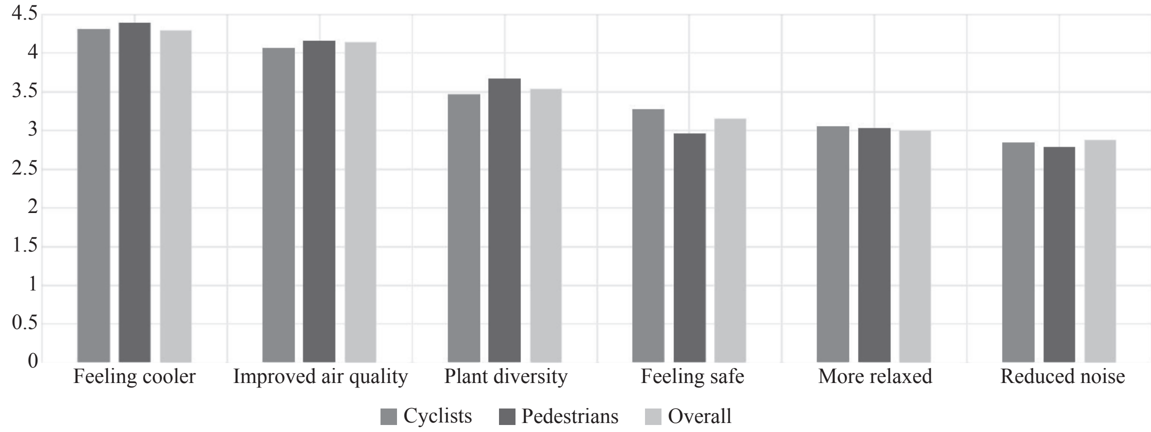

Figure 4 – Subjective attitudes towards the benefits of street green space

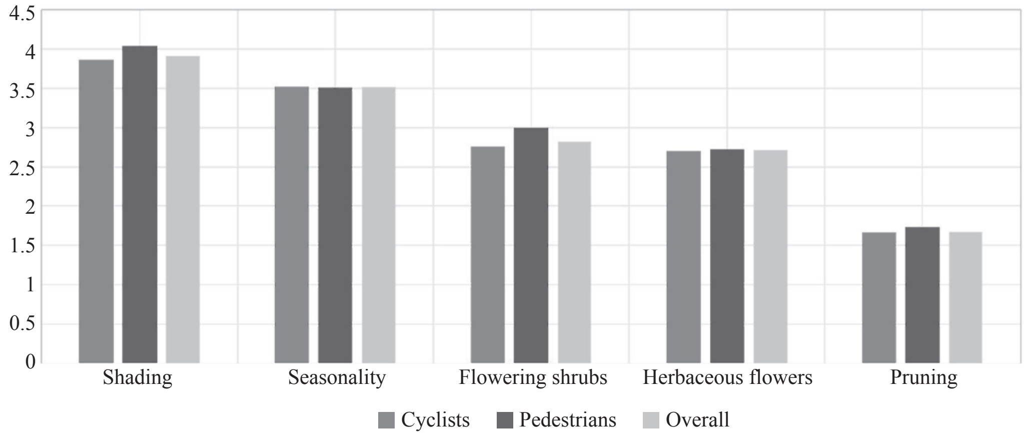

Figure 5 – Subjective attitudes on the characteristics of green plantings

lower than 'shading' and 'seasonality'. Respondents have the lowest preference for topiary plants (*Figure 5*). The preference trend of cyclists and pedestrians is consistent except for 'shading' and 'flowering shrubs'. The difference indicates that pedestrians care more about shading and flowering shrubs than cyclists, and it also shows that pedestrians pay more attention to the details of planting configuration.

3.3 Parameter values

Preferences for street greenscape are calculated by the multinomial logit model, and the parameter estimation values of each variable correspond to the preference characteristics. A total of 35 parameters are estimated in this study, and the results show that the sociodemographic variables are all insignificant to preferences, so they are omitted here. We calculated estimations by pedestrians and cyclists, as well as the whole sample, respectively, and took 'absence of trees', 'absence of bushes by the cycle track', 'absence of bushes by the sidewalk' and 'absence of seats on the sidewalk', 'bright planting hues', 'plantings in front of buildings' as the references in the models.

The model parameters are presented in *Table 4*. The Prob>chi^2 values of the three models are all 0.000, showing that they are all significant at the 99% confidence level. The pseudo-R^2 is 0.0892, 0.2082, 0.0916 for the whole sample, cyclists and pedestrians, respectively, and the model of cyclists has the best goodness of fit.

Preference for planting locations of all respondents

'Common size trees by the sidewalk' (Tcr, p=0.249) is not significant in this model. Except for 'flowers by the sidewalk' (Bf, p=0.080), which is significant at the 90% confidence level, the part-worth utilities for the other attributes in this model reach the 99% significant confidence level. Specifically, the coefficients of 'seats on the sidewalk', 'grey planting hues', 'buildings as interface', and 'coffee seats in front of buildings' are significantly negative, while others are positive.

Among the tree attributes, the estimated part-worth utilities for the highest two levels are 'large size trees by the cycle track and sidewalk' (Tl2, β=1.4671) and 'common size trees by the cycle track and sidewalk' (Tc2, β=1.4496). Followed by 'large size trees by the sidewalk' (Tlr, β=0.8356), 'large size trees by the cycle track' (Tll, β=0.7457), and 'common size trees by the cycle track' (Tcl, β=0.7049) in turn. It is suggested that respondents preferred trees symmetrically planted, and the preference for large size trees is higher than for common ones.

Within the elements 'bushes by the cycle track', the estimation of 'shrubs by the cycle track' (Vs, β=0.8683) is significantly higher than all three levels, followed by 'grass' (Vg, β=0.7760), 'flowers' (Vf, β=0.5839), and 'hedges by the cycle track' (Vh, β=0.4701). Within the elements 'bushes by the sidewalk', the estimation of 'hedges by the sidewalk' (Bh, β=0.9341) is significantly higher than all three levels, followed by 'shrubs' (Bs, β=0.5773), 'grass by the sidewalk' (Bg, β=0.4889), 'flowers by the sidewalk' (Bf, β=0.2110). The above results show that respondents prefer shrubs planted by the cycle track and hedges planted by the sidewalk.

'Seats on the sidewalk' (S1, β=-0.6729) have a negative evaluation when compared with their absence (reference situation). 'Gray plantings' (Gr, β=-0.3912) have a negative evaluation when compared with bright colours. 'Buildings as interface' (Bu, β=-0.7308) and 'coffee seats in front of buildings' (Co, β=-1.2132) also have negative evaluations compared with green plantings in front of buildings. This indicates that respondents prefer sidewalks without seats, green plantings in front of buildings, and green configurations with bright colours, such as woody plants with bright green hues and herbaceous flowers with bright colours.

Table 4 – Estimation results of the attributes differed from three groups

		Cyclists and pedestrians		Cyclists		Pedestrians	
		Estimations	$P > \|z\|$	Estimations	$P > \|z\|$	Estimations	$P > \|z\|$
Trees	Tll	0.7457	0.000	-0.2894	0.338	1.6369	0.000
	Tlr	0.8356	0.000	0.1309	0.578	1.5943	0.000
	Tl2	1.4671	0.000	1.8216	0.000	1.4368	0.000
	Tcl	0.7049	0.000	1.3738	0.000	0.0898	0.724
	Tcr	0.1830	0.249	-1.2142	0.249	1.3426	0.000
	Tc2	1.4496	0.000	1.0973	0.000	2.1256	0.000
Bushes by the cycle track	Vs	0.8683	0.000	2.3543	0.000	-0.1020	0.571
	Vh	0.4701	0.000	2.0847	0.000	-0.6203	0.000
	Vf	0.5839	0.000	1.7332	0.000	-0.0710	0.612
	Vg	0.7760	0.000	2.8869	0.000	-0.7006	0.000
Bushes by the sidewalk	Bs	0.5773	0.000	1.2153	0.000	0.2744	0.208
	Bh	0.9341	0.000	1.5936	0.000	0.4394	0.017
	Bf	0.2110	0.080	-0.2628	0.188	0.7978	0.000
	Bg	0.4889	0.000	0.8724	0.000	0.3328	0.033
Seats	S1	-0.6729	0.000	-1.1037	0.000	-0.3363	0.031
Planting hues	Gr	-0.3912	0.000	-0.9735	0.000	0.0151	0.097
Interfaces of buildings	Bu	-0.7308	0.000	-0.7856	0.000	-1.0163	0.000
	Co	-1.2132	0.000	-2.1397	0.000	-0.7435	0.000
	Cons	-0.5937	0.030	-0.9259	0.040	-0.5403	0.169
	N	6944		3486		3458	
Prob > chi^2		0.0000		0.0000		0.0000	
Pseudo-R^2		0.0892		0.2082		0.0916	
Log likelihood		-4384.0276		-1913.2718		-2177.2612	

Cyclists' preferences for planting locations

The part-worth utilities for Tl2, Tcl, Tc2, Vs, Vh, Vf, Vg, Bs, Bh, Bg, S1, Gr, Bu, Co reach 99% significant confidence level in this model. 'Large size trees by the cycle track' (Tll, p=0.338), 'large size trees by the sidewalk' (Tlr, p=0.578), 'common size trees by the sidewalk' (Tcr, p=0.249), and 'flowers by the sidewalk' (Bf, p=0.188) are not significant. Specifically, the coefficients of 'seats on the sidewalk', 'grey planting hues', 'buildings as interface', and 'coffee seats in front of buildings' are significantly negative, while others are positive.

Among tree attributes, the highest estimation is 'large size trees by the cycle track and sidewalk' (Tl2, β=1.8216), followed by 'common size trees by the cycle track' (Tcl, β=1.3738) and 'common size trees by the cycle track and sidewalk' (Tc2, β=1.0973). The results also proved that trees planted symmetrically are necessary. Alternatively, trees by the cycle track separating the bicycle lane and the vehicle road are essential.

Within bushes by the cycle track, 'grass' has the highest parameter value (Vg, β=2.8869), followed by 'shrubs' (Vs, β=2.3543), 'hedges' (Vh, β=2.0847), and 'flowers' (Vf, β=1.7332). Within bushes by the sidewalk, the estimation of 'hedges by the sidewalk' (Bh, β=1.5936) is higher than 'shrubs' (Bs, β=1.2153) and 'grass by the sidewalk' (Bg, β=0.8724). The parameter values of Vg, Vs, Vh, and Vf are all higher than Bh, Bs, and Bg. These results show that cyclists pay more attention to the greenery being isolated from motor vehicles, as opposed to pedestrians.

'Seats on the sidewalk' (S1, β=-1.1037), 'grey planting hues' (Gr, β=-0.9735), 'buildings as interface' (Bu, β=-0.7856) and 'coffee seats in front of buildings' (Co, β=-2.1397) have negative evaluations when compared with the reference situations for cyclists. Those attributes will reduce the utilities of the cyclists. The reference variables bright planting hues, sidewalk without seats, and green plantings in front of buildings are preferred by cyclists.

Pedestrians' preferences for planting locations

This model's part-worth utilities for Tll, Tlr, Tl2, Tcr, Tc2, Vh, Vg, Bf, Bu and Co reach 99% significant confidence level. 'Hedges by the sidewalk' (Bh, p=0.017), 'grass by the sidewalk' (Bg, p=0.033), and 'seats on the sidewalk' (S1, p=0.031) are significant at the 95% confidence level. 'Gray planting hues' (Gr, p=0.097) is significant at the 90% confidence level. 'Common size trees by the cycle track' (Tcl, p=0.724), 'shrubs by the cycle track' (Vs, p=0.571), 'flowers by the cycle track' (Vf, p=0.612), and 'shrubs by the sidewalk' (Bs, p=0.208) are not significant in this model. Specifically, the coefficients of 'hedges and grass by the cycle track', 'seats on the sidewalk', 'buildings as interface', and 'coffee seats in front of buildings' are significantly negative, while others are positive.

Among trees attributes, the highest estimation is 'common size trees by the cycle track and sidewalk' (Tc2, β=2.1256), followed by 'large size trees by the cycle track' (Tll, β=1.6369), 'large size trees by the sidewalk' (Tlr, β=1.5943), 'large size trees by the cycle track and sidewalk' (Tl2, β=1.4368) and 'common size trees by the sidewalk' (Tcr, β=1.3426). The estimations of bushes by the cycle track and sidewalk attributes are 'flowers' (Bf, β=0.7978), 'hedges' (Bh, β=0.4394), and 'grass by the sidewalk' (Bg, β=0.3328) decrease gradually. Two significant negative levels 'hedges by the cycle track' (Vh, β=-0.6203) and 'grass by the cycle track' (Vg, β=-0.7006) show that pedestrians prefer plantings absent by the cycle track, implying that pedestrians ignore the green space between bicycles lane and motor vehicles. For the greenery beside the sidewalk, flowers are the most preferred compared to hedges and grass. 'Gray planting hues' (Gr, β=0.0151) has the highest parameter value. 'Seats on the sidewalk' (S1, β=-0.3363), 'coffee seats in front of buildings' (Co, β=-0.7435), and 'buildings as interface' (Bu, β=-1.0163) have negative evaluations when compared with the reference situations for cyclists, indicating that pedestrians favour sidewalks without seats, green plantings in front of buildings and green configurations with grey colours.

4. DISCUSSION

4.1 Trees locations

Trees planted by the cycle track and sidewalk symmetrically are the most preferred choice, and large size trees are preferred more than common size trees by all the respondents. This indicates that street tree density has a positive relationship with preference. Trees, especially mature trees with large crown sizes, would be enjoyed more, consistent with previous research (e.g. [25, 33, 34]). The results of the perceptual analysis also prove that giving shade is the most important benefit of street trees, as shown by [33] and [35]. With respect to the preferences of cyclists and pedestrians, we find a similar trend for tree location preferences. Trees planted next to cycle lanes symmetrically or on the side near the motor vehicle improve the utilities of cyclists. They prefer trees for shading and keeping motorised traffic away, which contributes to the comfort of biking. This is also applicable to pedestrians. It is better to plant trees to separate motorists and cyclists from the sidewalk. We analysed the safety perceptions of cyclists and pedestrians with respect to tree locations and found that safety is a crucial concern for cyclists and walkers. That is why they prefer separating lanes from motorised traffic by planting tree strips. However, in many urban streets in small cities of China, the sidewalk, cycle track, and motorised lane are non-separated, neglecting the feeling of non-motor vehicle users. For the streets that separate bicycles and motor vehicles, lines or iron fences as segregation elements are inappropriate. Generally, the utilities of large size trees are greater than those of common size trees for cyclists, showing that they have a higher preference for large size trees. On the other hand, pedestrians prefer common size trees. The reason may be that common size trees are closer to pedestrians, resulting in a better perceptual experience.

4.2 Planting of shrubs, hedges, flowers and grass

Comparing the preferences between pedestrians and cyclists, we find that respondents have totally different preferences for bushes by cycle tracks and sidewalks. Cyclists have a higher preference for greenery as segregation between the bicycle lane and the motor lane, and they will consider the green space by the sidewalk last. For instance, cyclists prefer grass, shrubs, and hedges in turn, more than colourful flowers by the cycle track, and then hedges, shrubs, and grass by the sidewalk. This shows that cyclists have higher requirements for street greenscape quantity than quality, just as concluded in [17] and [20]. It might be because the faster moving speed and focused attention when cycling leads to less attention to the types and configuration of green plants. This finding differs from [17] in that cyclists prefer a cycle track separated from traffic with a hedge instead of a curb or marked line. But for pedestrians, flowers, hedges, and grass by the sidewalk are positively significant. They have a negative preference for hedges and grass by the cycle track. It means that pedestrians have no interest whatsoever in placement of bushes by the cycle track. Flowering plants are generally preferred by urban people in earlier studies [9], and our study proves it.

Further, we clarify that cyclists prefer flowers by cycle track and pedestrians prefer flowers by sidewalks, and both groups prefer flowers planted on their left side. Pedestrians are more sensitive to green plantings as the segregation between bicycle lanes and sidewalks. Generally, pedestrians' visual perception is more specific than that of cyclists. The types and complex configurations of greenscape are perceived as more delicate due to eye-level sensitive visual characteristics. Thus, street greening with flowers or pruned hedges is preferred for aesthetic perception and visual pleasure. This might be why cyclists do not have a significant positive preference for bushes by the sidewalk.

4.3 Other elements in the street environment

The estimation parameters of seats on the sidewalk, coffee seats in front of buildings and buildings as interface are all negative for cyclists and pedestrians. These variables decrease respondents' utilities, suggesting that sidewalks are favoured without seats and plantings in front of buildings. Seats will break the continuity of sidewalks, which is essential for the quality of the walking environment [36]. In practice, seats consume valuable walking space, and sidewalks easily tend to get crowded, affecting perceptions of pedestrians [37]. This might be another reason that seats are not preferred on the sidewalk in living streets. Cyclists and pedestrians most prefer buildings with green plants in the front yard. The street design with high-intensity greenscape elements is more positive for the public. However, not all streets have buildings with front yards, and studies have shown that vertical green could improve preferences, and green facades essentially receive positive evaluations [23, 38]. As to planting hues, there is no doubt that cyclists prefer bright colours such as red, pink, and yellow, rather than grey or brown. This finding is consistent with the conclusion drawn by [9]. It proves that the seasonal changes of plantings are important for the landscape design of bicycle roadsides. However, the parameter value of grey hues is a little higher than bright hues for pedestrians, suggesting that pedestrians prefer a variety of colours, both bright and grey.

4.4 Implications for street green space planning

Through this study, we find that the configuration of street plantings is more meaningful for pedestrians than cyclists, especially flowering shrubs, herbaceous flowers, and pruning hedges in greenery designs for sidewalks. Cyclists also prefer different plant configuration modes [23], but they do not pay much attention to them when cycling. The study also indicates that the seasonal aspect of street plants is the most important characteristic they are concerned about, except for shading. An earlier study also supported 'autumn colour' as a major benefit, second to 'pleasing to the eye' [35]. It is necessary to increase diversity changes of trees, such as seasonal leaves and flowering species. As greenery inside the segregations between sidewalks and cycle lanes is more likely to be pruned and shaped, flowers and hedges can be planted to a greater extent. The types of plants for the separation of cycle tracks and motor lanes are not critical. Otherwise, essential features of the cycling experience on the street include safety, and relaxed and undisturbed riding. Clean and wide sidewalks, more open walking spaces, and brightly coloured greenery can improve street experience.

However, the preference differences between cyclists and pedestrians have been overlooked for a long time by administrative departments. Basically, the cost of production and maintenance is considered foremost. We call for appropriate plants and their locations to be considered in future decisions. Planners should consider the preferences of people who choose different travel modes and develop solutions for different groups and street green space landscape design (*Table 5*).

Table 5 – Comparison of greening preferences between cycle tracks and sidewalks

Cycle track	Sidewalk
– quantity of greenscape – large size trees – shading and seasonal changes – safe, relax, and undisturbed – greening should be simple and bright – green plants in the front yard – green segregation from motor lanes is needed	– configuration of greenscape – common size trees – shading and seasonal changes – pruning and shaping – clean and wide – more open walking space – variety of colours – green plants in front yards

Although previous research found that some sociodemographic variables influenced the perception and preference of street vegetation, their impact is minimal [39]. In this study, the variables of gender, age, income, and education level are insignificant to the preferences of street plantings, and this indicates that street greenery design is independent of the basic personal attributes of the sample. This may be limited by the sample, or, as shown in [40], the time they spend on the street and their experiences may have a more significant impact on the individual level.

5. CONCLUSION

In this paper, a stated choice experiment is used to investigate the landscape preferences for green space in virtual streets through an online questionnaire. The conclusions are as follows:

1) The suitable planting locations of trees is symmetrically along the cycle track. If the greenscape design is limited by the street space, cost, or other factors, it is more suitable to plant large size trees for the segregation between the cycle lane and the motor vehicle lane. Cyclists prefer trees by the cycle track for shade and keeping motorised traffic away. Pedestrians prefer trees to separate motor vehicles and cyclists from the sidewalk. Generally, tall and large size trees are more preferred than common size trees.
2) There are significant differences in preferences as to the locations of shrubs, hedges, flowers, and grass between cyclists and pedestrians. Cyclists prefer grass, shrubs, and hedges over colourful flowers by the cycle track, and hedges, shrubs, and grass by the sidewalk. They have stronger requirements for the quantity of street greenscape than for quality. Flowers, hedges, and grass by the sidewalk are positively significant for pedestrians. They are more sensitive to green plantings on the segregation between bicycle lanes and sidewalks. In addition, pedestrians negatively prefer hedges and grass by the cycle track, which means pedestrians do not care about bushes for the separation of the cycle track and the motor vehicle lane.
3) For other elements, the respondents do not like seats on the sidewalk. Buildings with green plants in the front yard are more preferred by respondents than facades or coffee seats. Greening in the street should be simple and bright. Cyclists prefer bright colours rather than grey. However,

there are slight differences for pedestrians, suggesting that a variety of colours is essential for them.

The conclusions have important implications for policymakers and academic studies. This study provides a new idea for improving street greenscape, but it also has some limitations. (1) The virtual model is idealised, and the widths of the sidewalk, cycling path, and vehicle road are constant. Virtual images focus on visual stimuli, but other complex environmental elements which increase the natural experience and environmental perception, such as air, sound, and smell, are all ignored. (2) The simulation of different transportation modes only depends on picture viewing. The dynamic feeling of walking or cycling should be further considered. Virtual reality technology can be used to simulate the different speeds and heights of different transportation modes in future studies. (3) This survey uses a network questionnaire based on snowball sampling. The snowball sampling process is difficult to control, it may partly have impact on the results. For example, it is not easy to collect the preferences of older adults as they use the internet to a lesser extent. In future research, we can adopt other sampling and experimental methods to conduct a more extensive investigation. (4) The respondents from different climate regions and native plant species may influence road users' preferences for street green space. Additional studies can be made to analyse more specific preferences of local people according to different climate conditions.

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步行者与骑行者对街道绿色景观设计的偏好研究

摘要

近年来，公众与街道绿色空间的接触逐渐增多，这使得人们对街道绿色空间设计越来越关注。本研究采用离散选择实验方法，通过设置虚拟街道环境，对步行者与骑行者的街道绿色景观设计偏好进行了在线问卷调查。随后利用多项Logit模型，对陈述性偏好数据进行分析。结果表明，人们更偏好于在自行车道和人行道之间对称式地种植乔木。而与普通大小的乔木相比，人们更加青睐冠幅大、高度高的大型乔木。此外，步行者与骑行者对灌木、绿篱、花卉和草坪的位置偏好差异较大。骑行者更加偏好于自行车道与机动车道之间的隔离带植有草坪，却最不喜欢人行道与自行车道之间的隔离带种植草坪。而步行者对人行道与自行车道之间的隔离带种植花卉、绿篱和草坪的偏好依次降低。此外，与仅仅呈现建筑立面或建筑物底层外部空间布置咖啡座相比，建筑物外部空间布置绿色植物会更受欢迎。本研究有助于更好地理解以非机动方式出行的公众的景观偏好，同时也对景观设计师和政府在设计以人为本的街道绿地空间时具有一定的指导作用。

关键词

生活性街道；种植偏好；种植位置；离散选择实验

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