Reimagining Shared (Space) Street Design: Segregating to Better Integrate?

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Abstract

The shared space concept proposes to reduce traffic control to integrate road users. Yet, defining boundaries to create a pedestrian safe zone is particularly relevant for a successful implementation. Therefore, to determine if road users also expect a protective barrier delimiting the safe zone, this paper presents part of the results of an online survey that evaluated the preferences of pedestrians and cyclists. A total of 408 participants completed the survey and ranked the alternatives (i.e. none, bollards, bushes, and stones) according to their preferences. Approaches suitable for ranking data were then applied to further understand the results, which indicated that only providing a safe zone with visual separation is not necessarily preferred when compared to the provision of additional physical barriers. Both pedestrians and cyclists prefer bushes over the presented alternatives. As bushes objectively provide less physical protection than bollards and stones, it can be assumed that the sense of segregation, rather than the physical protection itself, should be considered in shared space design. By challenging the concept of user integration, this paper suggests reinterpreting the shared space design to combine physical barriers in an attempt to better accommodate vulnerable road users.

Keywords: urban street; streetscape; safe zone; visual preference; online survey

1 Introduction

Shared space is a design concept characterised by integrating road users while reducing traffic control. With no priority rule, more space and freedom of movement are granted as long as road users mutually negotiate their actions. As the design usually presents a levelled surface without markings or segregation, attention to people's behaviour is crucial to avoid conflicts. This condition tends to contribute to decreasing traffic speed and increasing objective safety (Hamilton-Baillie, 2008; Karndacharuk et al., 2014). Yet, the attention-demanding atmosphere can easily create dissatisfaction, confusion, and a sense of unsafety as people have preconceived ideas about how to behave in a street environment (Akgün-Tanbay et al., 2022; Moody and Melia, 2014; Peters, 2017).

Imrie (2012) criticises the inability of the shared space design in providing adequate care and protection for vision-impaired people, which creates social and spatial divisions in the urban environment. Previous studies in shared space schemes have also indicated that vulnerable road users tend to avoid interaction with motor vehicles and often concentrate their movements at the periphery of the scheme, naturally replicating their inclination for segregation (Anvari et al., 2016; Batista and Friedrich, 2022; Moody and Melia, 2014). On that account, Jayakody et al. (2018) concluded that inclusive design is paramount for a successful shared space implementation, highlighting the importance of considering pedestrian safe zones protected by a transitional area and street furniture.

Although contradicting the concept of completely integrating different road users in a common space, it is evident that defining boundaries to create a safe zone for vulnerable road users is a meaningful approach to shared space design. To determine if road users also expect a physical barrier, this paper presents part of the results of an online survey that evaluated the preferences of pedestrians and cyclists. Therefore, scenarios with varying traffic conditions and four different alternatives for delimiting the safe zone, such as no physical barrier, bollards, bushes, and stones, were evaluated. By confronting no physical protection with the presence of traditional elements (i.e bollards) and uncommon elements (i.e. bushes and stones), a better understanding of the desire for more evident segregation and protection is then further explored.

In the New Zealand approach to shared space design (Karndacharuk et al., 2014), this soft segregation between traffic modes is already considered by implementing shared zones and accessible routes. This paper considers that incorporating a degree of segregation in shared space design does not necessarily mean getting rid of the concept altogether. The idea is to benefit from the shared barrier-free environment while providing physical protection to road users who are unwilling to share the space with other faster users, such as motor vehicles and cyclists. Furthermore, since the preferences of pedestrians and cyclists in contrasting traffic conditions were evaluated, the results can contribute to support decisions in the design of different types of shared infrastructure, such as shared paths and non-motorised shared spaces.

2 Literature review

Certain performance parameters, such as an increase in pedestrians' freedom of movement and a reduction in traffic speed, have been established as successful contributions to implementing the shared space design (Karndacharuk et al., 2014; Ruiz-Apilánez et al., 2017; Schönauer et al., 2012). On-street interviews have shown that vulnerable road users were mainly satisfied with shared space schemes when accomplishing these parameters. Still, they also tend to feel uncomfortable, unsafe, and unsure about sharing space with motor vehicles (Hammond and Musselwhite, 2013; Lawson et al., 2022; Moody and Melia, 2014). There are several important aspects of the behaviour and perceptions of road users to consider when designing a shared space. Yet, understanding the expectations of vulnerable road users is paramount to creating spaces where they can feel integrated.

2.1 Road users' preferences for shared space design

Kaparias et al. (2012) analysed the perceptions of pedestrians and drivers regarding shared space using a web-based stated-preference survey, presenting both road users with different combinations of scenarios. They developed logit models to analyse specific factors for pedestrian comfort and drivers' willingness to share space. In general, low traffic flow, high pedestrian traffic, and the provision of safe zones make pedestrians feel more comfortable, while high traffic flow, high pedestrian density, in particular children and elderly, and the provision of street furniture have negative effects on drivers. Similarly, Hsu and Lee (2017) quantified the effects of design-specific factors and endorsed the findings of Kaparias et al. (2012) by using a multinomial logit modelling technique to describe pedestrians' and drivers' preferences for shared space design from a photo survey. Yet, Hsu and Lee (2017) also concluded that the provision of safe zones tends to reduce driver alertness.

Xu et al. (2022) evaluated pedestrians' and drivers' acceptance to three shared street layouts using a virtual reality (VR) experiment and questionnaire. The scenarios varied in terms of separation, pavement, parking, and some aesthetic elements. The participants experienced a completely open and integrated layout without any type of separation, a layout with soft segregation presenting visual and physical design elements delimiting a pedestrian safe zone, and another layout with the pedestrian zone clearly demarcated by street furniture. Overall, the evaluated scenarios were preferred over the conventional street design. Nevertheless, the layouts with soft and obvious segregation were preferred by both pedestrians and drivers, endorsing their hesitation in sharing the same space with each other.

Focusing on cyclists, Kaparias et al. (2013) concluded that paving materials and the provision of bicycle facilities had a positive effect after the redevelopment of Exhibition Road in London, UK. As discussed by Kang et al. (2019), the provision of facilities to park and take a break (i.e. benches) are favourable aspects of promoting cycling. Still, cyclists also tended to positively rate the ease of movement and perceived safety in this shared space environment, but expressed confusion about the area they should cycle, emphasising an issue on the clarity of the design (Kaparias et al., 2013). Similarly, Akgün-Tanbay et al. (2022) indicated that a non-motorised shared space scheme is perceived as chaotic for both walking and cycling.

Shared infrastructure, even in a low-speed zone, is more attention-demanding and time-consuming for cyclists, who then prefer segregation from both motor vehicles and pedestrians (Caviedes and Figliozzi, 2018; Vedel et al., 2017). At least in a non-motorised shared space, strategies to better accommodate different road users seem to be necessary. That includes the separation of modes, particularly with soft measures, to increase their perception of the design (Akgün-Tanbay et al., 2022; Gkekas et al., 2020). Therefore, a pertinent solution needs to consider road users' perceptions and needs. Reimagining the shared space design, in this context, means providing an in-between solution to still ensure the benefits of a shared space while incorporating a small degree of segregation, as the shared zones and accessible route in the New Zealand design (Karndacharuk et al., 2014).

There are numerous ways to guarantee the provision of a safe zone in shared space schemes (Jayakody et al., 2018; Sarkar, 1995). Nevertheless, it is also key to understand the preferences of road users, particularly regarding the integration of an additional traffic calming element. Compared to conventional street design, shared space schemes can ensure a low-speed environment, yet, the simple presence of a motor vehicle can already influence how people behave (Peters, 2017). Past studies have suggested certain conditions to improve the perceived safety and comfort of vulnerable road users. Therefore, it is also fundamental to evaluate concrete measures to accomplish them in reality.

2.2 Virtual environments in online surveys

Virtual environments are usually created by computer simulations to be incorporated into VR experiments. However, this type of experiment requires suitable equipment, further guidance, and assistance, as conducted by Xu et al. (2022). Allowing participants of an online survey to freely move inside a virtual environment to complete tasks is still applicable in some cases (Jiang et al., 2018). Yet, in this context, virtual environments are generally incorporated as animations since they are perceived as a realistic representation of the scenario in question, and, consequently, they are capable of inducing reliable reactions (Bishop and Rohrmann, 2003; Lim et al., 2006; Lovett et al., 2015).

Past studies have used virtual environments to model real-life experiences, particularly to evaluate controlled experimental environments in online surveys. In an attempt to understand the influence of certain urban park attributes on visitors, van Vliet et al. (2020) developed a stated-choice task using videos from a virtual park. Similarly, Kasraian et al. (2021) applied a comparable methodology to understand how walkability is rated and experienced by pedestrians using dynamic 3D representations of different scenarios. In a more robust experiment, Jiang et al. (2018) developed an online virtual reality application to investigate how traffic restrictions and shared street design affects people's perceptions and experience in relation to urban soundscape.

Since online surveys can easily reach a wider audience than experiments or on-street interviews, incorporating virtual environments can further facilitate engagement by creating an experience close to reality, as seen in Jiang et al. (2018), van Vliet et al. (2020), and Kasraian et al. (2021). On the other hand, due to the lack of supervision and mediation, some of the issues that might arise are potential bias derived from inattention and time interruptions as well as technical issues (Lovett et al., 2015; Roth, 2006).

3 Methodology

The research was conducted as an online survey using animated virtual environments. Four scenarios were designed, so the participants could experience and rank different situations concerning the absence and presence of different physical barriers delimiting a safe zone in a shared space scheme.

3.1 Study design

This study considered a shared street layout inspired by a German shared space scheme, Frankfurter Straße in Bad Rothenfelde, which has a levelled surface with design elements designating pedestrian safe zones on both sides. Yet, only its land use characteristics and the street cross-section were used for creating the shared street layout. Based on the road users' perceptions of shared space in previous studies, the levelled surface was kept, but with contrasting paving materials to create a stronger visual separation between traffic modes and highlight the provision of safe zones.

As there are already many studies focusing on the driver's preferences and Batista and Friedrich (2022) indicated that motor vehicles and cyclists tend to follow similar paths in shared space schemes, only the cyclists' perspective is considered in this study. To evaluate the preferences of pedestrians and cyclists regarding the delimitation of a pedestrian safe zone, apart from the visual separation, three other design elements were considered as physical barriers, namely bollards, bushes, and stones. Furthermore, as road users' density influences how people perceive a shared space environment, different conditions were considered to design four scenarios:

- Scenario P1: Pedestrian perspective with higher flow of motor vehicles (see Figure 1a)
- Scenario P2: Pedestrian perspective with higher flow of cyclists (see Figure 1b)
- Scenario C1: Cyclist perspective with low flow of pedestrians (see Figure 1c)
- Scenario C2: Cyclist perspective with high flow of pedestrians (see Figure 1d)

Motor vehicles, cyclists, and pedestrians were presented in all scenarios following the mean flow characteristics observed in Frankfurter Straße (Batista and Friedrich, 2022). For P1 and P2, the volume of pedestrians was kept constant while the percentage of motor vehicles and cyclists was swapped accordingly. Conversely, the volume of motor vehicles and cyclists was constant in scenarios C1 and C2, while no pedestrians were sitting on the benches in C1 and pedestrian flow was doubled for C2.

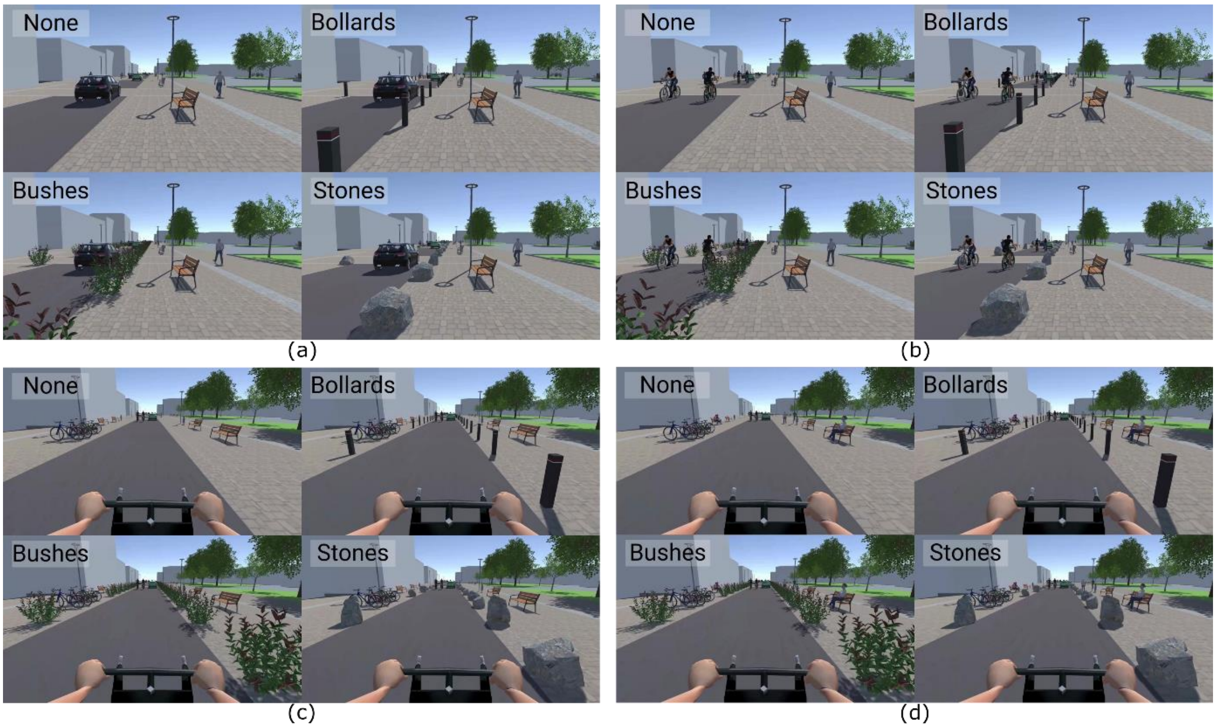

Figure 1. Frame of the video in the survey for scenarios (a) P1; (b) P2; (c) C1; (d) C2.

3.2 Dynamic 3D scenarios

The shared street together with buildings, street furniture, and vegetation was modelled in SketchUp using information from study visits and online maps. Once the environment was generated, material texture and other design elements were integrated. The buildings were kept as neutral as possible, by not applying any texture to their exterior, in an attempt to emphasise the street design.

After recreating the shared street, the 3D model was imported into the Unity game engine to integrate road users, namely the animation of motor vehicles, cyclists, and pedestrians. The speed of road users was then randomised within ranges of 10-20 km/h for motor vehicles and cyclists and 2-4 km/h for pedestrians, in line with the observations in Batista and Friedrich (2022). All scenarios were dynamic and seen either from the viewpoint of a moving pedestrian or cyclist. Nevertheless, no sound was added to the scenarios.

The location of the road user's perspective, where exactly the viewpoint of a moving pedestrian and cyclist would be, was also decided based on the trajectories analysed in Batista and Friedrich (2022). The pedestrian safe zone in the shared street is relatively wide and different street furniture is also included, such as street lighting, garbage bins, and benches. Therefore, the moving pedestrian was walking near and parallel to the driving zone, so the effect of the different scenarios would be better perceived and also more relatable to narrower facilities. For the cyclist, since it is a two-way street, the viewpoint was near and parallel to the edge of the driving zone.

3.3 Web-based survey

The scenarios were part of a web-based survey, conducted by the authors, about shared space design. The questions were only available in English and related to videos of different virtual environments to understand the preferences of pedestrians and cyclists on different design attributes in shared space schemes. More details about the structure and results of the entire survey are the subject of a future publication. For this paper, the goal is to analyse the preferences of the participants regarding a physical barrier element between the driving and walking zones of a shared street, which refers to one of the seven sections of the survey.

This survey had eight different groups of questions related to distinct viewpoints and shared space designs. Upon the start, a random combination with four numbers was internally assigned to each participant to allocate a certain group of questions. As mentioned above, for this paper, only a specific section of the survey is presented, in which the participants watched a video for one of the four scenarios described in 3.1 Study design. As shown in Figure 1, this video showed a compilation of four other videos representing the shared street with the alternatives for a physical barrier element (i.e. none, bollards, bushes, and stones). Nevertheless, the participants also had the option to enlarge and watch each of these videos separately.

Participants needed to rank the alternatives (see Figure 2) based on their preferences as a pedestrian or cyclist, accordingly. They were required to rank all options and could not choose to only rank some of them. The alternative options appeared in random order and the participants could drag or double-click the options to place them in the ranking. In addition, before submitting their responses, the participants were also asked about socio-demographics and travel behaviour.

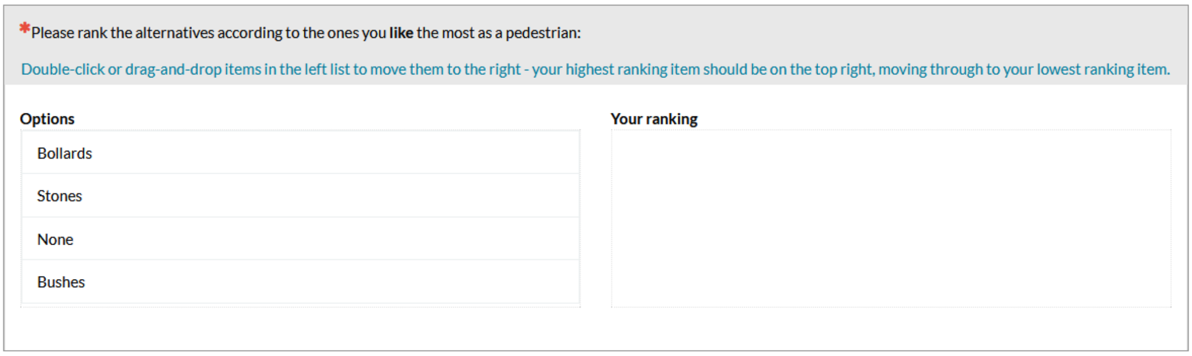

Figure 2. Screenshot of the question to rank the alternatives as a pedestrian.

3.4 Participants

The survey was conducted between September and October 2022 and invitations were distributed on social media, survey exchange platforms, and emails to different organisations, institutes, researchers, and students in the field of traffic and urban planning. In total, 410 participants completed all the tasks in the survey, with missing socio-demographics and travel behaviour data for two of them.

Although participants were randomly assigned to one of the four scenarios, different dropout rates per scenario created unequal sample sizes. Of the 410 participants, 203 responded to the pedestrian perspective, 98 to scenario P1 and 105 to scenario P2, and 207 participants responded to the cyclist perspective, 109 to scenario C1 and 98 to scenario C2. The two participants with missing socio-demographics and travel behaviour data were from the cyclist perspective, one for each of the two scenarios. Table 1 presents further characteristics of the 408 participants as a whole as well as considering the sample responding to the scenarios from pedestrian and cyclist perspectives and Figure 3 illustrates their travel behaviour.

Table 1. Overview of the participants' characteristics.

Variables	Total (n = 408)	Pedestrian (n = 203)	Cyclist (n = 205)
Experienced shared space			
Yes	348 (85.3%)	176 (86.7%)	172 (83.9%)
No	16 (3.9%)	9 (4.4%)	7 (3.4%)
Not sure	44 (10.8%)	18 (8.9%)	26 (12.7%)
Age group			
17 or younger	2 (0.5%)	1 (0.5%)	1 (0.5%)
18 to 24 years old	88 (21.6%)	38 (18.7%)	50 (24.4%)
25 to 30 years old	157 (38.5%)	84 (41.4%)	73 (35.6%)
31 to 40 years old	77 (18.9%)	41 (20.2%)	36 (17.6%)
41 to 50 years old	38 (9.3%)	16 (7.9%)	22 (10.7%)
51 to 60 years old	30 (7.4%)	13 (6.4%)	17 (8.3%)
61 to 70 years old	12 (2.9%)	7 (3.4%)	5 (2.4%)
Older than 70	3 (0.7%)	2 (1.0%)	1 (0.5%)
Prefer not to say	1 (0.2%)	1 (0.5%)	0 (0.0%)
Gender			
Female	215 (52.7%)	99 (48.8%)	116 (56.6%)
Male	183 (44.9%)	101 (49.8%)	82 (40.0%)
Non-binary	6 (1.5%)	1 (0.5%)	5 (2.4%)
Other	2 (0.5%)	2 (1.0%)	0 (0.0%)
Prefer not to say	2 (0.5%)	0 (0.0%)	2 (1.0%)
Continent of residence			
Europe	338 (82.8%)	169 (83.3%)	169 (82.4%)
Americas	42 (10.3%)	20 (9.9%)	22 (10.7%)
Asia	16 (3.9%)	8 (3.9%)	8 (3.9%)
Oceania	10 (2.5%)	4 (2.0%)	6 (2.9%)
Africa	2 (0.5%)	2 (1.0%)	0 (0.0%)

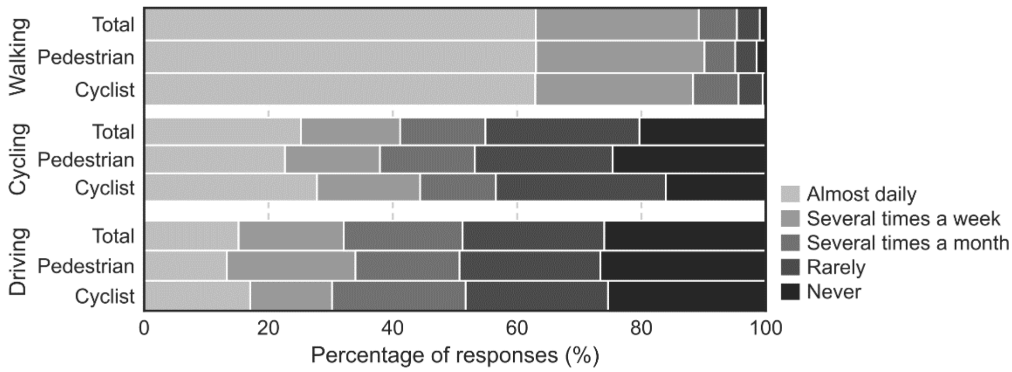

Figure 3. Distribution of responses in percent for travel behaviour of the participants.

3.5 Analysis of ranked response data

The survey results were analysed using different statistical analyses and approaches suitable for ranking data, following Finch (2022) and Turner et al. (2020). As the goal is to understand the preferred option and not how they are related to each other, descriptive statistics to explore the results in terms of distribution of ranks for all participants, pedestrian perspective, and cyclist perspective was computed. In addition, the mean ranks for each option were calculated for the four scenarios.

One helpful parameter for ranking data is the probability of participants ranking the options in a particular order. The Plackett-Luce model (PLM) is an approach designed to express the importance of each item in the participants' ranking (Finch, 2022; Turner et al., 2020). The PLM can identify the relative importance of options to a reference, an option that is set with zero as the worth parameter. Therefore, the PLM was fit to the data to understand the relevance of the physical barrier elements in relation to the option with no physical barrier elements (i.e. none). Furthermore, as the PLM also provide the relative importance of the options in terms of the probability of being placed on top of the ranking, this parameter was generated for all options in the four scenarios.

For the purpose of extending the analysis to reflect the relationship between the ranking data and other variables in the socio-demographics and travel behaviour data, Finch (2022) and Turner et al. (2020) suggested the application of the Plackett-Luce tree (PLT). By partitioning the rankings using covariates to identify subgroups with different PLM, it can estimate whether ranking patterns are associated with other specific characteristics. The PLT approach was then used to investigate the possibility of participants ranking the options for each scenario differently as well as the possibility of individual characteristics being correlated with the ranking.

4 Results

The frequency of the physical barrier elements in each position of the ranking is presented in Table 2. Bushes as an alternative were most often in position 1 considering the rank in all scenarios (47.3%), the pedestrian perspective (45.8%), and the cyclist perspective (48.8%). Similarly, the presence of none of the physical barrier elements (i.e. none) was most seen in the last position of the rank for the three cases.

Table 2. Frequency of each alternative in the ranking positions.

Rank	Perspective	Frequency (%)			
		None	Bollards	Bushes	Stones
Position 1	Both	14.6	26.3	47.3	11.7
	Pedestrian	8.9	28.6	45.8	16.7
	Cyclist	20.3	24.2	48.8	6.8
Position 2	Both	15.1	27.6	26.3	31.0
	Pedestrian	12.8	26.1	21.7	39.4
	Cyclist	17.4	29.0	30.9	22.7
Position 3	Both	15.4	34.4	18.0	32.2
	Pedestrian	13.8	31.5	21.7	33.0
	Cyclist	16.9	37.2	14.5	31.4
Position 4	Both	54.9	11.7	8.3	25.1
	Pedestrian	64.5	13.8	10.8	10.8
	Cyclist	45.4	9.7	5.8	39.1

The mean ranks for the four alternatives are presented in Figure 4. Bushes were the highest-ranked alternative for the four scenarios. The least preferred alternative was none for scenarios P1, P2, and C1. Interestingly, stones were the second preferred alternative for scenario P1 and the least one for scenario C2. Bollards were the alternative with the most consistent mean rank across all the scenarios.

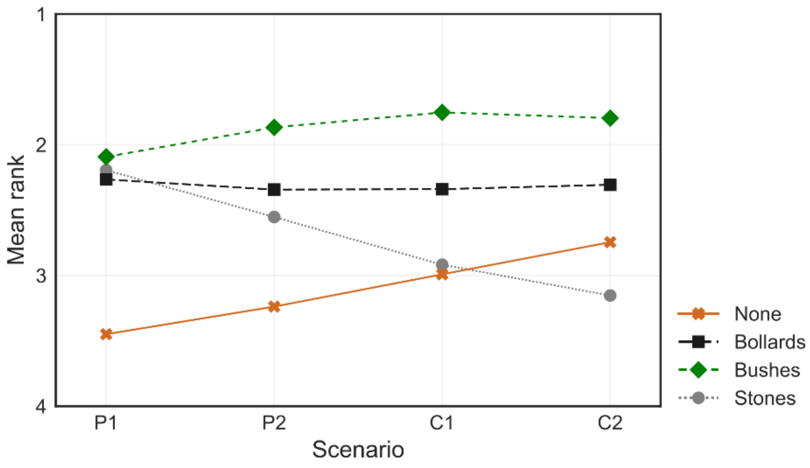

Figure 4. Mean rank of the alternatives for the four different scenarios.

To investigate the relative importance of the physical barrier element alternatives to their absence, Table 3 presents the results of fitting the PLM to the ranking data. Considering a significance level of 0.05, except for stones in scenarios C1 and C2, all the other cases had statistically significant positive estimate values. Therefore, similar to the results illustrated in Figure 4, it is then notable that, for all scenarios, most physical barrier element alternatives are preferred over the option none. In addition to the relative importance of each alternative to the absence of a physical barrier element, Figure 5 presents the probabilities of each alternative being the most preferred. In all scenarios, bushes are more likely to be preferred by both pedestrians and cyclists.

Table 3. Plackett-Luce model parameter estimates.

Scenario	Option	Estimate	Std. error	z value	p-value
P1	None	0.00	NA	NA	NA
	Bollards	1.34	0.22	6.18	<0.001
	Bushes	1.52	0.22	7.01	<0.001
	Stones	1.50	0.22	6.97	<0.001
P2	None	0.00	NA	NA	NA
	Bollards	1.12	0.20	5.65	<0.001
	Bushes	1.58	0.21	7.57	<0.001
	Stones	0.97	0.20	4.96	<0.001
C1	None	0.00	NA	NA	NA
	Bollards	0.87	0.19	4.72	<0.001
	Bushes	1.54	0.20	7.78	<0.001
	Stones	0.30	0.19	1.60	0.109
C2	None	0.00	NA	NA	NA
	Bollards	0.59	0.19	3.09	<0.001
	Bushes	1.12	0.20	5.69	<0.001
	Stones	-0.22	0.19	-1.14	0.256

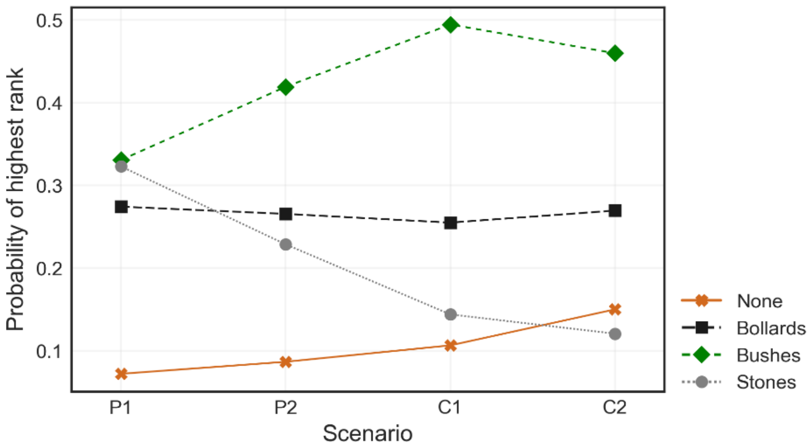

Figure 5. Probabilities of participants ranking the alternative as the most preferred.

A PLT was fit to the data considering only the scenarios as well as considering other variables related to socio-demographics and travel behaviour data as the covariates. Considering a significance level of 0.05, the results indicate that both the pedestrian (P1 and P2) and cyclist (C1 and C2) scenarios can be definitely considered as two individual subgroups. Nevertheless, statistically, it is not relevant to consider each scenario as an individual group.

On the other hand, when considering all the socio-demographics and travel behaviour data, the PLT could only split the data into subgroups considering the cycling behaviour of the participants. Yet, since the contrasting preferences within the identified subgroup are not necessarily pertinent to this paper, these results were not further investigated.

5 Discussion

The provision of safe zones is certainly a meaningful component of the shared space design. Although contradicting the concept of user integration, providing a dedicated space for vulnerable road users is beneficial for their perceived safety and comfort when navigating a shared space. Still, in such circumstances, Hsu and Lee (2017) indicated a reduction in driver alertness as they might take less care by expecting other users to only use the safe zone. On that account, a pragmatic discussion of a shared space design to consider the contrasting behaviour, perceptions, and needs of road users is paramount.

Both pedestrians and cyclists prefer a shared street layout with a protective barrier. The results of this paper have indicated that in all the evaluated scenarios, a physical barrier alternative was preferred over none. Interestingly, the alternative with no physical barrier was already visually separated from the driving zone. Therefore, a mere indication of a dedicated area does not seem to satisfy road users' expectations. This would be in line with results on cyclists' route choice because cyclists usually feel safer and prefer paths where they are physically separated not only from motor vehicles but also from pedestrians (Kang et al., 2019; Vedel et al., 2017).

Bushes as physical barriers were the alternative most preferred. Although it does not objectively provide more protection than bollards or stones, the greenery is potentially more appealing to road users. It could be argued that, in a shared space scheme, the sense of segregation might be more effective than the physical protection itself. Particularly because, in theory, it is already a low-speed zone. Furthermore, it is suggestive that stones were ranked quite differently from the cyclist perspective. As cyclists tended to rank them lower than pedestrians, one may assume that stones might be perceived as hard obstacles that could easily lead to an accident in case of a crash. In contrast, bollards are easier to deviate and bushes would potentially not lead to a harmful accident in the event of a crash.

Despite not collecting information on the driver perspective, evidence from past studies also highlighted drivers' hesitation in sharing road space with other users. Whilst dedicated space for motor vehicles might maximise their dominance in the shared road space, if implemented in combination with visual narrowing, it can in fact accentuate low speed. Not only visual features, such as paving materials but also street furniture, including physical barrier elements, can emphasise this feature. Consequently, the thought that a safe zone decreases driver alertness might then be counterbalanced.

Different studies have shown that it is crucial to reimagine shared space design. Accordingly, incorporating soft segregation represents a positive measure to better accommodate vulnerable road users in the space. The idea is not to remove the levelled surface or limit the freedom of movement but ensure that the needs of vulnerable road users are considered. Forcing user integration might contribute to intensifying social and spatial exclusion as discussed by Imrie (2012) and Lawson et al. (2022). Clearly, only the addition of another traffic calming element is not the solution. Although this study pointed out that bushes are preferred over other alternatives, it is no evidence that they should be installed without further consideration in a shared space. Still, several other factors must be considered, such as the type of bushes and their height since they should not hinder road users' visibility or the movement of people using wheeled walkers or wheelchairs. Attention to physical design in combination with road users' perceptions and needs is the starting point for developing better streets and, potentially, reinterpreting the shared space design.

This paper not only shows the preferences of pedestrians and cyclists for a protective barrier in shared street layout, but it presents an approach in which road users could be consulted and included in the design process. Certainly, using animated virtual environments in a web-based survey comes with several limitations, such as bias in the participants and lack of control, mediation or interaction with different groups of users. Still, for this specific study, even when only presenting controlled scenarios, the results present an initial idea of the resistance of the participants in preferring a shared street layout with only visual separation between driving and walking zones.

6 Conclusions

This paper investigated the preferences of pedestrians and cyclists for a protective barrier in a shared street layout using animated 3D scenarios in an online survey. A total of 408 participants completed the survey and ranked the alternatives (i.e. none, bollards, bushes, and stones) according to their preferences. Approaches suitable for ranking data, such as the calculation of mean ranks and frequencies as well as using the Plackett-Luce model, were then applied to further understand the participants' preferences.

The findings of this study highlighted that only providing a safe zone with visual separation is not necessarily preferred by road users when compared to the provision of additional physical barriers. Both pedestrians and cyclists prefer bushes as physical barriers delimiting a safe zone. As bushes objectively provide less physical protection than bollards and stones, it can be assumed that the sense of segregation, rather than the physical protection itself, might be particularly relevant in shared space design. Although the evaluated scenarios are based on a German shared space scheme, their representations were sufficiently generalised to extend the results to different types of shared infrastructure.

By challenging the concept of user integration, this paper proposes to reinterpret the shared space design to combine an additional traffic calming element as soft segregation in an attempt to better accommodate vulnerable road users. That does not mean eliminating the shared space concept altogether as it absolutely works to increase pedestrians' freedom of movement and reduce traffic speed. Still, it is crucial to understand and integrate certain conditions, particularly coming from the most vulnerable road users. Otherwise, the shared space design is kept at a generic level and continues to reinforce divisions in the urban environment.

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