Cyclists' Preferences regarding General and Design related Aspects of Regional Bicycle Paths

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Abstract

An increased use of bicycle paths outside urban areas requires a more detailed look at the design of this type of regional bicycle paths. In this paper attention is paid to bicyclists' preferences regarding general and design related aspects of regional bicycle paths. The following general aspects are included: Safety, Clarity, Comfort, and Speed. The included design related aspects are Road marking, Street lighting, Pavement, and Greening. In an extensive online questionnaire, respondents were invited to give their preferences by comparing various sets of two aspects in a pairwise comparison. In total, 416 respondents completed, among other things, these pairwise comparisons.

Analyses show that bicyclists evaluate the general aspect 'Safety' as most important, with 'Comfort' surprisingly left behind. The aspect 'Lighting' is evaluated as the most important design related aspect. Further investigation shows that some differences in preferences exist between groups of respondents. Most occurring differences are noticed between females and males, and between medium and highly educated respondents. Thus, there appear to be specific types of cyclists with their own preferences regarding bicycle paths. However, safety is shown to be a crucial factor for the user experience of regional bicycle paths across all cyclists.

Introduction

In the past, limited attention has been paid to separate bicycle paths that are located outside urban areas. In the Netherlands, these regional bicycle paths are usually located along regional roads (Figure 1). The recent rise in popularity of electrical bicycles and an increased emphasis of policy makers on sustainable transport modes resulted in an increased use of both urban bicycle infrastructure and bicycle infrastructure located outside urban areas (VeiligheidNL & Rijkswaterstaat, 2017). These developments have urged transportation planners to pay more attention to the design of bicycle paths outside urban areas. To optimize the design of these types of bicycle paths, additional insight regarding cyclists' preferences is needed (Xing et al, 2018): Which aspects of bicycle paths are important for cyclists when deciding to cycle and/or selecting a specific regional cycling route?

Moreover, the increased use of regional bicycle paths has resulted into an increase in accidents. Figures from regional and nation authorities show that the difference in share of accidents inside and outside urban areas is becoming smaller (Schoon & Bos, 2002; VeiligheidNL & Rijkswaterstaat, 2017; Krul et al, 2018), indicating the rise of regional biking accidents. Here, often occurring accidents are the so-called Single-Bicycle crashes like a fall or obstacle collision (Schepers & Klein Wolt, 2012). Thus, an important factor for improving safety on these regional bike paths could be the design of the path itself.

Figure 1 Example of bicycle path outside urban area

When designing bicycle facilities several aspects have to be considered. The Dutch knowledge organization CROW (2016) defined five basic requirements bicycle paths have to meet: coherence, directness, safety, attractiveness, and comfort. However, these requirements were more specifically set up with urban areas in mind. According to Hendriks et al (2016) regional bicycle routes have to be direct, safe, and comfortable routes to support daily use by students and commuters. Additionally, Heinen et al (2011) concluded that commuters base their decision to cycle on 'direct benefits' in term of time, comfort, and flexibility. Furthermore, Ayachi et al (2015) concluded that cyclists consider comfort as an important aspect when looking at

performance of cycling, with safety also playing a considerable role. In line with this finding, Xing et al (2018) found in their study that cyclists' perception of comfort and safety plays an important role to the degree to which individuals enjoy cycling. Investigating bicycle use in everyday commuting, Biernat et al (2018) showed similar findings in Poland with respect to comfortability of bicycle routes. Finally, Schepers et al (2017) concluded that low cycling speed contributed to a higher level of cycling safety. Together, these studies appear to agree that comfort and safety related factors are most relevant to the user experience of regional bicycle paths. However, how cyclists evaluate additional general aspects (clarity and speed) and more specific, design related aspects of regional bicycle paths remains largely unknown.

From the literature, it appears that a trade-off between various bicycle path related aspects is rarely investigated. The same is true for comparing perceptions of different groups of bicyclists (DiGioia et al, 2017). This paper aims to provide insights into cyclists' preferences regarding various bicycle path related aspects with special attention to regional bicycle paths. In addition, the paper presents the application of pairwise comparison and some details regarding different types of bicyclists. The topic is part of a broader exploration of cyclists' preferences regarding separate bicycle paths outside urban areas (Van der Waerden, 2018). The remainder of this paper is organized as follows. First, the adopted research approach will be outlined. Next, attention is paid to the data collection and the composition of the sample. The following section presents the results of the analyses. The papers ends with the conclusions, limitations of the study, and recommendations for practice and future research.

Research approach

To find out what aspects of regional bicycle paths are important for cyclists, two pairwise comparisons are set up (Saaty, 1990; Teknomo, 2006). The first comparison included four general aspects that are based on the basic requirements of CROW (2016), the literature described above, and on previous studies conducted by the Urban Planning and Transportation group of Eindhoven University of Technology (Van der Waerden et al, 2004; Van der Waerden et al, 2011; Van Overdijk et al, 2015): Safety, Clarity, Comfort, and Speed (Figure 2). In addition, a comparison is created including four design related aspects: Road marking, Street lighting, Pavement, and Greening (Figure 3). While comparing two aspects, respondents were invited to indicate what aspect they consider as more important when cycling on regional bicycle path.

Hieronder ziet u steeds twee aspecten die te maken hebben met uw beoordeling van fietsroutes. Geef aan welk aspect u belangrijker vindt bij het beoordelen van een fietsroute buiten de bebouwde kom.

Korte uitleg: Vindt u een aspect aan de linker zijde het belangrijkst, kies dan een optie links van het midden in de tabel. Vindt u een aspect aan de rechter zijde het belangrijkst, kies dan een optie rechts van het midden in de tabel. Vindt u beide aspecten even belangrijk, klik dan op het middelste rondje.

ASPECT 1	Heel belangrijk	Belangrijk	Gelijk belang	Belangrijk	Heel belangrijk	ASPECT 2
Veiligheid	○	○	◉	○	○	Duidelijkheid
Comfort	○	○	◉	○	○	Snelheid
Duidelijkheid	○	○	◉	○	○	Comfort
Snelheid	○	○	◉	○	○	Veiligheid
Comfort	○	○	◉	○	○	Veiligheid
Snelheid	○	○	◉	○	○	Duidelijkheid

Figure 2 Pairwise comparison, general aspects

Figure 3 Pairwise comparison, design related aspects

Data

The pairwise comparisons were included in an extensive online questionnaire consisting of four groups of questions. The first group of questions focused on the respondents' experiences with cycling and bicycle paths outside the urban area. The second group of questions included the two pairwise comparisons discussed in this paper. The third group of questions covered a stated choice experiment regarding bicyclists' preferences of bicycle path marking (van der Waerden et al, 2020). The questionnaire concluded with some questions regarding the respondents' personal characteristics: gender, age, and educational level.

In February 2018, invitations to fill out the questionnaire were sent to members of an online panel provided by PanelClix, an organization specialized in online marketing research (www.panelclix.nl). The invitations were sent to the members without any preselection. The first two questions of the questionnaire took care of selecting only members who are familiar with cycling in general and cycling on regional bicycle paths in particular. The data of 416 respondents are used in the analyses presented in this paper. Some details of these respondents can be found in Table 1. The percentages show a reasonable distributed sample, more or less following the composition and experiences of the Dutch population.

Table 1 Overview of some sample statistics (N=416)

Characteristics	Levels	Frequency	Percentage
Gender	Female	226	54.3
	Male	190	45.7
Age	Younger than 35 years	138	33.5
	36-53 years	149	35.8
	54years and older	129	31.0
Education	Medium level education	142	34.1
	High level education	274	65.9
Cycling frequency	Sometimes	230	55.3
	Regularly	186	44.7
Cycling distance	10 kilometer or less	171	41.1
	11-50 kilometer	165	39.7
	More than 50 kilometer	80	19.2
Cycling with children	Never	111	26.7
	Sometimes	237	57.0
	Regularly	68	16.3
Bicycle type	Standard bike	312	75.0
	Other	104	25.0

Analyses

The respondents evaluated all aspects in two separate pairwise comparisons (see before). These evaluations are analyzed using the method presented in Teknomo (2006). First, per respondent an importance score for each aspect is calculated. After this calculation, the importance score is checked on consistency using a consistency ratio. This ratio tests if a respondent is consistent in his/her evaluation. Therefore, the ratio can be used as an indication of how well the participant understood the comparison task, or how seriously it was filled in. Respondents who were not consistent in their evaluations were thus removed from further analyses.

The average importance scores for the remaining sample are shown in Figure 4. It appears that Safety has the highest average importance score, followed by clarity. An Analysis-of-Variance (ANOVA) test shows that the average importance scores of the aspects differ significantly (F-value 508.030 with significance 0.000). The partial Eta squared (0.479) provided by SPSS shows a medium effect size (Cohen, 1988).

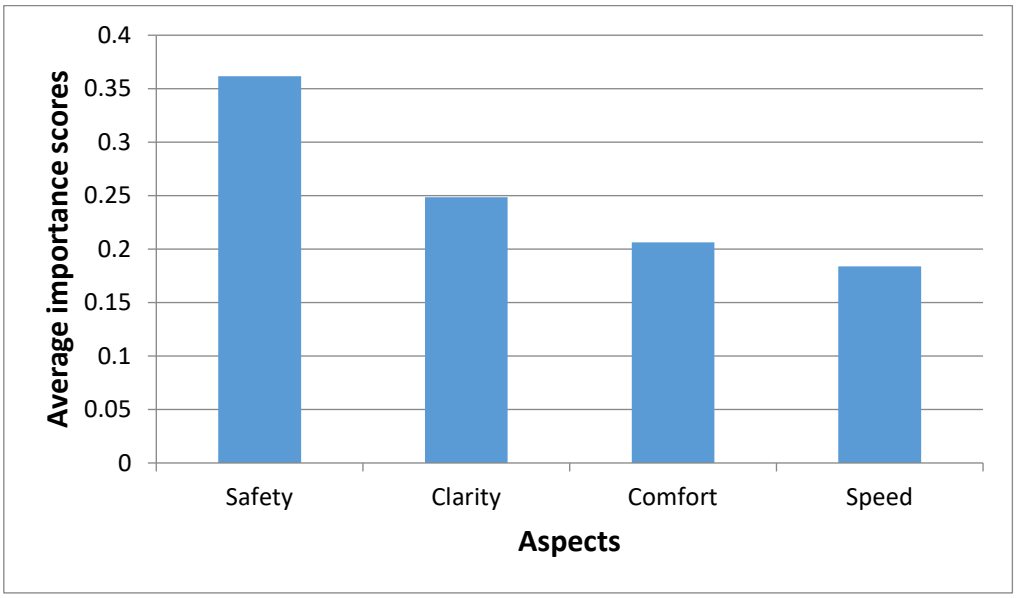


Figure 4 Average importance scores of the general aspects (N=416)

Figure 5 shows the average importance scores of the design related aspects. Respondents evaluated lighting as most important followed by pavement and marking. It is clear that greenery is evaluated as least important. The average importance scores differ significantly (ANOVA test: F-value 298.115, significance 0.000). Also in this case, the partial Eta squared (0.352) provided by SPSS shows a medium effect size (Cohen, 1988).

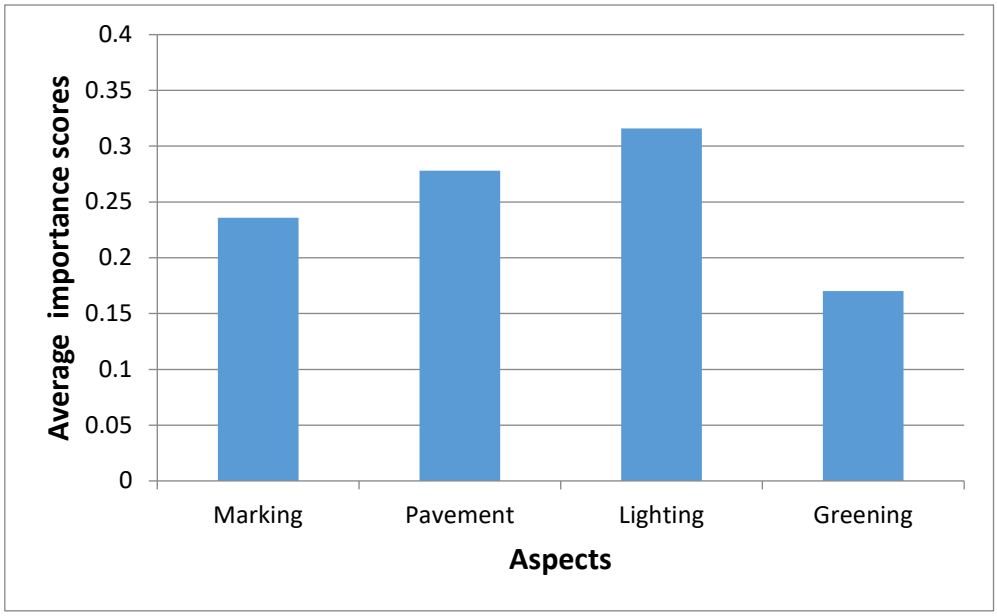


Figure 5 Average importance scores of the design related aspects (N=413)

The next step of the analyses includes a more detailed look at the average importance scores. Per aspect, differences in average importance scores between groups of respondents are tested using Analysis-of-Variance (ANOVA). The results of the tests are presented in Tables 2 and 3. Regarding the test results of the general aspects, it appears that the characteristics gender, education, cycling with children and bicycle types show significant (at 95 percent confidence level) differences when looking at the average important scores (Table 2).

Table 2 ANOVA test results, general aspects

General aspect	Background	F-value	Significance
Safety	**Gender**	18.621	0.000***
	Age	0.469	0.626
	Education	0.449	0.503
	Cycling frequency	0.077	0.782
	Cycling distance	0.214	0.807
	Cycling with children	0.890	0.411
	Bicycle type	0.411	0.522
Clarity	Gender	0.875	0.350
	Age	1.515	0.221
	Education	3.230	0.073
	Cycling frequency	0.185	0.668
	Cycling distance	1.466	0.232
	Cycling with children	0.057	0.945
	Bicycle type	5.414	0.020*
Comfort	Gender	3.846	0.051
	Age	2.918	0.055
	Education	4.522	0.034*
	Cycling frequency	0.006	0.937
	Cycling distance	0.227	0.797
	Cycling with children	3.187	0.042*
	Bicycle type	5.275	0.022*
Speed	**Gender**	21.612	0.000***
	Age	5.668	0.004**
	Education	7.574	0.006**
	Cycling frequency	0.483	0.487
	Cycling distance	0.359	0.698
	Cycling with children	0.856	0.426
	Bicycle type	0.233	0.629

*Significances at * p<0.05; ** p<0.01, and *** p<0.001 respectively*

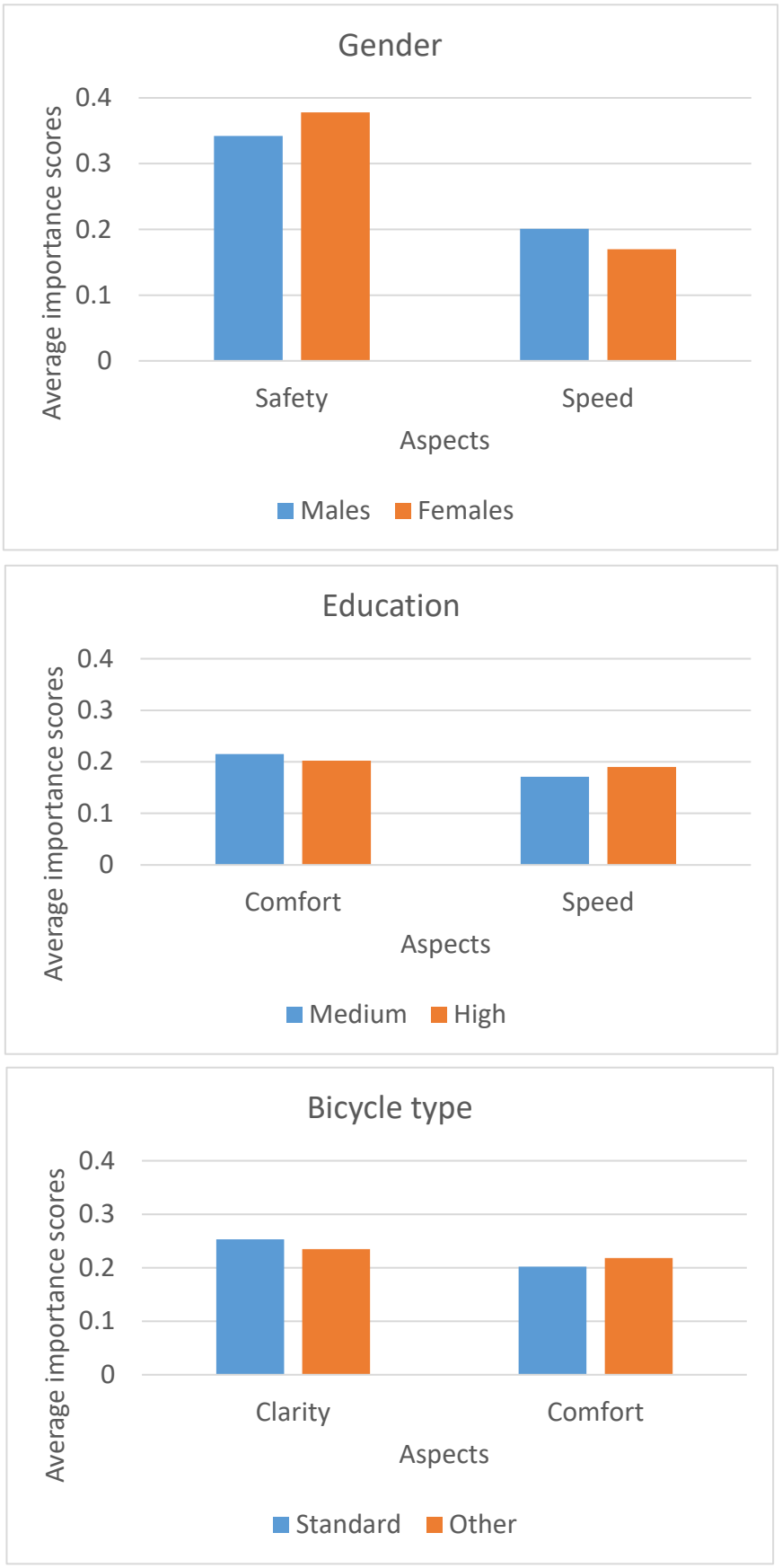


Figure 6 Details of general aspects and background characteristics

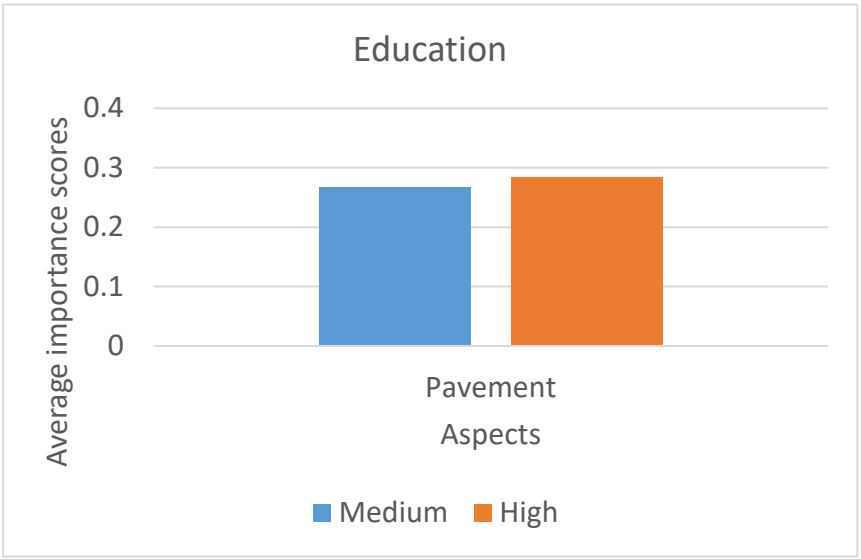
Table 3 ANOVA test results, design related aspects

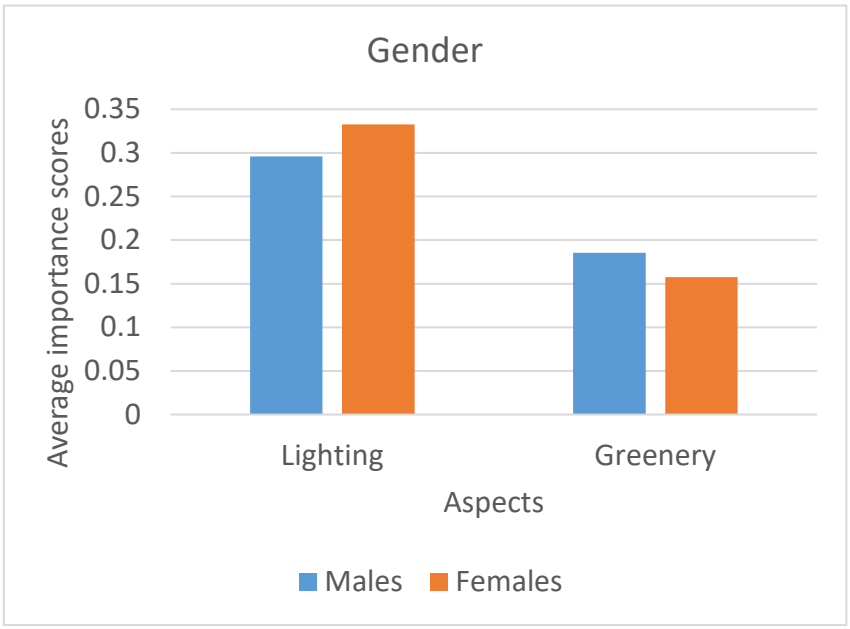
Design aspect	Background	F-value	Significance
Marking	Gender	0.009	0.926
	Age	0.546	0.580
	Education	3.009	0.084
	Cycling frequency	0.435	0.510
	Cycling distance	0.380	0.684
	Cycling with children	0.463	0.630
	Bicycle type	4.193	0.041*
Pavement	Gender	1.713	0.191
	Age	0.813	0.444
	Education	4.482	0.035*
	Cycling frequency	2.363	0.125
	Cycling distance	1.117	0.328
	Cycling with children	0.233	0.792
	Bicycle type	0.677	0.411
Lighting	**Gende**r	21.101	0.000***
	Age	0.345	0.709
	Education	1.195	0.275
	Cycling frequency	3.055	0.081
	Cycling distance	0.634	0.531
	Cycling with children	0.001	0.999
	Bicycle type	0.749	0.387
Greenery	**Gender**	16.552	0.000***
	Age	0.161	0.851
	Education	0.459	0.498
	Cycling frequency	0.035	0.851
	Cycling distance	0.174	0.840
	Cycling with children	1.141	0.320
	Bicycle type	0.000	0.983

*Significances at * p<0.05; ** p<0.01, and *** p<0.001 respectively*

A more detailed look at the differences provides the following insights (Figure 6). For gender, the results show that in the case of the aspects safety and speed, the average important scores of females differ significantly from the average importance scores of males. The difference shows that women consider safety as more important than males, while males consider speed as more important. In the case of education, the results show that participants with a medium level of education consider comfort more important than highly educated respondents do. For the aspect speed, the opposite is true; it is evaluated as more important by the high education group.

The test results regarding the design related aspects are presented in Table 3. The background characteristics bicycle type, education and gender show differences on design related aspects. More specifically, respondents using a standard bicycle evaluate marking as more important than respondents using another type of bicycle. In addition, respondents with a high education level evaluate pavement as more important than respondents with a medium education level. Gender differences show that females evaluate lighting as more important than males, while males evaluate greenery as more important.





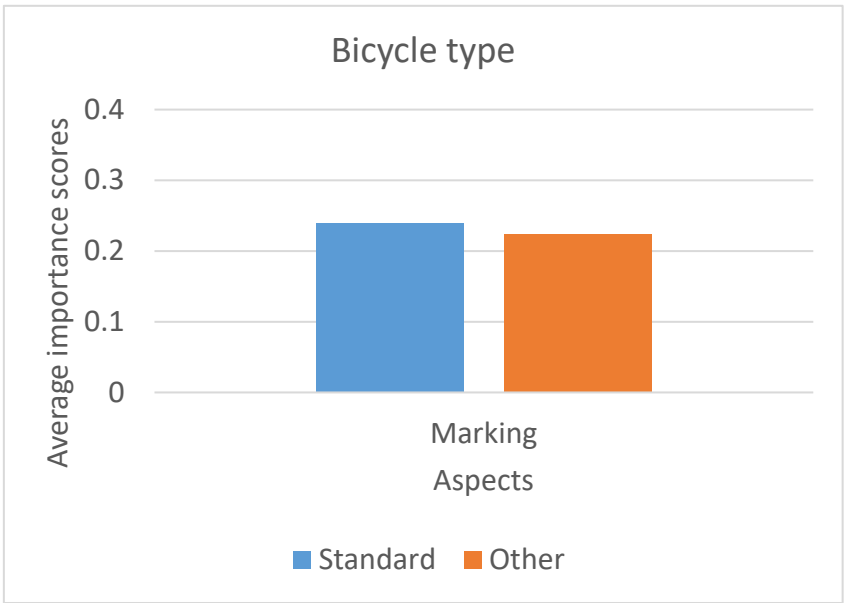


Figure 7 Details of design aspects and background characteristics

Conclusions

This paper presents some insights into bicyclists' preferences regarding several general and design related aspects of bicycle paths outside urban areas. The preferences are retrieved using a pairwise comparison method where bicyclists are invited to evaluate sets of two aspects and indicate the importance of each aspect relatively to the other. The pairwise comparison shows that bicyclists evaluate the general aspect 'Safety' as most important. It is also appears that women evaluate 'Safety' as more important than men do. In line with this, the aspect 'Lighting' is evaluated as most important design related aspect. Again, women evaluate it as more important than men.

In correspondence with the existing literature, safety proved to be a very important factor for the user experience of regional bicycle paths (e.g., Xing et al, 2018). Surprisingly, comfort is deemed much less important, even though it is arguably the most common user experience factor in previous studies (e.g., Ayachi et al, 2015). A possible explanation for these findings could be that comfort is a more accessible concept (comfort being more top-of-mind for cyclists), while the direct confrontation with both factors emphasizes the importance of safety. Future studies could further investigate the relation between concepts of safety and comfort and their importance in the context of regional bicycle paths.

In terms of physical design aspects of regional bicycle paths, greening turns out the least important feature which is in accordance to previous findings in Van der Waerden et al, (2004) and Snizek et al, (2013). The other aspects, the most important being lighting, play a bigger role in cyclists' evaluation of regional paths. These design related results appear to be congruent with the general factors, as it makes sense that lighting would contribute to safety and greening more to comfort (Van der Waerden et al, 2004). Including personal characteristics confirms this notion, showing that women evaluate both safety and lighting as more important than men do. However, it should be noted that a direct link between the presence of lighting and safety cannot be established based on present results alone. Further research should thus aim to investigate what the direct relations between design aspects and general evaluations of regional cycle paths are, starting with lighting and safety. For practice, the findings of this study indicate that designers should focus especially on safety and lighting when designing bicycle paths outside urban areas. More practically oriented future studies could investigate which specific (physical) measures best fulfill the general requirements for regional bicycle paths.

With the increasing use of regional bicycle paths, this study suggests that safety is crucial. Different types of cyclists do appear to value bicycle path characteristics differently, indicating there might not be one solution that fits with all individual preferences. However we choose to deal with the increased use of these types of regional pathways, safety should always come first.

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