Quantifying the Negative Impact of Interactions Between Users of Pedestrians-Cyclists Shared Use Space

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Abstract. In recent years, many efforts are being made for the promotion of active modes of transport. Due to this reason, as well as due to the limited available public space, the co-existence of pedestrians and cyclists is a very common phenomenon, which requires extensive investigation. The design and implementation of pedestrians-cyclists shared use space is a widely used technical choice, when the road infrastructure is unsuitable for hosting cyclists and thus the separation of cyclists from the motorized traffic is considered advisable. However, the co-existence of pedestrians and cyclists is not always harmonious and the interactions between them can have a negative impact in their perceived comfort and safety. The present research aims to quantify this negative impact of the various kinds of interactions, by considering the users' attitudes and by applying the Analytical Hierarchy Process method. The attitudes of users were captured through questionnaire surveys, that were directed to both pedestrians and cyclists in the city of Palermo, Italy. The results of the analysis are being compared with the results of a previous attempt to quantify the impact of interactions. Through this comparison, useful conclusions and notes for further research are deriving.

Keywords: Pedestrians · Cyclists · Shared space · Analytical Hierarchy Process (AHP)

1 Introduction

One of the main transport policy aims in European level is the promotion of walking and cycling for commuting [1, 2]. The prioritization of this aim is attributed to the fact that walking and cycling provide significant benefits in terms of health, well-being, environment and economy [3–8]. However, in order to achieve this goal, appropriate infrastructures within cities should be developed. To facilitate the design and management of transport infrastructures, it is crucial to use methodologies for their

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evaluation. The most widespread scale for measuring the satisfaction that a transport system or infrastructure provides to the users and therefore to assess them, is the level of service (LOS), which takes values from A to F; LOS A expresses the higher level of satisfaction and LOS F expresses the lowest level of satisfaction [9].

For the assessment of pedestrians' and cyclists' infrastructures various methodologies have been proposed. Some of these methodologies are based on quantitative characteristics of the infrastructure [9–11], other methodologies are based on qualitative characteristics [12–15] and there are also other methodologies that combine quantitative and qualitative characteristics of the infrastructure [16, 17]. Also, many studies apply microsimulation tools for the evaluation of pedestrian infrastructures [18–20].

Concerning the assessment of infrastructures that are being used equally by pedestrians and cyclists, i.e. pedestrians-cyclists shared spaces, a notable methodology is the one that has been proposed by Botma [21], which was later incorporated in the Highway Capacity Manual. Botma's methodology proposes the hindrance concept, where pedestrians' and cyclists' perceived hindrance can be expressed by the "events", that is the interactions between the shared-use infrastructures' users. Botma defined two types of events, the meetings and the passings (or overtakings) and the main assumption of his methodology was that overtakings have twice a negative impact to the users comparing with the meetings. A recent study attempted to investigate this negative impact and to cover this research gap, by conducting questionnaire surveys in both pedestrians and cyclists in the city of Thessaloniki, Greece [22].

The present paper aims to examine the negative impact of the interactions between the pedestrians-cyclists shared-use infrastructures' users, in the city of Palermo, Italy. The examination of the impact of these phenomena can provide an answer in the research question "Can the quantified negative impact of the events that was computed in the city of Thessaloniki be considered as global or the negative impact of the events differs from country to country, or even from city to city?".

2 Methodology

Based on an extension of Botma's definition of events, which was proposed by Hummer et al. [23], there are six possible types of events that a pedestrian can experience in a shared-use infrastructure:

- Face-to-face interaction (meeting) with another pedestrian
- Face-to-face interaction (meeting) with a cyclist
- Interaction while overtaking (passing) another pedestrian
- Interaction while a pedestrian is being passed by another pedestrian
- Interaction while a pedestrian is being passed by a cyclist
- Delayed passing

and six types of events that a cyclist can experience in a shared-use infrastructure:

- Face-to-face interaction (meeting) with a pedestrian
- Face-to-face interaction (meeting) with another cyclist
- Interaction while passing a pedestrian

- Interaction while passing another cyclist
- Interaction while a cyclist is being passed by another cyclist
- Delayed passing.

These event types are presented in Fig. 1; where the upper sketches present the meetings, sketches (d), (e), (f) the overtakings and the last sketch express the delayed passing (this event describes a situation when a user wants to pass another user or a group of users, but he/she is forced to reduce his/her speed and wait behind people due to high users' density in the infrastructure).

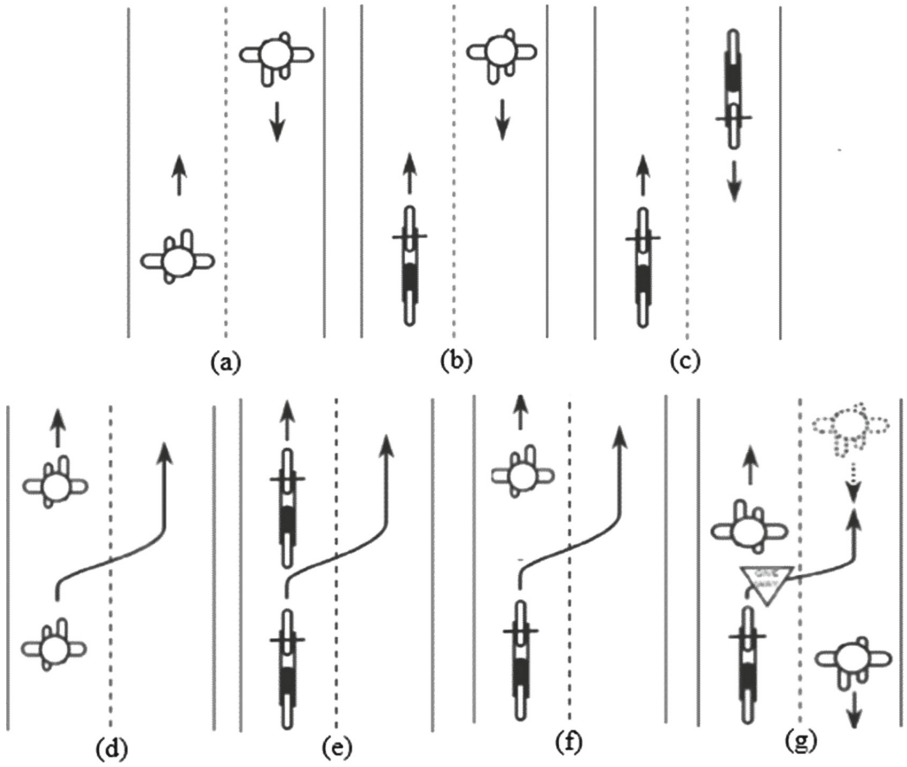

Fig. 1. Graphical presentation of the events between users of pedestrians '-cyclists' shared-use infrastructures (adapted from: [24]).

For the quantification of the negative impact of the abovementioned event types, taking into account the users' attitude, several methods for assigning weights can be used. Examples include the Analytical Hierarchy Process (AHP) [25, 26], the Conjoint Analysis (CA) [27], the Potentially All Pairwise RanKings of all possible Alternatives (PAPRIKA) [28] methods. Based on the selection of the weighting method, the questionnaire is being developed. In the present paper, the AHP method was selected in order to be consistent with the previous attempt of assigning weights to the events [22]

and to ensure that possible differences are not a result of the selected method. In addition, for keeping the consistency between the two studies, as well as to keep the questionnaires brief, it was opted to include only eight pairwise comparisons in the questionnaires and to examine the additional seven pairwise comparisons indirectly, through the transitivity rule. In these pairwise comparisons the users had to evaluate the negative impact in terms of comfort and safety, of one event type in comparison with the negative impact of another event type. The responses were then analyzed through descriptive statistics and through AHP techniques for computing the weights.

3 Description of the Undertaken Research

3.1 Study Area

The analysis focuses in the city of Palermo, Italy. The city of Palermo which has over 600,000 inhabitants and a large percentage of tourists has undergone a transformation from the point of view of mobility in the last decade, applying some strategies aiming to reduce noise and environmental pollution, as well as to enhance the attractiveness of the historic center. Among the strategies that the Local Administration applied, notable is the pedestrianization of via Maqueda and the orthogonal area called Cassaro, that goes from the Cathedral to the port area. These strategies have led to greater use of shared mobility and micro-mobility, with the presence of scooters and mono-wheels. Generally, there are about 27 cycle routes scattered throughout the city of Palermo and its province with slopes varying between 5 and 28%. In the historical center there are currently about 17 km of cycle paths.

In the city of Palermo there is a historic and important street, which is called Via Maqueda and it is also known as la Strada Nuova. Via Maqueda has over the years seen a radical transformation from a road completely for vehicular use into a pedestrian-only street. The under-study section is above all a Limited Traffic Zone (Zona a Traffico Limitato – ZTL), where vehicle transit is guaranteed only during specific hours for loading and unloading of goods in favor of commercial activities. Three years ago, a one-way cycle lane was established from Piazza Verdi towards the Quattro Canti. In this section, many conflicts between pedestrians and cyclists are being observed, provoking controversy on several occasions. For years this area had suffered from a slow downturn that has stopped, since a few years ago (around 2015) car traffic was restricted. At the same time, various commercial and restaurant activities have arisen, promoting trade in this area. Also, this street is about 1.5 km long and runs along many historical and architectural sights and has become a significant destination for tourists and many citizens who prefer using it either for work or leisure during all days of the week. At this time, Via Maqueda is a shared space (see Fig. 2), which is regularly being used by micro-mobility vehicles and classic bicycles or bicycles with pedal assistance.



Fig. 2. Snapshots from via Maqueda.

3.2 Data Collection

Researchers utilized a questionnaire from a previous study [22] and they adapted it in order to keep it brief and comprehensive. The main aim of the questionnaire is to capture the attitudes of the shared space users concerning the impact that the various events have on their comfort and safety (as perceived by them). To achieve this several pairwise comparisons between the different events were included. Also, through the questionnaire the demographic characteristics of the users, as well as their opinion about the level of service of the infrastructure and the possibility of sharing the same space without segregating pedestrians and cyclists were captured.

The questionnaire survey was carried out between 16th of January and 28th of February 2020, with the method of face-to-face interviews. This method was considered appropriate, since the clarifications to the users about the pairwise comparisons were necessary. Finally, 275 valid questionnaires were gathered by pedestrians and 210 valid questionnaires were gathered by cyclists, who were using the Via Maqueda street.

4 Survey Results

4.1 Descriptive Statistics

Pedestrians' Questionnaires. The sample of pedestrians is approximately equally distributed regarding gender, since 52.7% of the respondents are male and 47.3% are

female. The sample is also well distributed concerning the age of the respondents, since 28.9% of them are aged between 25 and 39 years old, 29.7% are aged between 40 and 54 years old, 27.8% are aged between 55 and 64 years old and 13.6% are older than 64 years old. The 35.4% of the respondents use the via Maqueda every day and an additional 35.4% use the specific infrastructure at least one time per week. Regarding the level of service (LOS) that the pedestrians perceive when using the specific infrastructure, the most popular answer is D (44.4%). Only 1.1% of the sample perceive LOS B or greater, while 40.4% of the sample perceive LOS E or lower.

Cyclists' Questionnaires. The sample of cyclists is unequally distributed between males (71.4%) and females (28.6%). This difference in the percentages may indicate that males are much more likely than females to use bicycle for their daily trips; as this is usually the case in countries where cycling in not a popular mode of transport [29–31]. The age distribution of the cyclists' sample also follows a different pattern comparing with the one of pedestrians' sample. The 12.4% of the respondents are aged between 25 and 39 years old, 25.2% are aged between 40 and 54 years old, 51.4% are aged between 55 and 64 years old and 11% are older than 65 years old. In contrast with pedestrians, only 4.3% of the cyclists' sample use via Maqueda daily with a bicycle, but an additional 32.9% cycles in the specific infrastructure at least one time per week. Regarding the cyclists' perceived satisfaction, extremely low LOS were stated. More specifically, any of the cyclists of the sample stated LOS A or LOS B, while just 1 (0.5%) cyclist stated LOS C. On the other hand, a strong 95.2% of cyclists perceive an unacceptable LOS (45.2% perceive LOS E and 50% perceive LOS F). The negative assessment of via Maqueda is attributed to the fact that pedestrians occupy a large portion of the street and therefore cyclists often have to wait behind people, reduce their speed and make maneuvers through the crowd.

4.2 Assignment of Weights

Weights from Pedestrians' Viewpoint. Through the use of the transitivity rule and the application of the AHP techniques, weights were computed and assigned to the various event types (see Table 1). It can be understood that pedestrians perceive higher annoyance when they are being passed by a cyclist. "Delayed passing" and "meeting a cyclist" were also considered very annoying situations when walking in the shared-use infrastructure. Finally, the event types that concern interaction with another pedestrian (i.e. being overtaken by another pedestrian, meeting another pedestrian, overtaking another pedestrian) were found less annoying.

Weights from Cyclists' Viewpoint. The corresponding procedure for analyzing the responses in the pairwise comparisons was also made for the sample of cyclists. The obtained results for the events' weights from cyclists' viewpoint are presented in Table 2. It can be seen that both "delayed passing" and "passing a pedestrian" create great annoyance to cyclists when using a shared-use infrastructure. "Passing another cyclist" and "meeting a pedestrian" are also two undesired situations for cyclists. On the other hand, the event types "being passed by another cyclist" and "meeting a cyclist" turned out to be less annoying.

Table 1. Assignment of weights from pedestrians' viewpoint.

Event type	Weight
Being passed by a cyclist	0.26
Delayed passing	0.20
Meeting a cyclist	0.18
Being passed by another pedestrian	0.13
Meeting another pedestrian	0.13
Pass another pedestrian	0.10

Table 2. Assignment of weights from cyclists' viewpoint.

Event type	Weight
Delayed passing	0.21
Passing a pedestrian	0.21
Passing another cyclist	0.19
Meeting a pedestrian	0.18
Being passed by another cyclist	0.13
Meeting another cyclist	0.08

5 Discussion and Conclusions

The identification and the quantification of the negative impact of the various types of events on pedestrians' and cyclists' perceptions is essential for the development of reliable methodologies that attempt to capture the LOS of the infrastructures, that are being used by different user types. Before the present paper the only research that attempted to assign weights in the different event types was carried out in the city of Thessaloniki, Greece [22]. Thus, the main objective of the present paper is to investigate if the weights that were computed in the case of Thessaloniki can be generalized or they are different per country, or even per city.

Both similarities and differences can be identified by comparing the events' weights in the city of Palermo with those in the city of Thessaloniki. The most important similarity is that pedestrians tend to be more annoyed by interactions which involve cyclists, and cyclists tend to be more annoyed by interactions which involve pedestrians. The enhancement of this conclusion by the present paper makes clear that the co-existence of different types of users is not always harmonious, due to their different characteristics (e.g. mass, speed, unpredictable change of direction). Thus, when designing shared-use infrastructures, appropriate measures are needed for minimizing the interaction points and more importantly the conflict points between pedestrians and cyclists. In addition, the results from Palermo provide more evidence that Botma's assumption, i.e. overtakings negative impact is twice stronger than that of meetings, cannot be considered valid, at least for some cases. It seems that overtakings have

slightly more strong negative impact comparing to meetings, but not as much as Botma assumed.

On the other hand, the main difference in the results from the two cities concern the "delayed passings". In contrast with the results from Thessaloniki, where the "delayed passings" were found to be by far the most annoying event type for both pedestrians and cyclists, the results from Palermo indicate that this event is indeed much undesired by the shared-use infrastructure users, but its' quantified negative impact is close enough to the quantified negative impact of other event types. This difference in the results in the two cities, could possibly indicate a difference in shared space users' perceptions, based on the culture, habits and infrastructure attributes.

For the facilitation of the evaluation of pedestrians-cyclists shared-use infrastructures through the usage of appropriate methodologies, it is essential to identify standard values, which will express the various event types' weights, in terms of the negative impact on the perceived comfort and safety of pedestrians and cyclists. In order to achieve this, the conduction of similar surveys and analyses in other countries is necessary. This process can provide globalized values that are well adapted to the results of the different individual countries, or it can alternatively provide values that are well adapted to clusters of countries if it is considered preferable to group countries on the basis of their mobility and infrastructure characteristics.

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References

1. COM (2011) 144: White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. European Commission, Brussels (2011)
2. Campisi, T., Acampa, G., Marino, G., Tesoriere, G.: Cycling master plans in Italy: the I-BIM feasibility tool for cost and safety assessment. Sustainability **12**(11), 4723 (2020)
3. Oja, P., et al.: Health benefits of cycling: a systematic review. Scand. J. Med. Sci. Sport. **21**(4), 496–509 (2011)
4. Singleton, P.: Walking (and cycling) to well-being: modal and other determinants of subjective well-being during the commute. Travel Behav. Soc. **16**, 249–261 (2018)
5. Vaitsis, P., Basbas, S., Nikiforiadis, A.: How eudaimonic aspect of subjective well-being affect transport mode choice? The case of Thessaloniki, Greece. Soc. Sci. **8**(1), 9 (2019)
6. Litman, T.A.: 2017. Evaluating active transport benefits and costs. guide to valuing walking and cycling improvements and encouragement programs. Prepared for Victoria Transport Policy Institute (2017)
7. Blondiau, T., van Zeebroeck, B., Haubold, H.: Economic benefits of increased cycling. Trans. Res. Proc. **14**, 2306–2313 (2016)

8. Ignaccolo, C., Giuffrida, N., Torrisi, V.: The queensway of New York city, a proposal for sustainable mobility in queens. In: Pezzagno, M., Tira, M. (eds.) Town and Infrastructure Planning for Safety and Urban Quality: Proceedings of the XXIII International Conference on Living and Walking in Cities (LWC 2017), CRC Press, Boca Raton (2018)
9. HCM 2010: Highway Capacity Manual. Washington, D.C.: Transportation Research Board (2010)
10. Landis, B.W., Vattikuti, V.R., Ottenberg, R.M., McLeod, D.S., Guttenplan, M.: Modelling the roadside walking environment: A pedestrian level of service. Transportation Research Record 1773, TRB. Washington, D.C: National Research Council (2001)
11. Tan, D., Wang, W., Lu, J., Bian, Y.: Research on methods of assessing pedestrian level of service for sidewalk. J. Transp. Syst. Eng. Inf. Technol. **7**(5), 74–79 (2007)
12. Dixon, L.: Bicycle and pedestrian level-of-service performance measures and standards for congestion management systems. Transportation Research Record 1538, TRB. Washington, D.C: National Research Council (1996)
13. Jaskiewicz, F.: Pedestrian level of service based on trip quality. transportation research circular, Transportation Research Board. National Research Council, Washington D.C (2000)
14. Asadi-Shekari, Z., Moeinaddini, M., Zaly Shah, M.: A pedestrian level of service method for evaluating and promoting walking facilities on campus streets. Land Use Policy **38**, 175–193 (2014)
15. Frazila, R.B., Zukhruf, F., Ornando Simorangkir, C., Burhani, J.T.: Constructing pedestrian level of service based on the perspective of visual impairment person. In: MATEC Web of Conferences vol. 270, pp. 03009 (2019)
16. Mōri, M., Tsukaguchi, H.: A new method for evaluation of level of service in pedestrian facilities. Transp. Res. Part A Gen. **21**(3), 223–234 (1987)
17. Nikiforiadis, A., Basbas, S.: Can pedestrians and cyclists share the same space? The case of a city with low cycling levels and experience. Sustain. Cities Soc. **46**, 101453 (2019)
18. Campisi, T., Basbas, S., Canale, A., Tesoriere, G., Nikiforiadis, A., Vaitsis, P.: Sensitivity analysis and the alternative optimization of the pedestrian level of service: some considerations applied to a pedestrian street in Greece. In: XXIV International Conference Living and Walking in Cities, Brescia, Italy (2019)
19. Amprasi, V., Politis, I., Nikiforiadis, A., Basbas, S.: Comparing the microsimulated pedestrian level of service with the users' perception: the case of Thessaloniki, Greece, coastal front. In: 2nd International Congress on Transport Infrastructure and Systems in a changing world, Rome, Italy (2019)
20. Basbas, S., Campisi, T., Canale, A., Nikiforiadis, A., Gruden, C.: Pedestrian level of service assessment in an area close to an under-construction metro line in Thessaloniki, Greece. In: 2nd International Congress on Transport Infrastructure and Systems in a changing world, Rome, Italy (2019)
21. Botma, H.: Method to determine level of service for bicycle paths and pedestrian-bicycle paths. Transp. Res. Rec. **1502**, 38–44 (1995)
22. Garyfalou, I.M., Meintanis, I., Papas, T., Trouva, M., Nikiforiadis, A., Basbas, S.: Application of the Analytical Hierarchy Process for the investigation of the impact of different event types on the safety and comfort of pedestrians and cyclists in shared-use infrastructures. In: 9th International Congress on Transportation Research, Athens, Greece (2019). (in Greek)
23. Hummer, J., et al.: User perceptions of the quality of service on shared paths. Transp. Res. Rec. **1939**, 28–36 (2005)
24. Fowler, M., Lloyd,W., Munro, C.: Technical Paper e Shared Path Widths. IPENZ Transportation Group Conference Christchurch (2010)

25. Saaty, T.L.: The Analytic Hierarchy Process. McGraw-Hill, New York (1980)
26. Ignaccolo, M., Inturri, G., García-Melón, M., Giuffrida, N., Le Pira, M., Torrisi, V.: Combining Analytic Hierarchy Process (AHP) with role-playing games for stakeholder engagement in complex transport decisions. Transp. Res. Proc. **27**, 500–507 (2017)
27. Green, P., Srinivasan, V.: Conjoint analysis in consumer research: issues and outlook. J. Consum. Res. **5**, 103–123 (1978)
28. Hansen, P., Ombler, F.: A new method for scoring additive multi-attribute value models using pairwise rankings of alternatives. J. Multi Criteria Decis. Anal. **15**, 87–107 (2009)
29. Heinen, E., van Wee, B., Maat, K.: Commuting by bicycle: an overview of the literature. Transp. Rev. **30**, 59–96 (2010)
30. Pojani, D., Bakija, D., Shkreli, E., Corcoran, J., Mateo-Babiano, I.: Do Northwestern and Southeastern Europe share a common "Cycling Mindset"? Comparative analysis of beliefs toward cycling in the Netherlands and the Balkans. Eur. J. Transp. Infrastruct. Res. **17**, 25–45 (2017)
31. Prati, G.: Gender equality and women's participation in transport cycling. J. Transp. Geogr. **66**, 369–375 (2018)