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Transportation Research Procedia 82 (2025) 2964–2975

Transportation Research Procedia

www.elsevier.com/locate/procedia

16th World Conference on Transport Research (WCTR 2023)

Cyclist-Pedestrian Cohabitation : Lessons to learn from a pilot project on pedestrians streets in Montréal (Canada)

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Abstract

Among Montreal pedestrian streets summer projects in 2021, two locations (Mont-Royal Avenue and Wellington Street) have set up a pilot project considering the cohabitation between pedestrians and cyclists by authorizing cyclists to stay on their bike at a slow pace while it's forbidden on other pedestrian streets. This paper aims to document this cohabitation at three specific sites (two where cyclists are permitted and one where they are not) based on observations of cyclist's behaviours and their interactions with pedestrians. Direct observations of cyclists (n=1371) were conducted through a grid regrouping items about cyclist characteristics, actions and interactions with a pedestrian. The results show that cyclists' behaviours are fairly predictable and one third of them were involved in an interaction with a pedestrian. For the small number of cyclists who engaged in unsafe behaviours, young males and other vehicle types (i.e., Segways, rollerblades, cargo bikes, etc) are overrepresented.

Keywords: pedestrian streets; cyclist; interactions; cohabitation

1. Introduction

Cities can play a role in reclaiming public spaces for purposes other than motorized traffic. As a result, many jurisdictions have experimented different options over the past decade. The City of Montréal, Canada, is one of the cities that, as early as 2015, implemented an initiative to increase the number of public spaces dedicated to pedestrians. This Pedestrian and Shared Streets Implementation Program was inspired by the "small steps" approach to transforming streets into public spaces by involving the communities in the targeted neighbourhoods and thus promoting walking and socialization (City of Montréal, 2016).

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10.1016/j.trpro.2024.12.230

The social distancing measures resulting from the 2020 pandemic, combined with the knowledge and insights gained from this program, have led to a deeper reflection on the idea of transforming streets into public spaces for pedestrians, while also contributing to the economic vitality of local commercial arteries. This is precisely what led to the creation of the "active safe routes" (ASR)—a 112-km network of bike and pedestrian paths—in the summer of 2020 (City of Montréal, 2020). Given the extension of the health measures and the success of the first year, these ASR were transformed into various local projects aimed at the pedestrianization of commercial arteries, with the collaboration of the merchants. It was then suggested that a slow zone, "zone lenteur" in French, be introduced on certain arteries, allowing cyclists as well as those using scooters, skateboards, rollerblades, or any other wheeled vehicle, to circulate at walking speed, thereby encouraging harmonious and inclusive cohabitation for all.

These projects quickly raised issues of access and safety, particularly due to the presence of cyclists on these streets, which were initially dedicated solely to pedestrians. This is why a pilot project allowing cyclists to ride on two pedestrian streets (out of 13 streets) was implemented during the summer of 2021, giving all stakeholders, pedestrians and cyclists, merchants, borough officials and elected officials of the two targeted neighbourhoods wanted to evaluate the impact of pedestrian and cyclist cohabitation (City of Montréal 2021). The objective of this article is to document this cohabitation at three specific sites (two where cyclists are permitted and one where they are not) based on observations of cyclists' behaviours and their interactions with pedestrians.

1.1. The vulnerability of pedestrians—above and beyond cyclists

According to the Organisation for Economic Co-operation and Development (OECD), the term *vulnerable road users* (VRU) describes those "unprotected by an outside shield, as they sustain a greater risk of injury in any collision with a vehicle and are therefore highly in need of protection against such collisions" (OECD, 1998, p. 9).

For example, pedestrian injuries can result from the vehicle driven by the protagonist involved in a collision (car, truck, bicycle, electric scooter, etc.) or from contact with the ground during the post-impact fall (Fredriksson et al. 2010). These users also have a generally slower speed than both motorized vehicles and cyclists, which greatly increases their vulnerability. Indeed, the speed of a vehicle is closely related to the increased risk of injury to pedestrians, particularly due to the increased force of impact in a collision, greater braking distance at higher speeds, and a reduction in reaction time (World Health Organization, 2015). Furthermore, the automobile-prioritized design of 20th-century North American cities leaves very few dedicated and safe spaces for pedestrians, forcing them to interact with all other road users in spaces that are not designed for it (Dumbaugh and Rae, 2009). Not only are these conditions unsafe for all pedestrians, the risk of fatalities in collisions is greater for certain age groups, namely pedestrians 60 years and older (Rod et al., 2021). In addition, the risk of collision involving a vehicle is greater for child and adolescent pedestrians due to their physical attributes, which reduce visibility, and due to their lower risk-assessment abilities (Stevenson, Sleet, and Ferguson, 2015).

1.2. Origin of shared spaces

Public spaces within the road network are largely separated by mode of transportation, through the creation of sidewalks, bike lanes, bus lanes and car lanes. At the same time, certain spaces are considered shared spaces, and several modes co-exist within these shared spaces. The first experiments with shared spaces were conducted in the Netherlands in the 1960s and 1970s using woonerfs and shared streets. This redistribution of roadways was aimed at calming traffic and creating safe spaces for socializing in the city (Hamilton-Baillie, 2008). Highway engineer Hans Monderman, one of the pioneers of these shared spaces, saw the shared street as an open space, with no specific road markings or signs that might restrict a certain type of user. Thus, in his vision of this type of design, the sharing of space is based on informal social protocols and on-the-spot negotiation by road users, which occurs organically (Hamilton-Baillie, 2008).

Several types of shared spaces now exist around the world— shared streets, shared paths and trails, open streets and ciclovía—and are the subject of various studies. First, the shared street is a broad concept whose definition varies in different regions of the world. The different types of shared streets do, however, have several points in common, including "the concern to create a pedestrian-scaled space, a distinct architectural style, and the pursuit of reduced speeds, to provide a better living environment" (Bruneau, 2017). Shared paths and trails are usually located off-road, where cyclists and pedestrians are side by side, occasionally with some form of separation (e.g., pavement markings) (Boufous, Hatfield, and Grzebieta, 2018). Finally, ciclovía and open streets are streets that are temporarily closed to motor vehicles in order to accommodate cyclists and pedestrians (Bertolini, 2020).

Shared spaces involve the cohabitation of different modes of transportation at different speeds. When the trajectories of different users cross in these spaces, it is possible that they are not even aware of it, that an interaction involving a change in trajectory occurs, or that it leads to a conflict or near-collision that can deeply affect users (Laureshyn, Svensson and Hydén, 2010; Hosford, Cloutier and Winters, 2020). This is an interesting continuum to study in order to better understand cohabitation in various urban spaces, most notably shared spaces, without having to rely on the less frequent and more difficult to obtain data on collisions or injuries.

1.3. Pedestrian-cyclist interaction in shared spaces: an issue seldom examined

While the popularity of shared spaces is growing, only a handful of researchers have focused on the interactions between pedestrians and cyclists on shared paths, and few studies have been identified to date regarding shared streets.

Studies examining user safety on shared paths show that the risk of collision is low (Chong et al., 2010). However, this risk varies according to several environmental and social factors. Pedestrians such as the elderly, children, people with disabilities, and those with less experience on shared paths are at greater risk of experiencing a conflict or collision (Chong et al., 2010). Several studies also show relationships between the density of users on these trails, the speed of cyclists, and the number of interactions. In a context of higher pedestrian density, there would be more interactions with cyclists, but the latter's speed would be lower in this case. Conversely, when pedestrian density is low, interactions are less frequent, but cyclist speed is higher (Beitel et al., 2018; Gkekas, Bigazzi, and Gill, 2020; Essa, Hussein, and Sayed, 2018). Similarly, a study conducted in Australia analyzed behaviours related to cyclist and pedestrian safety on shared paths using direct observations (Hatfield and Prabhakharan, 2016). The results show that safety issues can arise when cyclists are distracted or riding too fast. In addition, the vast majority of pedestrians involved in an interaction with cyclists maintained their initial position, while cyclists generally adapted to the situation by going around pedestrians.

While the City of Montréal's initiatives have led to the implementation of pedestrian streets that are similar to the open street concept, it should be noted that only some of these streets do permit cyclists. As such, many question the safety of pedestrians in these spaces and no research seems to address the issue as we understand it. This article therefore seeks to document the interactions between cyclists and pedestrians on pedestrian streets to assess how the proposed cohabitation impacts pedestrian safety.

2. Methodology

2.1. Study area

Three pedestrianized streets were studied in the City of Montréal, a city of 19 boroughs having jurisdiction over their local network: Mont-Royal East Avenue (n=617 observations), in the borough of Plateau-Mont-Royal; Wellington Street (n=505), in the borough of Verdun-Île-des-Soeurs; and Bernard Avenue (n=249), in the borough of Outremont. Note that the first two pedestrian streets permit cyclists to ride at pedestrian speed, while the third street (Bernard) requires cyclists to dismount in the pedestrian zone.

For each site, two sections (n=6 sections in total) were selected based on three criteria: a strong pedestrian presence in the vicinity (measured by the City of Montréal's pedestrian counters), commercial activity and diversity (measured by a pre-field work survey of businesses) and the presence of design related to pedestrianization (e.g., street furniture, pavement markings, etc.) (Figures 1 and 2).

2.2. Data collection

The collection method used was direct observation with the aid of an original form created specifically for this project, using items from our existing work (Dommes et al., 2015; Cloutier et al., 2017; Hosford, Cloutier and Winters, 2020). Figure 3 illustrates the different items observed for each of the selected cyclists on the section. These items are grouped into three broad categories: cyclist characteristics, cyclist actions (1 to 5 actions could be identified), and cyclist interactions with a pedestrian, if applicable. An interaction was reported when the two users were two meters or less apart when they passed each other. The onset of an action was defined as a change in the cyclist's speed or movement. For example, an observed cyclist could potentially ride straight through into the section (action 1) only to slow down (action 2), go around a pedestrian (action 3), and ride straight out of the section (action 4), implying that 4 actions were recorded for that specific cyclist. Once the actions are identified, the observers had to subjectively assess if the riding of the cyclist was dangerous. The cyclists' "dangerous riding" variable was judged by the observers according to the overall conduct of the observed cyclist, looking mainly at factors such as speeding too fast for the volume of pedestrians present or using a cell phone while cycling. The data collection schedule was established each week based on the weather and all sections were visited twice between 3:00 and 6:00 p.m. (3-hour block each time) from June 16 to August 11, 2021. Once on site, the two observers would position themselves in the middle of the section to randomly observe cyclists from both entrances. The observation began when the cyclist entered the section and ended when the cyclist exited or made a final stop. Observations were recorded on the ESRI-designed Survey123 iPad application.

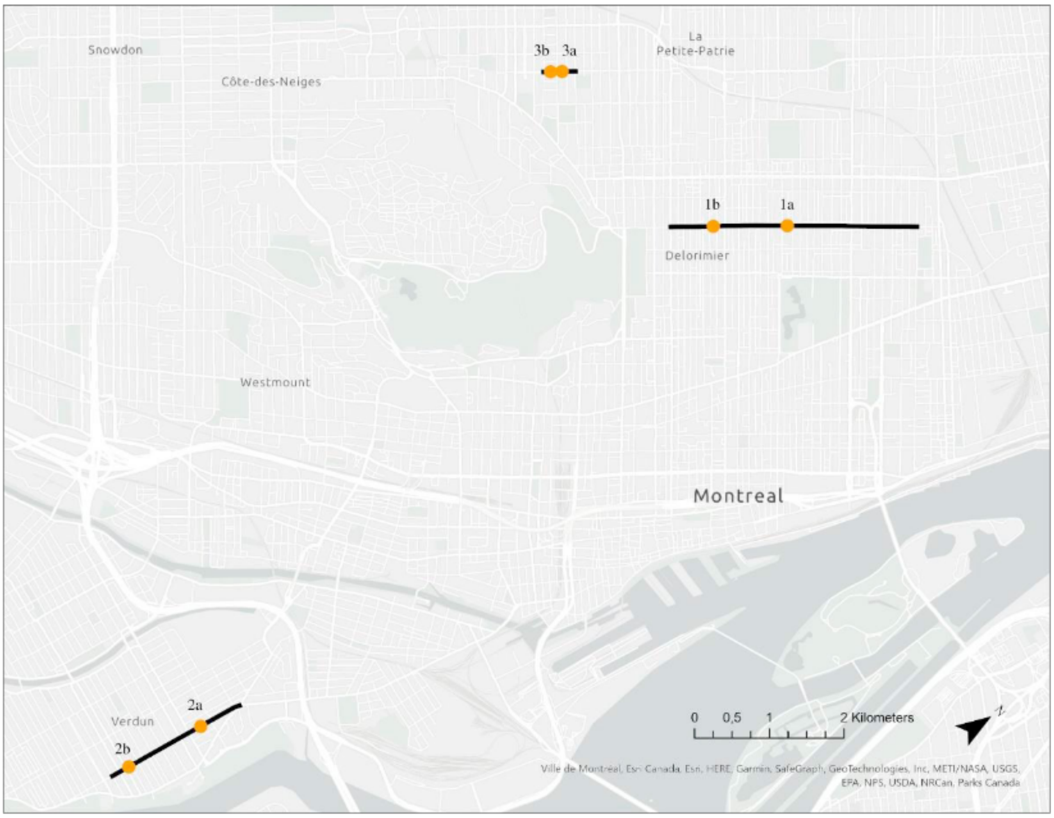

Fig. 1. Study sites

Fig. 2. : Images of the entrances of the six studied sections

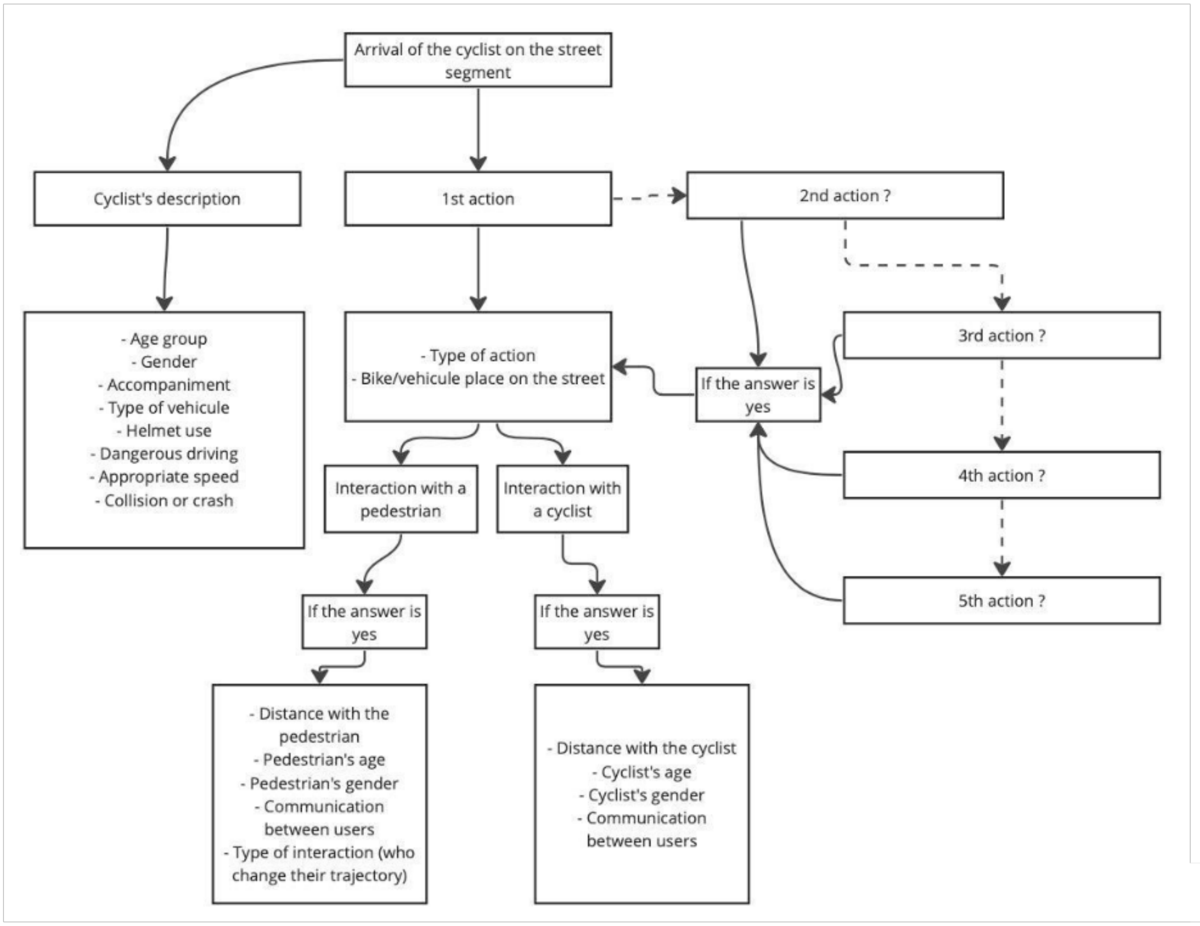

Fig. 3. : Items included in the observation grid

2.3. Data validity and analyses

Data validity was verified for a subsample of the observations where both observers observed the same cyclist. Observations with two observers (n=235, 17% of total observations) were compared using the Kappa coefficient, which quantifies inter-observer agreement. The Kappa coefficient considers the possibility that the two observers arrived at the same result by chance, while the percentage of agreement indicates the proportion of identical responses during the same observation. According to the Kappa coefficient, the variables used here obtained moderate (0.41 to 0.60), substantial (0.61 to 0.80) or perfect (0.81 to 1.00) agreement. (Table 1).

Once the inter-rater reliability analyses were completed, we randomly selected one of the two entries for each of these observation pairs to retain in the final database. Analysis of the retained observations (n=1,371) included the use of descriptive statistics as well as chi-square tests. Modeling of variables that may influence the presence or absence of interaction with a pedestrian is underway.

Table 1 : % of concordance and Kappa coefficient for the selected variables

Variables	% of concordance	Kappa coefficient	Agreement
Gender	99%	0.981	Perfect
Type of vehicle/bike	97%	0.909	Perfect
Accompaniment	99%	0.949	Perfect
Presence of interaction with a cyclist	77%	0.736	Substantial
Actions	66%	0.683	Substantial
Presence of interaction with a pedestrian	60%	0.611	Substantial
Dangerous riding	97%	0.574	Moderate
Age group	82%	0.566	Moderate
Number of actions	69%	0.452	Moderate

3. Results

3.1. Characteristics of cyclists observed

Table 2 shows the characteristics of the 1,371 cyclists observed. A total of 82% of the observed cyclists were on pedestrian streets that allow cyclists to remain on their bicycles and 18% were on pedestrian streets that do not allow cyclists to remain on their bicycles (Bernard). Two-thirds of them were men (68%) and adults (69%), while the group of adolescents and young adults represents 16% of the cyclists observed. Where vehicle type is concerned, 79% had a “standard” bicycle while 7% had an electric bicycle. Furthermore, motorized mobility aids were observed more frequently on streets where cyclists were allowed (Mont-Royal East Avenue and Wellington Street) than on Bernard Avenue. Finally, with respect to whether the cyclists were accompanied, 89% were riding alone at the time of our observation.

Table 2. Characteristics of cyclists observed

Variables	Pedestrian streets that allow cyclists (Mont-Royal East and Wellington)		Pedestrian streets that do not allow cyclists (Bernard)		Total	
Number of cyclists observed	1122	81,8%	249	18,2%	1371	100%
Gender						
Men	784	69,9%	154	62,1%	938	68,5%
Female	337	30,1%	94	37,9%	431	31,5%
Age						
Children	29	2,6%	17	6,8%	3,4%	3,4%
Adolescents and young adults	169	15,1%	51	20,5%	16%	16%
Adults	782	69,8%	168	67,5%	69,3%	69,3%
Seniors	142	12,7%	13	5,2%	11,3%	11,3%
Type of vehicule						
Bike	873	77,8%	211	84,7%	1084	79,1%

Electric bike	79	7,0%	16	6,4%	95	6,9%
Motorized mobility aid	74	6,6%	1	0,4%	75	5,5%
Other	96	8,6%	21	8,4%	117	8,5%
Accompaniment						
The cyclist was not accompanied	1008	89,9%	217	87,1%	1225	89,4%
Accompanied by one person	92	8,2%	26	10,4%	118	8,6%
Accompanied by two or more people	22	2,0%	6	2,4%	28	2,0%

3.2. Actions performed by cyclists during observations

The data collected shows that cyclists performed only a few different actions while riding on the section observed, for a total of 2,255 actions for the 1,371 cyclists observed (Table 3). Indeed, more than half of the cyclists (61%) performed only one action and the average number of actions performed was 1.65 per cyclist and did not vary significantly among sites. The rest of the analyses were carried out on the first three actions since this represents 96% of the observed cyclists and we obtained an unsatisfactory interrater coefficient during actions 4 and 5. During the first three actions observed, there was no statistically significant difference between the two types of sites (allowing or not allowing cycling) during the most common actions. In fact, 67% the cyclists were riding straight ahead as prescribed, 66% on sites with cyclists permitted and 74% on the other site (χ^2=0,543, p=0,461). The remaining actions were relatively marginal in terms of percentage, with the actions of passing pedestrians representing 13% when cyclists are allowed and 10% when they are not (χ^2=0,491, p=0,483) and, with no significant difference between the two types of sites, except for a marginal effect for changing direction, representing 11% on sites with cyclists and only 3% on site not allowing cyclists (χ^2=3,602, p=0,057).

Table 3. Number and types of actions performed by cyclists observed

Variables	Pedestrian streets that allow cyclists (Mont-Royal East and Wellington)		Pedestrian streets that do not allow cyclists (Bernard)		Total	
Average number of actions	1,68 (n=1888)		1,47 (n=367)		1,65 (n=2255)	
Number of cyclists observed with…						
1 action	667	59,4%	168	67,5%	835	60,9%
2 actions	200	17,8%	47	18,9%	247	18,0%
3 actions	206	18,4%	31	12,4%	237	17,3%
4 actions	42	3,7%	3	1,2%	45	3,3%
5 actions	7	0,6%	0	0,0%	7	0,5%
Type of action (including only actions 1 to 3)						
Riding straight ahead as prescribed	1208	65.9%	257	73.6%	1465	67,2%
Slowing down	75	4.1%	10	2.9%	85	3,9%
Stopping	40	2.2%	7	2.0%	47	2,2%
Accelerating	17	0.9%	3	0.9%	20	0,9%
Passing or riding around a	236	12.9%	36	10.3%	272	12,5%

pedestrian						
Sudden avoidance	3	0.2%	0	0.0%	3	0,1%
Zigzagging/changing direction	206	11.2%	10	2.9%	216	9,9%
Getting on/off bike	15	0.8%	17	4.9%	32	1,5%
Parking bike	23	1.3%	5	1.4%	28	1,3%
Other	9	0.5%	4	1.1%	13	0,6%

3.3. Cyclist-pedestrian interaction during observations

Of the 2,255 actions observed at the sites, 30% resulted in an interaction involving a pedestrian (Table 4). Most pedestrians involved in interactions were adults (62%), while a minority were seniors (11%) or adolescents/young adults (11%). In terms of respecting the pedestrian right of way, the majority of cyclists avoided the pedestrian by changing their trajectory (55%) without the pedestrian having to do so. In a significant proportion of interactions, neither user had to change their trajectory (40%). In this type of interaction, the two users were two meters or less apart, but they passed each other in this confined space without having to change their respective trajectories. Finally, situations in which the pedestrian changed his or her trajectory when the cyclist passed to avoid him or her were infrequent, representing less than 4% of all interactions recorded.

Table 4. Characteristics of interactions observed between pedestrians and cyclists on pedestrian streets

Variables	Pedestrian streets that allow cyclists (Mont-Royal East and Wellington)		Pedestrian streets that do not allow cyclists (Bernard)		Total	
Total number of actions	1885		370		2255	
Number and % of actions involving interaction with a pedestrian	595	31,6%	88	23,8%	683	30,3%
Interactions according to age group of pedestrians involved						
Children	21	3,5%	4	4,5%	25	3,7%
Adolescents and young adults	61	10,1%	14	15,9%	74	10,8%
Adults	367	61,7%	54	61,4%	421	61,6%
Seniors	64	10,8%	12	13,6%	76	11,2%
Unknown	83	13,9%	4	4,5%	87	12,7%
Respecting pedestrian priority						
The cyclist changed trajectories	331	55,6%	46	52,3%	377	55,2%
The pedestrian changed trajectories	23	3,9%	3	3,4%	26	3,8%
Both changed trajectories	4	0,7%	2	2,3%	6	0,9%
No one changed trajectories	237	39,8%	37	42,0%	274	40,1%

3.4. Dangerous riding on the part of cyclists

Of the 1,371 cyclists observed, only 85 (6%) were judged by our observers to be riding dangerously. The proportion of dangerous cyclists was significantly higher among males at 8%, compared to females at 2,3% ($\chi2$ = 16,49, p<0,001) as well as among adolescents and young adults (10%) compared to children (4,3%), adults (5,5%) and seniors (5,2%) ($\chi2$ = 8,27, p<0,04).

Regarding the type of bicycle or wheeled device, the proportion of cyclist having a dangerous behaviour was similar for bicycles (5%), electric bicycles (6%) and mobility aids (5%). Other types of bicycles/vehicles—such as cargo bikes, Segways, hoverboards, and electric scooters—have a 24% share of the total number. Lastly, Table 5 shows that the presence of dangerous riding is significantly related to the number of interactions—either no interactions, one interaction, or two or more interactions (p < 0,01). Cyclists who were riding dangerously and had no interactions represented 33% while those who had either 1 interaction or 2 or more interactions represented 56% and 11%. Other Otherwise only 4 minor collisions (0,2%) were reported by the observers and no external data on collisions (e.g., from police report) were available at the time of our analysis.

Table 5 : Relationship between dangerous driving and the number of interactions per cyclist

Dangerous behaviour	No		Yes	
No interaction	743	58%	28	33%
1 interaction	488	38%	48	56%
2 interactions or more	55	4%	9	11%
Total	1286	100%	85	100%

4. Discussion

According to the results, cyclists' behaviours did not jeopardize the safety of pedestrians. In fact, the average number of actions per cyclist was low, and the most frequent action was riding straight ahead—a behaviour that makes it easier to anticipate a reaction, which is necessary for cohabitation. These results are similar to Hatfield and Prabhakharan's study (2016), where cyclists' behaviours on a shared path was predictable, with no change in direction in most instances. Furthermore, for every action performed, only one-third resulted in an interaction with a pedestrian, and most interactions were either uneventful or involved avoidance by the cyclist to respect pedestrian priority. In light of these observations, the majority of cyclist behaviours pose little danger to pedestrian safety, as confirmed by other studies on the low risk of collisions between cyclists and pedestrians in shared areas (Beitel et al., 2018; Chong et al., 2010; Grzebieta, McIntosh, and Chong, 2011).

Although only 6% of cyclists engaged in behaviour deemed dangerous to pedestrian safety, the male cyclists and young adults observed engaged more frequently in such conduct. These findings are consistent with studies spanning several decades that report the overrepresentation of young males in motor vehicle crashes and risk-taking on the road (Oxley et al., 2014). Although we did not identify similar studies on the relationship between cyclists and risk-taking, Chong et al.'s study (2010) identifying hospitalization reports for collisions involving a pedestrian and cyclist in Australia between july 1st 2000 and june 30th 2005 shows that the majority of cyclist injuries were suffered by young males. In our study, a greater number of dangerous behaviours were observed in the “other” category of vehicles—i.e., Segways, rollerblades, cargo bikes, etc. There is little literature available on the use of these types of vehicles in shared spaces given the relatively recent emergence of these means of transportation in the urban environment. However, this result nonetheless reminds us of the importance of better documenting this new reality, especially given the fact that some of these devices are electric, which makes them faster (Petzoldt et al., 2017). Lastly, it was demonstrated that dangerous cyclists also had more interactions, which is not in itself surprising given the nature of our observations: cyclists were judged on their speed, proximity to pedestrians and distractions (cell phone and other).

4.1. Methodological limitations

The results presented here are original because of the unique protocol used for data collection and the lack of existing studies on the sharing of space between pedestrians and cyclists in a pedestrian street context. Nevertheless, the project does have some methodological limitations related to the logistical restrictions inherent in a field collection project of this scale.

First, the time slots for observations were restricted to a single period of the day (3:00-6:00 pm) and the variables of both pedestrian and bicycle traffic and cyclist speed were not taken into consideration as they were in other studies (Beitel et al., 2018; Gkekas, Bigazzi, and Gill, 2020; Essa, Hussein, and Sayed, 2018). Also, data collection was only conducted during weekdays. Collecting data at other times of the day (in the morning, for example), and during high traffic periods on weekends could certainly alter cyclist behaviours and thereby our results. The observations were also conducted in generally favourable weather conditions. Data collection during periods of significant precipitation was avoided to ensure a maximize number of observations per field trip. Inter-observer bias for some of the more subjective variables is also possible despite our satisfactory inter-judge validation. In fact, certain items in our observation grid obtained lower Kappa coefficients. As such, training and clarification for each of the variables to be observed is necessary for the next rounds of collection during which these tools would be used.

5. Conclusion

The City of Montréal has set up a pilot project allowing cyclists to ride on two pedestrian streets during the summer of 2021. The objective of this research was to document the behaviour of cyclists and their interactions with pedestrians based on observations at two sites that allow pedestrians and cyclists to share the space and one site that does not. Considering our observations, the behaviour of cyclists is respectful of pedestrian priority, is not considered dangerous, is fairly predictable and the cohabitation between users remains safe for pedestrians.

Based on these findings from non-participant observations, it would be relevant to document pedestrians' perception of this same reality, using a qualitative survey, for example. This would allow for a better understanding of the pedestrian experience, in addition to obtaining the perceptions of pedestrian users on their safety and on this cohabitation in shared spaces. Moreover, the City of Montréal expanded the pilot project to other sites that allowed cyclists to ride on pedestrian streets in the summer of 2022. Expanding the collection of observations, in combination with exploratory walks with pedestrians, would allow for validation of the results in other environments. The literature on pedestrian-cyclist interactions shows a relationship between higher pedestrian density, increased interactions, and reduced speed on the part of cyclists (Beitel et al., 2018; Gkekas, Bigazzi, and Gill, 2020; Essa, Hussein, and Sayed, 2018), but few emphasize the variables describing the environment of these shared spaces. It would also be interesting to see which elements of each pedestrian street influence how well cohabitation works (i.e., street furniture, awareness campaigns, street design). Producing solid data on the cohabitation issues experienced by vulnerable users remains necessary to allow cities to make informed decisions on what to do next for these pedestrian and shared spaces that are so essential to the vitality of our neighbourhoods.

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