Australasian Transport Research Forum 2023 Proceedings
29 November – 1 December, Perth, Australia
Publication website: http://www.atrf.info

How our decision-making process impacts our street crossing habits: Exploring the factors behind use of desire lines

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1. Introduction

Desire lines are the most direct and shortest walking route between modes of transport but not necessarily the safest option. Where the provided safer route is longer and deviates from the desire line then a proportion of users may not use it, electing instead to take the shortest route. In these circumstances, control measures are enforced on desire lines, such as fences or plants, to actively dissuade/prevent usage. This study aims to examine the street-crossing behaviour of pedestrians and the factors affecting the choice of desire lines, at public transportation (PT) stations and interchanges instead of safe designated paths.

By conducting a field survey at two important tram stations in Melbourne, we collected data on the share of pedestrians using desire line at various times of day, different days and weather conditions as well as the perceived characteristics of pedestrians by the surveyors on the site (as listed in Table 1). To complement the field observation survey, we also intercepted a random sample of individuals and conducted a web-based survey to examine the impact of hypothetical external factors on the choice of desire line. The findings of this study revealed that some location-specific factors such as the traffic volume and specifications of PT platform design layouts would affect the rate using desire lines. Some other external factors such as severe cold and windy weather and afternoon hours could also prompt people to use desire lines. On the other hand, a number of control measures such as pedestrian signal countdown, CCTV cameras or highly visible line marking, and pedestrian signage would lead to safer pedestrian behaviours. Several individuals' characteristics turned out to influence the behaviours and the preference for opting for the desire lines such as being younger, male, and high-income earners.

2. Literature review

In recent years, several studies have examined pedestrian behaviour using shortcut routes or crossing the road during the red traffic light. These studies postulated that many factors influence a person's path choice, such as weather, congestion, individual characteristics, and walking time. We conducted a systematic literature review to identify the relevant factors mentioned by previous studies. A close look at the influences on pedestrian behaviour reported in the literature reveals that the influential factors on pedestrian behaviour may vary across different cities, cultures and countries. For this reason, it was very important to examine pedestrian behaviour according to each city or even at smaller scales to make more effective policies and strategies. The influencing factors were divided into five categories: (i) pedestrian-related, (ii) traffic-related, (iii) location-specific, (iv) weather and time-of-day, and (v) built environment. Detailed information on these categories is provided in the following subsections.

3. Method

We conducted a survey between Monday, January 30th, and Sunday, February 5th, through different timeframes that were selected based on busy hours in the survey sites, extracted from Google Maps. The Ethics approval was obtained from the University of New South Wales Ethics Committee. The survey aimed to collect data on the travel patterns and preferences of PT users in two selected locations in Melbourne. To ensure a representative sample, the survey was conducted for a total of 7 hours, covering various time slots such as the AM peak hour (7-9 am), AM off-peak (9-11 am), PM peak hour (4-6 pm), and late evening (7-8 pm). To gather data from a diverse range of commuters, the survey was conducted in two PT stations:(i) the Queensbridge at Crown; and (ii) the junction of Russell St. and Bourke St (see Figure 1).
To collect data on pedestrian behaviour at the stations, two methods were employed: (i) field observation; and (ii) intercept survey. During the field observation, surveyors completed a form to document various observable characteristics of pedestrian crossings, such as their perceived age, gender, walking direction and speed and more importantly the use of designated safe paths versus unsafe shortest paths. Additionally, the surveyors recorded any distractions or use of mobile devices by pedestrians. These observations were conducted at different times of the day, both during peak and off-peak hours, to capture the full range of pedestrian crossing behaviour patterns. In total, 4,544 complete field observation records were collected (after data cleansing). The observed information includes factors such as gender, age, weather conditions, time of day, disability or mobility impairments and most importantly the usage of safe and unsafe paths by pedestrians when crossing the street.

The intercept web-based survey included questions about socio-demographic information, cultural background, trip purpose and hypothetical scenarios of street crossing. The questions aimed to determine the cultural background, educational level, income level, and frequency of PT use of the respondent. The questionnaire also included questions about the familiarity of the respondent with the surveyed area, the purpose of the trip to the surveyed location, and whether the respondent was in a hurry while travelling in the surveyed location. Furthermore, the respondent was given a hypothetical situation (shown in Figure 2), featuring two street crossing options (path A or B). The respondent had to choose the likelihood of choosing either path A or path B in different scenarios involving specific factors of weather, traffic, etc. The survey respondents were presented with the following five options to indicate their path preference under different scenarios: "Definitely A", "Maybe A", "A or B equally possible", "Maybe B", and "Definitely B". Therefore, by using both field observation and an intercept survey, we gathered a more comprehensive understanding of pedestrian street crossing behaviour in PT stations. In total, 424 complete and correct responses were collected through web-based survey (after data cleansing).

In this research, the binary logit model is used to model pedestrian decision-making when it comes to choosing safe or unsafe paths. An ordinal regression model is utilised to analyse the hypothetical scenarios in the web-based survey, and to predict the likelihood of various responses based on a set of independent variables.

Figure 1: Survey locations

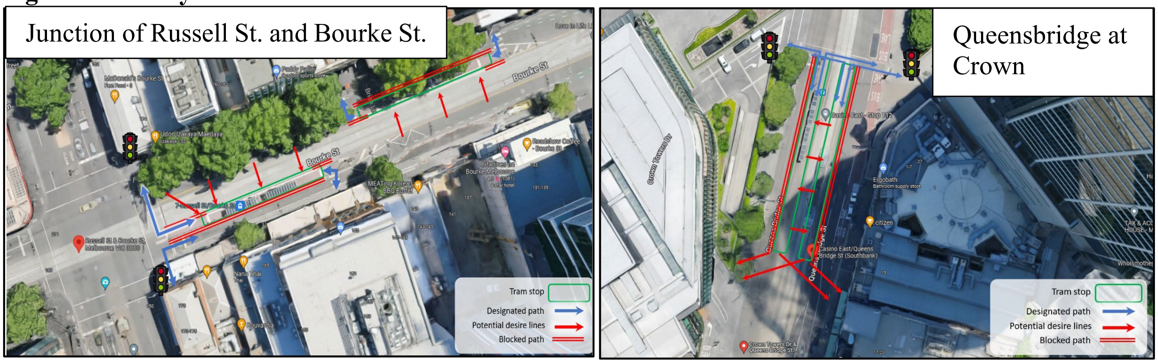
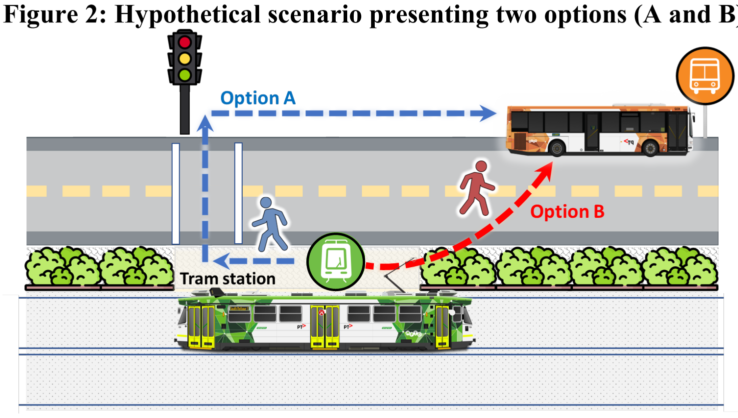


Figure 2: Hypothetical scenario presenting two options (A and B) in the online questionnaire.



4. Results

We estimated two sets of models, one for field observation and one for the hypothetical scenarios in the web-based questionnaire. The results of the model after performing model selection for field observation are displayed in Table 1. The results of field observations suggest that participants are less likely to choose an unsafe path at Russel site compared to Crown site. This could be due to the low foot and vehicular traffic at Crown site. The previous studies also confirmed that congestion on roads significantly reduces risky pedestrian behaviour or the use of non-designated paths (Pawar and Patil, 2016, Yoneda et al., 2019, Zhu et al., 2021a). Notably, the end side of the tram platform at Crown site does not have a zebra pedestrian crossing. This design layout enforces people to walk across the length of the platform to be able to use the zebra crossing at the intersection. If the PT passengers encounter red traffic light, then they have to wait even further for the green signal. Whereas the design layout of the platform at the Russel site provides pedestrian access and a zebra crossing at both ends of the platform, and results in less unsafe behaviours. The observational data also showed higher percentage of unsafe behaviours during the afternoon hours compared to morning hours. This result was in line with the literature and suggests that pedestrians were more likely to use desire lines during peak hours and when being in hurry to reach their destination (Wang et al., 2011).

Table 1: The variables influencing the likelihood of choosing unsafe desire line

Variables	Coefficient	Standard Error (SE)	t-Stat
Intercept	0.5619	0.0255	22.0330
CBD	-0.1453	0.0213	-6.8104
Morning Peak (7-9 AM)	-0.0566	0.0170	-3.3288
Morning off-peak (9-11 AM)	-0.0993	0.0164	-6.0525
Windy weather	0.4888	0.0320	15.2680
Male	0.0391	0.0128	3.0668
Senior	-0.1157	0.0359	-3.2198
Pram/trolley	-0.1411	0.0505	-2.7918

Walking with small children	-0.1874	0.0468	-4.0070
Carrying a heavy bag	-0.0525	0.0297	-1.7674
Business attire	-0.0430	0.0188	-2.2897
Walking fast	0.2126	0.0216	9.8588
Running	0.2787	0.0257	10.8410
Walking with somebody	-0.0579	0.0149	-3.8918
Mobile phone use	-0.0412	0.0226	-1.8217
Flow with	-0.2815	0.0152	-18.5780
Flow against	-0.3051	0.0361	-8.4574

The data collection covered periods of different weather conditions as two days of the data collection occurred during cold, windy as well as rainy weather. Our data suggest that cold windy weather is statistically a significant factor in prompting people to use desire line, as also suggested by the previous studies (Li and Fernie, 2010, Koetse and Rietveld, 2009, Liang et al., 2020).

Similar to the findings of previous studies, male individuals are more likely to choose an unsafe path compared to female participants (Aghabayk et al., 2021, Tom and Granié, 2011, Freeman and Rakotonirainy, 2015, Zhu et al., 2021b, Theofilatos et al., 2021, Papadimitriou et al., 2016, Zafri et al., 2022, Bergeron et al., 1998, Soathong et al., 2021) and senior participants are less likely to choose an unsafe path compared to younger participants (Soathong et al., 2021, Dommes et al., 2015, Sucha et al., 2017, Oxley et al., 2005, Lobjois and Cavallo, 2007, Ren et al., 2011, Ferenchak, 2016, Ni et al., 2017, Zhuang and Wu, 2011, Brewer et al., 2006, Liu and Tung, 2014). Moreover, participants who are carrying a pram, trolley, a heavy bag or walking with small children are less likely to choose an unsafe path compared to those who are not (Al Bargi and Daniel, 2020, Lanza et al., 2022, Dhoke et al., 2021). Similarly, less unsafe crossing behaviour was observed among people who are dressed in business attire, as also confirmed by the literature (Shaaban et al., 2021, Saxena et al., 2020).

While some previous studies suggest that distraction may result in unsafe street-crossing (Zhuang and Wu, 2011, Shaaban et al., 2018), our data suggests the opposite. Those who were observed walking with somebody else or using their mobile phones when crossing the street were less likely to use the unsafe desire line path. Interestingly, our data also suggest that people are less likely to choose the unsafe path when there is a high flow of people going in the same direction or when there is a high flow of people going in the opposite direction. This result suggests that using the unsafe desire line is less likely to be influenced by the behaviours of a large group in our case study, and suggest that the majority of PT passengers use the safe path. It should be noted that this finding is yet to imply that the herd behaviour does not exist in our case study. As suggested by the literature, only a small percentage of informed individuals (e.g. 5%) can guide a larger group of uninformed individuals to use an unsafe path or cross the road during the red traffic light.

Overall, it appears that walking fast, walking with somebody else, and the flow of people crossing in the same direction (presented by the "*Flow with*" variable) have the strongest impact on the likelihood of people choosing the safe path. Gender, seniority, pram/trolley, walking with small children, and weather conditions also have some impact, but to a lesser extent. The impact of morning peak, morning off-peak, carrying a heavy bag, and mobile phone use may be less significant. Having business attire and the flow in the opposite direction of crossing appears to have a smaller impact but still has a significant effect on the likelihood of people choosing the safe path.

We undertook a factor analysis to identify which questions exhibit comparable patterns of behaviour. After trying different numbers of groupings, it was found that grouping the variables into two factors yielded better results. This suggests that the variables can be simplified and represented by two major factors, named *Impulsivity* and *Risk aversion*. The chi-square test yielded a statistic of 188.8 on 64 degrees of freedom. Table 3 presents the results of the factor analysis. The results of presented hypothetical scenarios in the online survey suggest that the first group of factors influence the swiftness of movement which is more likely to result in deviating from the designated safe crossing path and opting for a shortcut or so-called desire line. We name this group of factors "*Impulsivity*". The impulsivity factors confirm our prior hypothesis as well as the literature that severe weather conditions (windy, rainy, very hot sunny days), being in a hurry, herd behaviour, poor line marking and signs of walkways, and making the shortcut to tap on the pay station as well as avoiding the crowd on the designated walkway could prompt people to deviate from the designated safe path and opt for the desire line. The estimates confirmed that these factors exacerbate unsafe and risky street-crossing behaviours and align well with the findings from the literature, as shown in Table 1.

Table 2: The results of the factor analyses

Factors	Impulsivity	Risk aversion
Severe weather conditions	0.600	
Carrying a heavy bag or walking with a pram or trolley		0.424
Rushing to destination	0.805	
Rushing to get on the PT service	0.852	
Herd behaviour	0.785	
Crowd avoidance on the designated walkway	0.640	
Lack of vehicular traffic	0.751	
Poor sign and line marking visibility	0.630	
Poor street lighting		0.595
Vicinity of Myki-card reader (pay station) to desire line path	0.641	
Presence of a pedestrian signal countdown		0.621
Driverless PT service		0.623
Presence of CCTV or police officer		0.648
Visual attractiveness of crossing path		0.706

However, some other factors prompt people to use the designated safe path. We name them "*risk aversion*" factors. These factors include carrying a heavy bag or walking with a pram, trolley or scooter. Also, during dark hours of the day or when there is not enough street lighting, individuals are more likely to stick to the safe path. The presence of CCTV or police officers also has a positive impact on prompting people to follow the rules. It also appears that the public does not perceive the driverless tram or autonomous bus as safe, and individuals prefer to not take a risk of using an unsafe shortcut. Interestingly, installing a pedestrian signal countdown and increasing the attractivity of walkways or street zebra crossings (such as having a shade or interesting pavement painting) can also prompt individuals to use the designated crossing path rather than the desire line. These results confirm the findings of the previous studies (Borst et al., 2009, Liu et al., 2020, Basu et al., 2022, Koh and Wong, 2013, Sarkar et al., 2015, Arhin and Noel, 2007, Ni et al., 2017). Notably, some respondents preferred the safe designated path in the presence of an autonomous tram or PT service, as also found in a number of studies suggesting that pedestrians may have a greater concern about interacting with driverless vehicles than they do with a human-operated vehicle due to the lack of meaningful eye contact or the absence of driver gestures that indicate their intention. (Blau et al., 2018, Merat et al., 2018). While as suggested by previous studies (Razmi Rad et al., 2020), pedestrians' crossing decisions are heavily influenced by their age and familiarity with driverless cars. Hence, in the next section, we present the relationship between the socio-demographic characteristics of respondents and choosing the desire line in the hypothetical scenarios. For example, we found a positive correlation between being a high-income earner and Melbourne resident and choosing the desire line which suggests more confidence in driverless technologies among this specific group of people.

5. Conclusions

This study aimed to identify the percentage of unsafe street crossings by PT users at two stations and the underlying causes and influential factors on these behaviours. Various potential factors were extracted from previous studies and were examined through field observation as well as web-based intercept surveys in two sites with different geometric design specifications of PT platforms and different foot traffic.

To avoid biases in the responses, the respondents were asked to state the five Likert scale likelihood of opting for an unsafe path in hypothetical scenarios. To examine the potential correlation between the actual behaviour and the stated response, a unique code was used to match the observed behaviour with the responses from the web-based survey. However, no statistical correlation was found between the indicated likelihood of choosing unsafe street-crossing and the actual observed behaviour. The lack of correlation between stated and revealed behaviour could be due to differences in hypothetical scenarios from the actual situation.

The influence of pedestrian characteristics on the revealed and stated behaviours was also examined. Some characteristics turn out to be influential in opting for unsafe paths and these characteristics were by and large in line with the literature. The field observation was undertaken at different time of day and for the duration of one week. Luckily, the observations were made in all different weather conditions such as cold windy, rainy, and sunny days. This enabled examining the impact of time of day, day of week and weather on pedestrian behaviours.

Moreover, this study attempted to test the hypothesis about herd behaviour in opting for an unsafe desire line. Overall, it appears that walking fast, walking with somebody else, and the flow of people crossing in the same direction have the strongest impact on the likelihood of people choosing the safe path. Being male, seniority, pram/trolley, walking with small children, and weather conditions also have some impact, but to a lesser extent. The impact of morning hours, carrying a heavy bag, and mobile phone use may be less significant. Having business attire and the flow in the opposite direction of crossing appears to have a smaller impact but still has a significant effect on the likelihood of people choosing the safe path.

The results revealed that some external factors may encourage pedestrians to use an unsafe pathway, while others may prevent them. For example, improving signage, increasing street lighting, widening the crosswalks, installing pedestrian signal countdowns or cameras, or locating Myki-card readers closer to the safe crosswalk can gauge pedestrians to navigate safe pathways during peak traffic hours or in adverse weather conditions. The collected data from field observations and an online survey at two locations in Melbourne also provided insights into socioeconomic factors, trip purpose or characteristics that would interplay with external factors such as weather or the design of the PT stations and affect the street crossing behaviours at the PT stations.

While some of the implications may be specific to the case study locations, most of these insights can be applied to other locations to improve the safety and experience of vulnerable road users, particularly PT users. To develop a comprehensive safety roadmap for PT services, however, further investigations into other sites with different characteristics would be advised.

Hence, we underscore the need for conducting experimental research to examine nudge strategies and various interventions and to identify effective design solutions that are tailored to the needs of diverse communities, people, or different built environments. Through this process, policymakers, designers and urban planners can develop comprehensive strategies that address the unique challenges faced by different communities and promote equitable access to safe, efficient, and sustainable transportation systems.

6. Acknowledgement

This research is funded by iMOVE CRC and supported by the Cooperative Research Centres program (an Australian Government initiative), the Victoria Department of Transport (Vic DoT), and the University of New South Wales.

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