Intersection roadway marking design: effects over cyclist's safety perception

Effects

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Abstract.

Bicycles as a transport mode, have many advantages in improving the quality of urban life for carbon-less cities, traffic congestion reduction, and good for resident's health. Despite these advantages, the number of new cyclists does not increase in cities with low cycling maturity. There is a large percentage of residents interested but concerned about the safety of cycling in urban streets. We developed an experiment with images simulating a cyclist's route in an urban road intersection to evaluate the level of safety perception in different types of cycling infrastructure. Three variables were studied: traffic density, cycleway types, and intersection designs. A set of images was shown to 300 individuals online who rated each image on a four-point scale related to their perception of safety. Safety perception was higher for low traffic density, painted cyclist lanes, and separation of cyclists from traffic. The simple presence of colored markings increased the safety perception relatedly with no design in the intersection environment. The more complex studied intersection design increased even more the safety perception. Naturally, the interventions of cycle design that include specific measures for cyclists need to increase not only the level of their safety perceived but also the likelihood of using bicycles. The complex design (Dutch model safety intersection design) is a good approach to increase security awareness. However, for this conclusion to be supported, more future studies are needed to assess the cyclist's perception in a more dynamic and realistic situation.

Keywords: Bicycle, Cycling Infrastructure, Safety Perception, Road Intersection.

1 Introduction

Cities have the challenge to promote sustainable transport with bicycles and one of the main barriers is the concern with the safety of cyclists in urban journeys. To increase cycling in cities, this deterrent must be overcome to increase safety traffic for

cyclists on urban trips (Winters et al., 2010; MacNeil, et al., 2017, Marshall and Ferenchak, 2019), particularly in countries with no cycling culture and limited cyclable infrastructure where the barriers are higher. In order to increase cycling in cities, especially in those ones with low cycling maturity, it is necessary to overcome cycling information deficiency concerning the needs of current and potential cyclists (Félix, 2019).
We start based on the premise that individuals feel safe, and this will have a positive effect on their choices of modes of transport. Thus, a positive perception of the safety of cyclists in the urban environment can increase cycling in urban environments. (Dill and Voros, 2006).

Several studies evaluated environmental perceptions of urban spaces with infrastructure, using several tools such as photos, models, videos, virtual reality, or local exposure. All offer advantages and disadvantages in different degrees of realism and experimental extent control they allow (Nasar, 2008). In these studies, there are aspects related to cycling situations and environmental perceptions that used virtual reality (Nazemi et al, 2019; Mouratidis and Hassan, 2021), manipulated photos (Mertens et al, 2014), videos (Cabral and Kim, 2022) and realistic images (Fixmyberlin, 2020). According to Cunningham et al. (2004), simulations allow to exploration of design options to test the safety, aesthetics, or desirability, to determine which combinations are most effective at the urban microscale……

The current study was inspired by the Fixmyberlin survey (2020). The survey which featured 21,000 participants, evaluated over 1000 combinations on variations of street scenarios with many structural feature variables. All were evaluated through a four-point scale concerning safety perception. The Fixmyberlin study presented the preferred situation with 99% in the sample's preference (Figure 1a) and the least secure, with only 11% of the sample feeling safe (Figure 1b).

Fig. 1a. Safer situation in Fixmyberlin. Font image: Fixmyberlin (2020).

Fig. 1b. Dangerous situation.

2 Methodology

To understand and articulate the closer link of cycle design qualities (Mertens et al, 2014, Liu et al., 2018) to transport planning and infrastructure interventions, we used a survey to examine the effect of visual design on the safety of cycling infrastructure, assessing the perceived level of safety in the characteristics of each type of bicycle lane in the cyclist's route at an urban intersection. An online survey was responded to by 300 residents most in cities with low cycling maturity (Félix, 2019), low cycling rates, and poor infrastructure for cyclists fifty four percent were male, and 46% were female, aged between 18 years to 30, (14%) and more than 30 years corresponding to 86% of the sample. Most held a bachelor's or post-graduate degree.

The 24 study images, showing the section of the cyclist's route in an urban road intersection environment, were modeled in the Twinmotion software. Figure 4, on the left, shows the camera view corresponding to the cyclist's point of view and, on the right, the aerial view perspective corresponding to one of the modulations created for the present study. The assessment was carried out by asking participants to express their perception of safety by evaluating a scene from the cyclist's point of view when presented with different bicycle design configurations. Images were rated using a four-point scale according to perceived safety as (1) fairly unsafe, (2) unsafe, (3) safe, or (4) fairly safe.

The 24 images used were a product of a within design with 2*4*3 conditions:

- 2 Traffic densities:
  - Low (a) and high (b); Figure 2.
- 4 Bicycle lanes:
  - a) a condition without bicycle lane;
  - b) a bicycle lane between motorized traffic lane and parking along;
  - c) a separated bicycle lane between the car parking lot on the left and the sidewalk on the right;
  - d) a separated large bicycle lane with garden pots and no parking on the left and a sidewalk on the right side. Figure 3.
- 3 Intersection design:
  - a) without design;
  - b) with marked lines and color;
  - c) with the safety intersection design model. Figure 4.

Fig. 2a. Low traffic volume

Fig. 2b. High traffic volume

Images were presented in Google Forms and the order of the presentation was randomized. A consent form was added to the survey, as well as biographic data to characterize the sample. Data was gathered during 4 months between December 2021 and April 2022. We show below the images related to the four types of infrastructure design evaluated in the perceived level of safety from the cyclist's perspective.

Fig. 3a. Street without bicycle lane.

Fig. 3b. Large bicycle lane separated by garden pots and no parking.

Fig. 3c. Bicycle lane separated by parking lot on the left side.

Fig. 3d. Bicycle lane between motorized traffic lane and parking along.

Fig.4a: Intersection line and color design

Fig.4b: Intersection safety design with line and color

3 Results and Discussion

The results presented in this paper concern a global treatment for each level of the independent variables studied. Thus, for the traffic density, the averages of the 12 images with low density and the 12 images with high density were calculated. For the second variable, Bicycle lanes, averages of 6 images were calculated for each of the four levels of this variable. For the variable, intersection design, which had three levels, the averages of the 8 images were calculated for each of the levels. Non-parametric statistics were performed for each variable, to evaluate if safety perception was affected by each level of the variables.

3.1 Traffic Densities

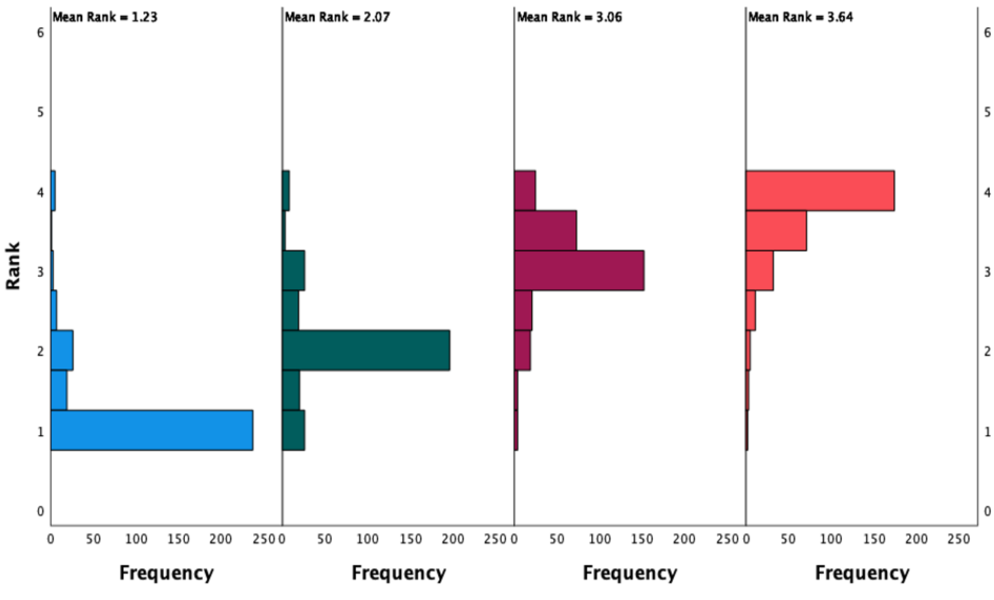
Low traffic density safety perception, was higher ($x=2.94$) than high traffic density ($x=2.67$). The non-parametric test for two dependent samples (Wilcoxon) was chosen. The test result revealed the existence of a statistically significant difference ($z=-11.84$ $p<0.001$) in the variation of traffic density on the road.

This result confirms that when the volume of traffic is high, the perception of risk for the cyclist increases (Winters et al., 2010, Teschke et al., 2012). Traffic density, conjointly with speed, is the most influential variable in studies of stated preference in choosing routes by American cyclists (Winters et al, 2010, 2011). Concluding, the perception of safety is inversely proportional to the traffic flow density on the road.

3.2 Bicycle Lanes

For the variable, Bicycle lane, we opted for a non-parametric Friedman test for dependent samples. The result revealed the existence of a statistically significant difference between the different levels of the variable Bicycle lane (χ^2 (3, n=298) =651.97, p<0.001). Post tests revealed statistically significant differences between all levels of the bicycle lanes variable. In the a-b comparison (z=-7.88 p<0.001); a-c (z=17.27 p<0.001); on a-d (22.74 p<0.001); in b-c (z=17.27 p<0.001); in b-d (z=14.86 p<0.001); and in c-d (z=5.4 p<0.001) (Check figure 3 to have a reference of the different bike lanes). The non-existence of a bicycle lane (Fig3 a) is the situation perceived as the least safe (x=1.8), followed by the (b) cycling lane (x=2.7). In situations where there is a separation from the bicycle lane (c and d), the value of perceived safety was higher. In positioning the bicycle lane to the side of the crosswalk and separated from motorized traffic by the parking lot it is the second situation perceived as more safety (c, x= 3.3), and the situation of the separated bicycle lane with garden pots (d, x=3.8) was the situation perceived as safer.

Bicycle lanes types results (a,b,c and d):



Bicycle lanes (a) (b) (c) (d)

Figure 5: Friedman’s Ranks for intersection design

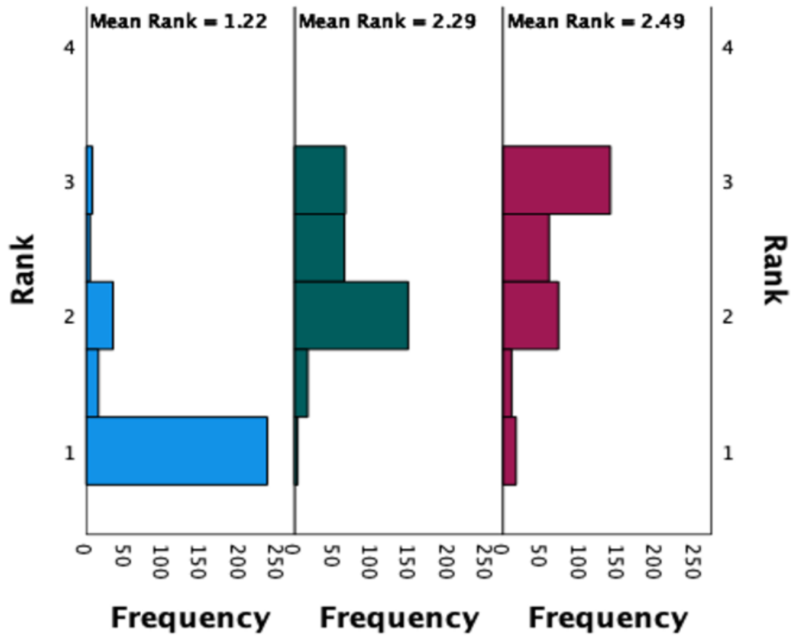
Figure 5, shows the ranks of the Friedman test for each level of the variable bicycle lane. It is very clear in this graphic the positive evolution of the safety perception from the left bicycle lane type (a) to the right bicycle lane type (d).

According to Winters et al., (2010), the preferred route types for cyclists are cycle lanes along main roads, as long as they are separated from traffic, and cycle lanes on residential streets with traffic moderation.

3.3 Intersection Line Design

The third variable under consideration is line and color design at the intersection. A non-parametric Friedman test for dependent samples was used. The results revealed the existence of a statistically significant difference between the different levels of the design variable in the intersection (χ^2(3, n=300) =325,27, p<0.001). Post-tests revealed statistically significant differences between all levels of the intersection line design variable (Checklist of variables 3: 3a-3b (z=-13.04 p<0.001); 3a-3c (z=15.55 p<0.001); 3b-3c (z=2.51 p=0.036).

Design



Design (a) (b) (c)

Figure 6: Friedman's Ranks for intersection design

In terms of average values, the analysis showed that the non-existence of design at the intersection was considered the least safe situation in the perception of the cyclist (3a, x=2.5). The existence of a marked line and color was the situation perceived as intermediate (3b x=2.9), and the safe intersection design model, was considered the safest (3c, x=3).

Figure 6, shows the rank of the Friedman test for each variable level of line and color design at intersections. It is very clearly seen in the graphic the perception of safety is much lower when there is no design (6a). However, in the situations with design intervention (6b and 6c), there are great overlap of rankings, but still, the higher ranks related to human higher safety perception are on the safety intersection model Dutch.

4 Conclusion

All three variables studied (traffic densities, bike lanes, and intersection design) have an impact on perceived safety. According to previous studies (Moudon et al., 2005, Winters et al., 2010, Teschke et al., 2012, Dill & MacNeil, 2013, 2016), it was already expected that the first two variables would have an impact on the safety perception. Again, high traffic densities generated a lower perception of safety and the segregation of bicycle lanes increased the perception of safety. Thus, the methodology used proved to be valid, as the results are similar to previous studies.

Therefore, we can reinforce the conclusion that the main variable under study, Intersection Design, also affects the cyclists' perception of safety. Consequently, the present study suggests that intersection design solutions be implemented, as they will have a positive effect on the perception of safety and can attract potential cyclists. Even the simplest intervention, placing marked lines and color continuation at the intersection, had a positive effect on safety perceptions. Thereby, if the economic conditions of the municipalities do not allow the implementation of a safe intersection design model solution (Dutch model), at least the marked lines and color, are simple and cost-effective solutions that should be implemented at intersections.

We know that the norm (Crow 2007) recommends that intersections should have uneven-level crossing passages, but recognize the costs of these solutions. Eventually, another compromise solution, which was not evaluated in this study, could be the simplified and more economical Dutch model, having only the paintings without the waiting crossing islands. With the urgency imposed by climate change for sustainable mobility solutions, we can conclude that intersection design measures with colored lines and colors placed at intersections are committed to increasing the perception of safety cycling on city streets.

According to Hull and O'Holeeran, (2014), design as an element of urban enhancement to increase the level of safety, comfort, and attractiveness of the urban infrastructure environment, plays an important role in attracting new cyclists. Marked lines and color at intersections are safer routes from the cyclist's point of view and the experienced and cautious cyclists. Disconnected infrastructure often means that cyclists have to share the street space with pedestrians or motor vehicles and must negotiate (Kircher et al., 2018), which is a risk for cyclists on the roads and a barrier to the growth of cycling. Indeed, the intersection design increased the level of safety perception in all types of bicycle lane situations analyzed in the approach that perceived environmental conditions contribute to the likelihood of cycling (Moudon et al., 2005) and appear to be an individual choice. Traffic density is an issue for cyclists, especially for less experienced ones. Density is inversely proportional to the perceived safety of cycling. And there are evidences that infrastructural aspects influence the desire to cycle (Buehler & Pucher, 2012; Dill, 2009; Hull & O'Holleran, 2014). Cyclists should avoid high-traffic roads, and routes on these high-density roads where should be physically separated from the faster traffic. It is confirmed in the literature (Broach et al., 2012, Mertens et al., 2014, Parkin, 2010, MacNeil et al., 2017 and Cabral & Kim, 2022). Although previous cycling research had linked the presence of bicycle lanes and low-density traffic to cycling (Moudon et al., 2005), they have found a non-linear relationship between the odds of bicycling and the perception of the car-oriented traffic environment. affects cyclists. But when there is a route chance of choice, the separated bicycle lanes as well as low-traffic streets are the preferred. Thus, policy and urban intervention to increase cycling must take into account real and perceived environmental conditions.

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