Cycling that makes sense - A qualitative exploration of cyclists' perception of bicycle infrastructure

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Cycling that makes sense - A qualitative exploration of cyclists' perception of bicycle infrastructure

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ABSTRACT

Bicycle infrastructure is in most cities a fairly recent addition and something that has, in many cases, been squeezed in where space has been available. Consequently, the properties of bike lanes differ a lot between different locations. An observation that is easy to make is that when bike lanes are wide, smooth, and straight, the variation in cyclists' behaviour is low. When on the other hand there are lanes that disappear, that takes long detours, or are blocked for various reasons, cyclists start to act in a way that from an outsider's perspective may look random or at least difficult to predict. This paper reports on a study where 17 cyclists have filmed their daily commute with GPS equipped action cameras. They then have looked at the film together with a researcher and explained how they perceive the route and how they make their choices in traffic. Based on the results of the study we argue that the cyclists' behaviour is very rational from the perspective of the cyclist's perceived action space, and that by understanding how different people interpret the bicycle infrastructure we can make small design changes that have less ambiguity and nudges cyclists towards a more uniform and safe behaviour.

Keywords: Nudging, bike safety, bicycle infrastructure, perceived action space, ambiguity, predictability

1 INTRODUCTION

Cycling is becoming more and more popular as a mode of transport and the car paradigm is challenged, not in the least in the current times of COVID-19. With an increased interest in cycling there is also an increased number of opportunities for conflicts between people on bicycles and other road users. It's not uncommon to hear people accusing cyclists as acting irrational and unlawful, even though there is no evidence of cyclists being less law abiding than e.g. car drivers. In fact, a recent study found that while only 5% of cyclists break traffic laws in intersections, while 66% of car drivers do so while driving (Vejdirektoratet, 2019). We argue that the reason for this perception might be founded in the design of the infrastructure, not only in terms of space limitations for different transport modes, but also in the ambiguity of the design of the infrastructure. This study was a part of the EU project MeBeSafe which investigated how small changes in the choice infrastructure, nudging (Thaler & Sunstein, 2008), can affect traffic behaviour. While there are numerous design manuals for how bicycle infrastructure *should* be designed (e.g. Trafikkontoret Stockholm, 2005, SKL/Trafikverket, 2010), the fact is that bicycle infrastructure in most cases is squeezed in where possible which leads to a huge variation in design. The question we have tried to answer is *how do cyclists perceive the bicycle infrastructure, and how do the design (on a detailed level) affect their behaviour?*

2 METHOD

In order to understand how cyclists perceive the bicycle infrastructure and how they reason when they manoeuvre their bicycle, a study was conducted where 17 participants were recruited (9 women, 8 men) by stopping cyclists in a bike-lane and inviting them to participate.

The participants were asked to do their daily commute with a GPS-equipped video camera (Garmin VIRB Ultra 30) attached to their bike. Next, each participant was invited to an interview where they watched their film together with a researcher. The interviews were semi-structured based on the participants' comments on circumstances observed in the film. Topics that were discussed were e.g. situations that the participant thought dangerous, pleasant, efficient et cetera, why they perceived the situations this way, and how they motivated their behaviour in different situations.

The interviews were transcribed, timestamped, and analysed via the software NVivo. The data was inductively coded in terms of objective aspects (e.g. objects, people, places, situations) and subjective aspects (e.g. valuation, priorities, feelings). The comments containing the subjective aspects where examined and generalized to a set of *behavioural factors.*

Additionally, a search-query was done to find comments relating to frequency (e.g. never, always, sometimes, rarely). Each comment and their corresponding video section were examined in order to recognize patterns in the bicycle environment. The analysis resulted in a set of *contextual factors* that affect cyclist behaviour. The contextual factors were combined to create generalized *layouts* of the cyclist environment.

3 RESULTS

The result of the analysis is a tentative model of cyclists' behaviour based on the design of the bicycle infrastructure. The model describes nine *behavioural factors* that relate more to the cognitive process forming cyclists' *perceived action space* – the sum of all actions that are *perceived to be possible* at a certain time and place (Strömberg, 2015). The model also describes seven *contextual factors,* that relate more to the physical space, which can be combined to create generalized *layouts* of the cyclist environment. Both sets of factors could arguably support predicting how cyclists will behave when encountered with a proposed bicycle infrastructure in a dynamic context among other road users (e.g. pedestrians, cyclists, car drivers) (Figure 1).

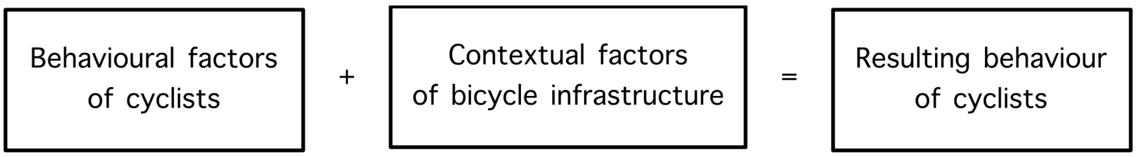

Figure 1. Tentative model of cyclist behaviour

3.1 Contextual Factors influencing cyclist action

The first group of factors that affects how cyclists behave in traffic, according to our tentative model, are what we choose to call *contextual factors (CF).* These factors are divided into two sets (see table 1) of which one relates to fewer interactions and less effort for cyclists (CF2, CF4, CF7, CF6b) and the other relates to more interactions and effort (CF1, CF3, CF5, CF6a, CF6c). They exist either by intention in design or by chance in practice.

Table 1. Definitions and examples of contextual factors (CF) of bicycle infrastructure.

Contextual Factor	Description	Examples	E[1]
CF1. Destinations for pedestrians (D_P)	Popular locations where people go to and from	Shops, residential houses, doors in general, bins, benches, school buildings, shopping malls, public transport stops, parked cars[2]	+
CF2. Obstacles for pedestrians (O_P)	Longitudinal elements posing as non-traversable barriers	Rivers, high fences, busy highways, back of buildings without doors	–
CF3. Obstacles for cyclists (O_C)	Elements located on or next to the bicycle infrastructure affecting passage or vision	Holes, ice patches, maintenance holes, uneven ground, edges of asphalt, leaves, gravel, pools of water, fruits or nuts from trees, vehicles, 'zig-zag' railing before road crossing, rumble stripes, tunnels, buildings	+
CF4. Dividers between lanes (V)	Elements increasing the distance between lanes	Stones, trees, cobble stones, spacing, railings, fences	–
CF5. Elevations for cyclist (E)	Elevation changes from one point to another	Hills, bridges, high ground to low ground and back to high ground again	+
CF6a. Lanes for car drivers (L_D)	Travel paths for car drivers	Car roads, highways, cyclist boulevards, Shared roads with car drivers and cyclists	+
CF6b. Lanes for cyclists (L_C)	Travel paths for cyclists	Bike lanes, cyclist boulevards, shared roads with pedestrians and cyclists, shared roads with car drivers and cyclists	–
CF6c. Lanes for pedestrians (L_P)	Travel paths for pedestrians	Pedestrian roads, shared roads with pedestrians and cyclists	+
CF7. Shortcuts for cyclists (S_C)	Short trajectory segments allowing for easier passage	Segments having less interaction with other road users, with less obstacles, being less uphill	–

1. Relation to number of interactions and amount of effort. Plus sign implies more and minus sign implies less.
2. Parked vehicles is a dynamic destination. Car drivers are pedestrians after they step out or before they step into the vehicle.

3.2 Relationship between contextual factors (layouts) and resulting behaviour

The importance of the *contextual factors (CF)* is that they result in different behaviours (see figure 2-7 for some examples). Cyclists will generally keep to a similar speed if they perceive it possible to change their trajectory. If they don't perceive it possible, they will decrease their speed or stop. Most CF:s will likely result in a trajectory-changing behaviour, if placed on one side of a bike lane (e.g. figures 2, 3) while if they are placed on both sides the resulting behaviour will likely be to decrease speed.

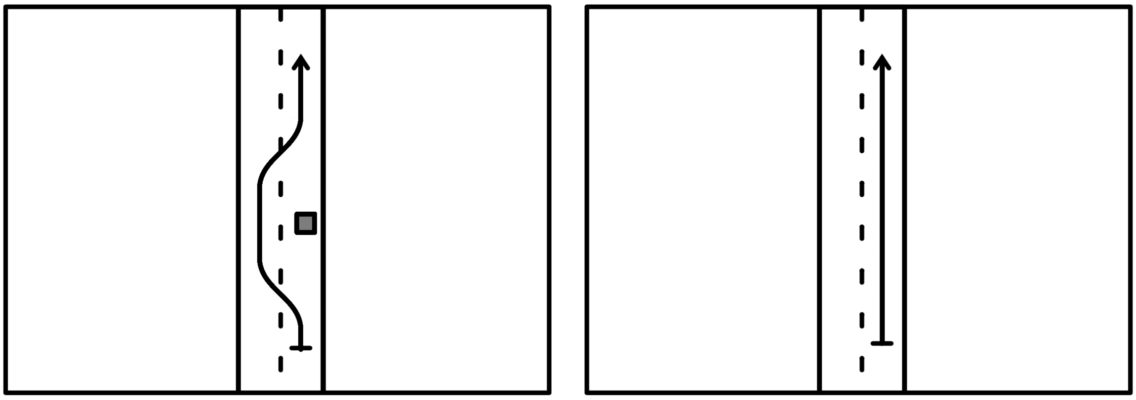

Figure 2. Obstacles for cyclists. *Left:* Cyclists are more likely to change trajectory as they wish to ride more comfortably or safely, or both (e.g. hole). *Right:* Cyclists are less likely to change trajectory as there exist no apparent reason.

Figure 2a. The rugged maintenance holes on the ground to the right acts as obstacles for cyclists. The cyclists travels to the left.

Nothing acts as obstacles for cyclists. The cyclist travels to the right.

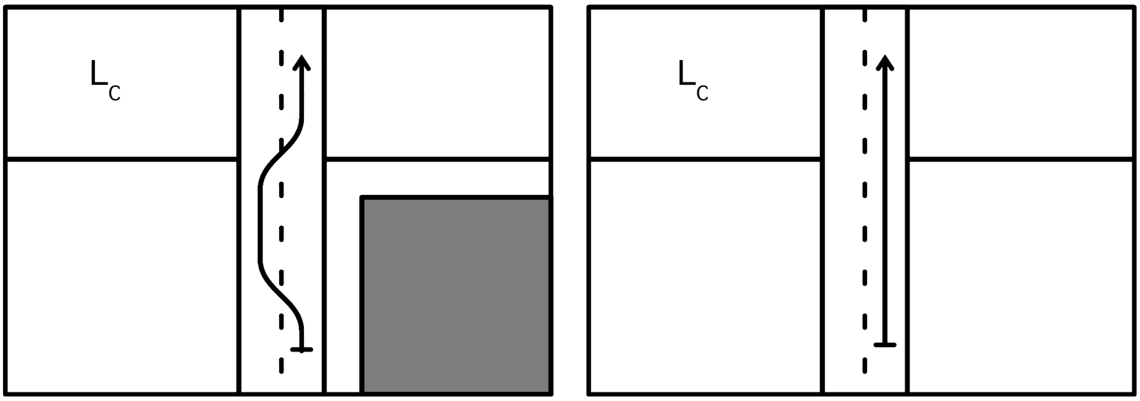

Figure 3. Obstacles for cyclists. *Left:* Cyclists are more likely to change trajectory as they wish to anticipate crossing traffic (e.g. view-obstructing building). *Right:* Cyclists are less likely to change trajectory as there exist no apparent reason.

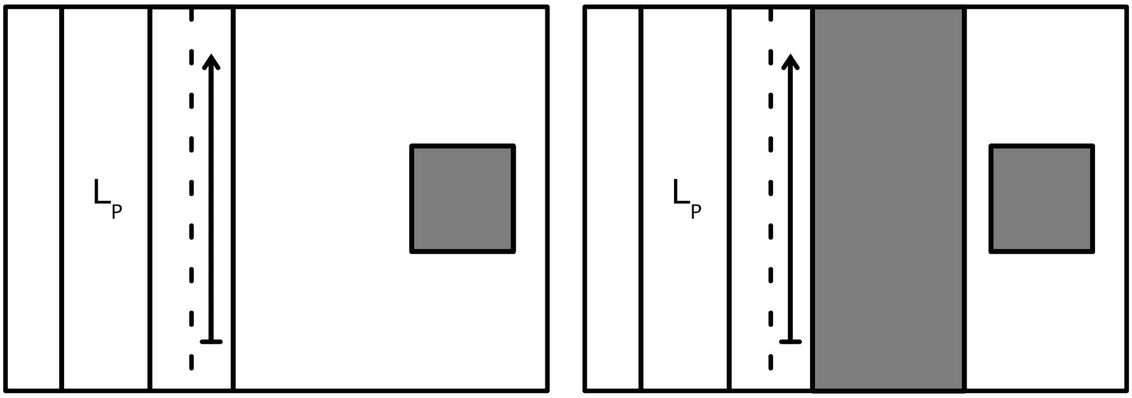

Figure 4. Obstacles for pedestrians. *Left:* Cyclists are more likely to interact with pedestrians, as they are more likely to cross (e.g. shop). *Right:* Cyclists are less likely to interact with pedestrians as they have less reason to cross (e.g. river).

Figure 4a. The narrow low-speed road does not act as an obstacle for the pedestrians to the left.

The wide high-speed road to the right acts as an obstacle for the pedestrians on the left.

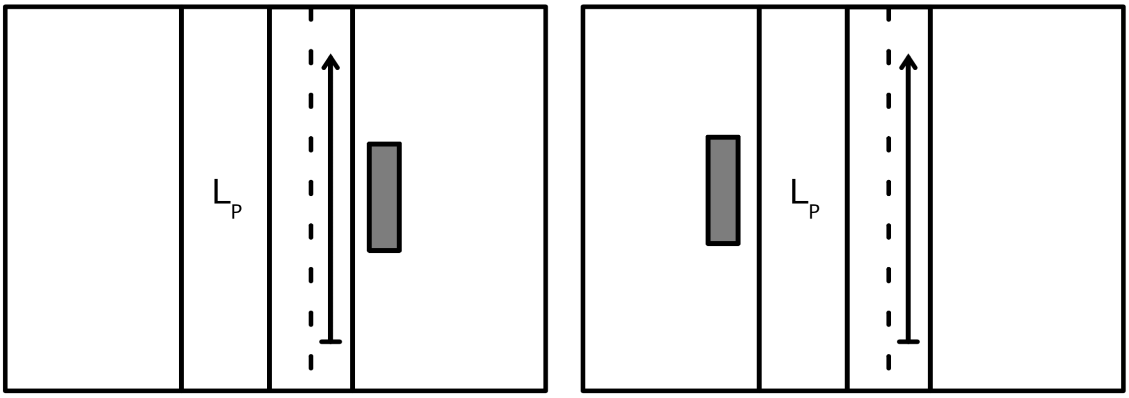

Figure 5. Destinations for pedestrians. *Left:* Cyclists are more likely to interact with pedestrians, as they are more likely to cross (e.g. bench). *Right:* Cyclists are less likely to interact with pedestrians as they have less reason to cross.

Figure 5a. The bench and bin to the left acts as destinations for the pedestrians walking to the right.

The bench and bin to the right act as destinations for the pedestrians walking to the right.

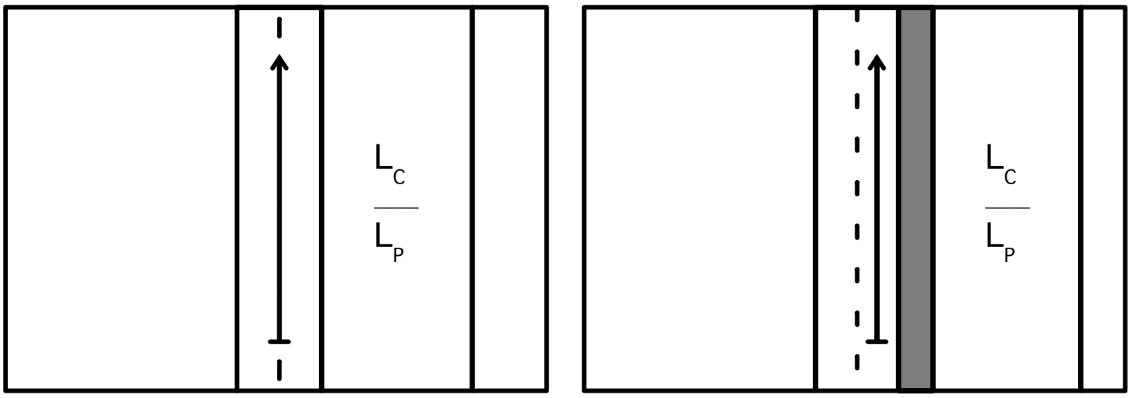

Figure 6. Dividers between lanes. *Left:* Cyclists are more likely to change trajectory as they prefer less interaction with other road users (e.g. open car doors, pedestrians entering bike lane). *Right:* Cyclists are less likely to change trajectory as distance is enough. (e.g. arrangement of grass)

Figure 6a. The lane edge to the right acts as an insufficient divider. Cyclists travel in the middle of lane.

The grass to the right acts as a divider between lanes. Cyclists travel on the right side of lane.

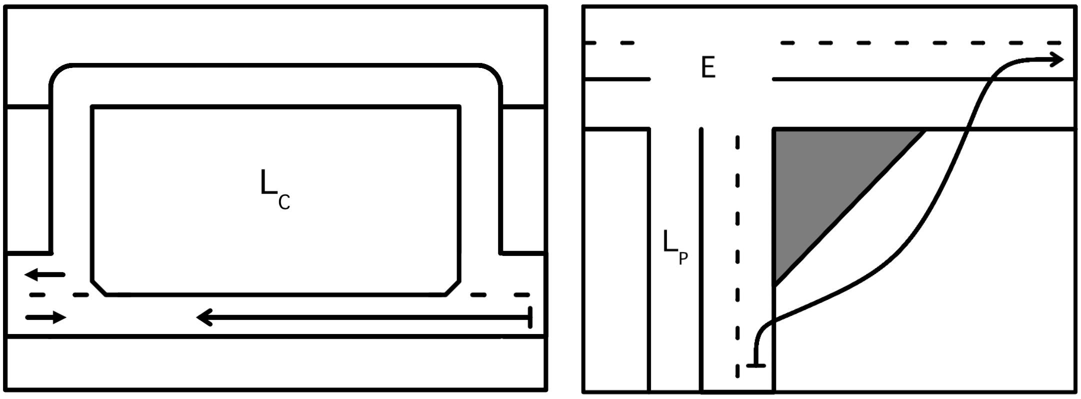

Figure 7. Shortcuts for cyclists. *Left:* Cyclists are likely to travel against the direction as they prefer to travel with less effort and/or risk (e.g. not crossing car road instead of crossing twice). *Right:* Cyclists are more likely to evade crossing if there's an alternative path nearby as they prefer to travel with less effort and/or risk (e.g. a crowded and elevated crossing)

Figure 7a Shortcut. Travelling to the right across a parking lot that eventually connects back to the bike lane… …instead of traveling straight forward, slightly uphill and more interactions with other road users.

Figure 7b Shortcut. Instead of travelling to the left along an S-shaped and narrow road… …the cyclists travel straight forward across a parking lot that eventually connects back to the bike lane.

3.3 Behavioural factors influencing cyclist action

The second group of factors that affects how cyclists behave in traffic, according to our tentative model, are what we choose to call *behavioural factors (BF).* Some of these factors relate to the cyclists themselves, i.e. their personality. Most of the behaviour factors, however, relate to external elements, i.e. are directly dependent on the situation around the cyclist, both other road users and the bicycle infrastructure (see table 2).

Table 2. Categories of cyclist behavioural factors (BF). They relate to bicycle infrastructure (BI) and other road users (ORU). Descriptions are found in table Y.

Behavioural factors	*… related to bicycle infrastructure (BI)*	*… related to other road users (ORU)*
… related to external elements	(BF1) Ambiguity of BI (BF2) Reasonableness of BI	(BF5) Distance to ORU (BF6) Timing to ORU (BF7) Understanding by ORU
	(BF3) Ease of sharing BI with ORU (BF4) Visibility of ORU from BI	
… related to internal elements	(BF8) Values and beliefs of cyclist (BF9) Culture among cyclists	

3.4 Relationship between cyclist behaviour factors and resulting actions

Similar to how contextual factors result in typical behaviours, each behavioural factor (BF) leads to one or more resulting behaviours. The resulting behaviour of each BF occurs if the cyclists perceive it possible to accomplish, which relates both to the environment and nearby road users.

The first Behavioural factor identified is **Ambiguity of Bicycle infrastructure** (BF1). One clear finding is that when there's room for interpretations – as with ambiguous bicycle infrastructure – the cyclists likely approach the same situation in diverse manners. This also results in that other BF:s become more dominant.

Related to BF1 is the **Reasonableness of Bicycle infrastructure** (BF2). Travelling from one point to another should preferably be reasonable – i.e. safe, logical and/or practical – in terms of time and distance. When bicycle infrastructure is perceived less reasonable, the cyclists will likely take shortcuts in terms of timing (e.g. running traffic lights) and distance (e.g.in an empty opposing lane).

Other road users, not surprisingly, have a large effect on cyclists' behaviour. **Ease of sharing Bicycle infrastructure with other road users** (BF3) is a BF that relates to how the individual cyclist perceive sharing the space with others. In particular, sharing space with large motor vehicles is perceived as unsafe – many cyclists try to avoid this. **Visibility of other road users** (BF4) is a behavioural factor stating that when bike lanes don't offer good visibility of other road users, the cyclists will likely increase their distance to view-obstructing objects. In general cyclists strive to keep **Distance to other road users** (BF5). The motivation behind BF4 and BF5 is that visibility and keeping distance benefits responsiveness to other road users' behaviour. When visibility or distance is anticipated to be too limited, cyclists will manoeuvre to increase distance even if it means travelling in the opposite lane or in the pedestrian lane.

In the same way as the presence of other road users will affect behaviour, so will absence. The behavioural factor **Timing to other road users** (BF6) indicate that when there are few nearby road users, the cyclists will likely be liberal in timing (e.g. travelling against red lights) and location (e.g. travel where there is no intended crossings or bike lanes).

The last of the behavioural factors relating to other road users is **Understanding by other road users** (BF7). How one is treated affects one's behaviour. When other road users – particularly drivers of large motor vehicles – don't understand that cyclists are traveling where the bicycle infrastructure tells them to, they will likely treat the cyclists with disapproval. As this could pose a great danger for cyclists, cyclists tend to avoid places where these situations occur.

The two final behavioural factors identified are of a more internal character. The first is **Values and beliefs of cyclist** (BF8) Values and beliefs are personal. When there's room for values and beliefs – as when there's lack of cues on how to act in a specific traffic situation – the cyclists will approach the same situation in diverse manners and other BF:s become more dominant. The final identified behavioural factor is **Culture among cyclists** (BF9). Cultures develop when people have something in common. Behaviours converge partially due to culture but will differ slightly due to personality. As culture is tacit, new cyclists will likely behave in more diverse manners before they assimilate the bicycle culture of a particular city.

4 DISCUSSION

We argue that one important purpose of bicycle infrastructure, besides being a means for transportation, is to converge the behaviour – position, trajectory and speed – of cyclists. The results suggest that this is not always the case in practice. Several factors (BF1, BF2, BF3, BF7, BF8, BF9) hints at a larger theme of ambiguity perceived among both cyclists and other road users. This ambiguity does lead to divergent cyclist behaviour. One can argue that there appears to be a lack of signifiers (Norman, 2008) for both cyclists and car drivers that tells them which actions are possible, for example when a bike lane suddenly ends. Some well-deliberated signifiers might very well lessen the ambiguity of the bicycle infrastructure, and consequently improve road user's understanding of cyclist action.

However, the study also shows that rules and clear signage is not enough. Even if cyclists know they are allowed to travel on a specific lane, they will not do so if they perceive risk or unpleasantry. This implies that clarity alone will not create uniform behaviour among cyclists. Important questions to ask when designing a piece of bicycling infrastructure are therefor - *What are the perceived risks and unpleasantries? How can we minimize them without removing reasonableness and clarity?* In a way, the findings provide dynamic rather than static guidelines. Instead of stating "always place garbage bins on the same side as the pedestrian lane" – we suggest studying a layout and see what problems that are likely to arise based on our model. Then change the layout so that these problems become as unlikely as possible to arise.

5 CONCLUSIONS

One of the fundamental purposes of traffic infrastructure – to create predictability and consensus among road users – falls short by allowing room for interpretation among road users and by specifically triggering diverse behaviour among cyclists. Despite being diverse, and consequently more or less unpredictable, we argue based on our tentative model of *behavioural* and *contextual factors* that cyclists' behaviour is very rational from the perspective of their perceived action space. By understanding how different people interpret the bicycle infrastructure we can make small design changes that have less ambiguity and nudges cyclists towards a more uniform and safe behaviour.

The proposed model can work as a design tool providing dynamic guidelines that grants understanding without being too rigid. For example, by looking at a proposed infrastructure layout and exploring which problems that are likely to arise based on the model, one can adapt the layout in such a way that the identified problems become less likely to arise.

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