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Cyclist efficiency and its dependence on infrastructure and usual speed

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ABSTRACT

Bicyclists are a heterogeneous group, with varying abilities, traffic education and experience. While efficiency was identified as an important factor on utility bicycle trips, it might be traded for experienced safety, for example by choosing different pathways in a given situation, or by relinquishing one's right of way. In a semi-controlled study with 41 participants, a grouping was made according to self-reported riding speed in relation to other cyclists. The participants cycled twice along a 3 km inner-city route, passing four intersections with different priority rules. The cyclists were free to choose how to negotiate the intersections. Speed and the traffic surroundings were recorded via gps and cameras on the bike of the participant and of a following experimenter. For each cyclist, the 'base' speed on undisturbed segments was determined as reference. Based on this, the efficiency in different types of intersections was computed per cyclist group. It turned out that infrastructural aspects, cyclist group and the presence and behaviour of interacting traffic influenced cyclist efficiency. Faster cyclists were delayed more when the infrastructure required a stop regardless of the traffic situation, like at a red traffic light or a stop sign. The members of the so-called 'comfort cyclists' group were delayed the most in a roundabout with mixed traffic, where many chose to get off their bike and walk. In a society working for equality of access to the transport system, it is recommended to develop solutions that consider and accommodate the behaviours of different cyclist groups when planning bicycling infrastructure.

1. Introduction

While traffic safety is a much discussed and researched topic, our main reason to take part in traffic is typically to get somewhere, and often the intention is to do so efficiently. This assumption is rarely disputed for motor vehicles, but in many countries, it is not as self-evident that bicycles are vehicles, whose riders have an interest in getting to their destination efficiently, and safely. Only recently this need has been acknowledged by some municipalities, with the introduction of so-called cyclist highways or superhighways (Jensen, 2013). However, so far, the measures related to bicycle infrastructure are isolated, differ between countries, and are characterised by a lack of a proactive approach, except for in the Netherlands

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(Wegman, Zhang, & Dijkstra, 2012). Currently, in many European countries, cyclists are largely subject to the same rules as motorised traffic, however, at the same time they are often recommended, or even required, to use bikeways, if provided. The infrastructure for cyclists has often been put in place retroactively, such that it is not always well connected, and there are many instances, in which cyclists and pedestrians are expected to share the same space, even though speeds and needs differ (Latham & Wood, 2015). Still, evidence exists that infrastructural aspects influence the willingness to cycle (Buehler & Pucher, 2012; Dill, 2009; Hull & O'Holleran, 2014).

Compared to motorised road users, who, in normal traffic, are able to move their vehicles at comparable speeds, regardless of the capabilities of the driver or the vehicle, cyclists are a much more heterogeneous group. They vary more than car drivers in age, physical and mental capability, and in their formal education about traffic rules. Some attempts have been made to categorise cyclists into groups, either through observation or via questionnaires (Bergström & Magnusson, 2003; Damant-Sirois, Grimsrud, & El-Geneidy, 2014; Dill & McNeil, 2013; Gatersleben & Haddad, 2010; Geller, 2006; Jensen, 1999; Kroesen & Handy, 2014). Groupings are made either with respect to the cyclists' propensity to cycle at all, for example based on the season, or as a general attitude, or how cyclists are perceived in their relationship to their bike and other road users, or how comfortable they are either using bicycle infrastructure or the roads.

Especially the latter has been discussed extensively (Forester, 2001; Laird, Page, & Shen, 2013; Lusk et al., 2011; Parkin, Wardman, & Page, 2007; Pucher, Dill, & Handy, 2010), with no clear consensus for either. Somewhat simplified, bikeway advocates claim that cycling becomes safer by separating cyclists from cars, while the main argument for so-called vehicular cycling is that cyclists are more visible to cars, when they share the same space, and that they are confronted with fewer crossing points with other vehicles' paths. This discussion does not always differentiate enough between different types of cyclists, however. A stated-preference study showed, that cycling in mixed traffic was experienced as less onerous for more experienced cyclists (Hunt & Abraham, 2007).

Cyclists' route choice preferences have been investigated via stated-preference questionnaires (e.g. Börjesson & Eliasson, 2012; Hunt & Abraham, 2007) and GPS-based tracking of cyclists' actual routes (Broach, Dill, & Gliebe, 2012). The study by Börjesson and Eliasson (2012), in which the majority of respondents were commuters in Stockholm, Sweden, revealed that cyclists valued time efficiency highly, along with space and economic efficiency. These factors were more important than the health aspect, showing that cycling should be seen as a competitor to other transport modes for efficiency. The study by Broach et al. (2012) was conducted in Portland, Oregon, with 164 cyclists, who reported riding at least once a week. When modelling the cyclists' preferences, short distances, but also routes avoiding turns, intersections and steep inclines were preferred, confirming that efficiency matters for cyclists. When given the choice, separated bike paths were preferred, as were streets with low traffic volumes.

While efficiency seems to be an important factor for cyclists, the actual attitude towards cycling speed and efficiency has not been a prominent factor in the cyclist categorisations mentioned above. Therefore, in the present study, a crude self-reported measure of cycling speed was used as grouping factor during recruiting.

Apart from speed, cycling efficiency is influenced by how cyclists deal with the traffic system itself, which is largely constructed with motorised traffic as benchmark. Regardless of whether there is a separated bicycle infrastructure available or not, there will always be crossing points, in which road user groups meet, and where certain rules of priority apply. One basic precondition for making an informed decision about rule compliance is rule knowledge. Compared to motorists, cyclists have not necessarily undergone a formal education about traffic rules, and it was shown that in children, rule knowledge increased with age (Van Schagen, Brookhuis, & Wierda, 1988). Even if cyclists are aware of the rules, their being based on motorised traffic, and therefore also being more applicable to motorised traffic, may lead to a negative attitude towards them (Aldred, 2013). A survey amongst cyclists and drivers about the perceived rule-following behaviour and predictability of the two road user groups showed, that drivers were generally perceived as more rule-following and predictable. This perception was especially strong in the group of drivers who never cycled (Goddard, Dill, & Monsere, 2016). An explanation for the perceived worse behaviour of a whole road user category is the possibility that in a system built for cars it is more difficult for cyclists to follow the rules and behave predictably.

When cycling, just as with many other aspects in life, people can either follow a known rule by principle, that is, they will always follow the rule, or they can be opportunistic rule followers (e. g. Pai & Jou, 2014), that is, follow the rules whenever they suit one's purposes, or they can disobey the rule by principle. The factors behind such behaviour can be connected to the perceived consequences of the behaviour, but also to social norms, or simply to the common understanding that rules provide a structure, which enables a smooth functioning of the system as a whole (McAdams, 2015).

For the present study, a semi-controlled field study design (Kircher, Eriksson, Forsman, Vadeby, & Ahlstrom, 2016) was chosen to investigate efficiency in intersections of different design and with different priority rules on a microscopic level, in contrast to the macro-perspective taken by stated-preference and travel-pattern studies. Thus, different groups of cyclists could be studied in the same environment, while still operating according to their own behavioural choices. This allowed for an assessment of how different infrastructural designs, as well as the cyclists' rule compliance and interactions with other road users, influence efficiency in terms of travel time.

Specifically, the main research questions investigated here were: Does the design of the infrastructure influence cyclist efficiency, and if so, how, and does this depend on cyclist type, operationalised via self-assessed relative speed?