Evidence for the 'safety in density' effect for cyclists; validation of agent-based modelling results

Dr Jason Thompson[1,2], Dr Jasper S. Wijnands[1], Dr Suzanne Mavoa[3], Katherine Scully[1], Professor Mark Stevenson[1]

[1]University of Melbourne, Transport, Health and Urban Design Research Hub, University of Melbourne, Australia, Ph +61 3 83447782, [2]University of the Sunshine Coast, Human Factors and Socio-Technical Systems Research Unit, [3]University of Melbourne, School of Population and Global Health

Abstract

Time-gap analysis of cyclists passing through an intersection was conducted using five hours of video-observation of a single intersection in Melbourne, Australia, where motorists were required to 'yield' to oncoming cyclists. Results demonstrated that potential collisions between motor-vehicles and cyclists reduced with increasing cyclists per minute in a manner analogous to the SiN effect. These results successfully validate 'synthetic' data gathered using agent-based models, supporting evidence of a proposed causal mechanism related to safety in density (SiD) rather than safety in numbers, per se. Results suggest that increased cyclist safety may be achieved through creating high-density strategic cycling corridors.

Background, Method, Results and Conclusions

The safety in numbers (SiN) effect for cyclists is a widely referenced and observed, but poorly understood phenomenon(Bhatia & Wier, 2011; Christie & Pike, 2015; Elvik & Bjørnskau, 2017). Although a wide range of academic and applied studies cite SiN as a potential solution to car vs cyclist crashes (Elvik & Bjørnskau, 2017; Fyhri, Sundfor, Bjornskau, & Laureshyn, 2016; Jacobsen, 2003; Robinson, 2005; Tin, Woodward, Thornley, & Ameratunga, 2011), there is little definitive evidence to guide policy-makers or transport planners in how to use SiN to create a safer cycling environment beyond simply encouraging 'more cyclists' into the system.

Results of agent-based models (ABMs) have shown the SiN effect can be replicated in simulated systems that lead to the formation of higher-density cyclist groups, indicating that the safety effect is a simple spatial mechanism rather than a result of learned behaviour by drivers. While acknowledged as a potential mechanism (Jacobsen, Ragland, & Komanoff, 2015), this 'safety in density' hypothesis has been criticised from the perspective that no in-situ empirical evidence exists that cyclists 'cluster' in the real world. The focus of this study was therefore to observe micro-level interactions of cyclists and vehicles at an intersection mirroring that created in prior ABMs to determine how cyclist density is associated with potential crash risk.

Method

Data collection occurred through recording 5 hours of video naturalistic traffic behaviour at an inner-city Melbourne cross-intersection. Coding of time-stamped video footage of car and cyclist interactions enabled the calculation of variables, including:

- the time gap of approaching cyclists to the intersection at the instant when drivers arrived at the intersection (sec);
- number of cyclists each driver gave way to before moving away from the intersection (n);

- time gap between each cyclist passing through the intersection (sec); and
- frequency of cyclists passing through the intersection (cyclists / min).

Results

The frequency of potential collisions (y) was modelled using the number of cyclists per minute (x) as a single explanatory variable. Potential collisions and the number of cyclists were counted each minute across the total five hours of captured video footage, resulting in an appropriate sample of cyclist density and potential collision counts (n = 385). The potential collision count was modelled using Poisson regression.

Parameter estimates are presented in Table 1 indicating that the number of cyclists per minute was strongly associated with potential collision risk for cyclists. Figure 6 shows this relationship in more detail, demonstrating that as the number of cyclists per minute moving through the intersection increased, the risk of collision per cyclist decreased dramatically up to the point of 8-10 cyclists per minute. This effect of cyclist density on collision risk was independent of behavioural adaptation by drivers.

Table 1. Parameter estimates of Poisson regression.

	Estimate	Std. error	z value	P(>|z|)
(Intercept)	0.57	0.07	8.11	.000
Number of cyclists	0.04	0.01	5.02	.000

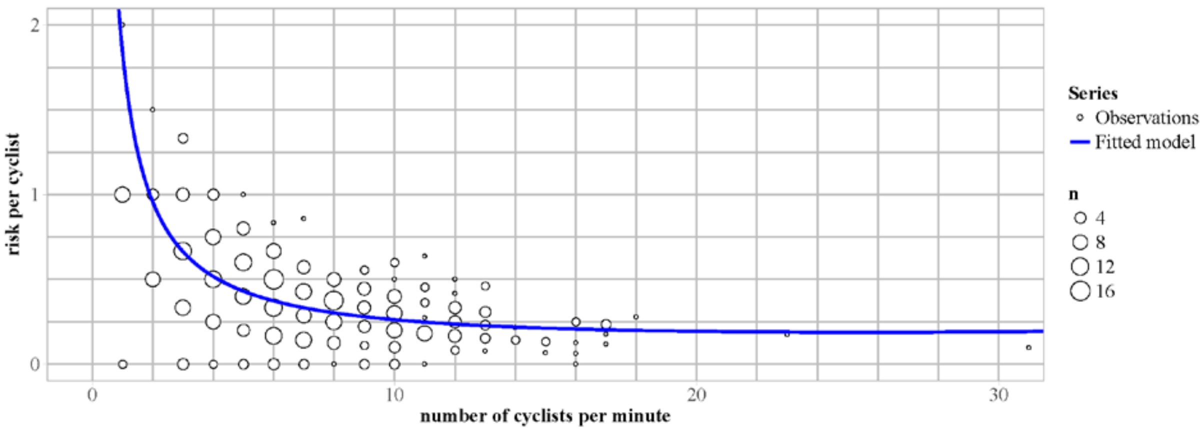

Figure 6. Potential crash risk with increasing count of cyclists per minute.

Conclusions

This study provided empirical validation of the ‘Safety in Density’ hypothesis’ operation in a real-world situation. It demonstrated that reduced crash risk was associated with reduced time-gaps between cyclists passing through intersections, which prevent motor-vehicles from attempting to move between on-coming cyclists (gap rejection). Using a methodology based on prior theoretical experimentation using ABMs, this work has provided further support for a candidate causal mechanism underlying the widely observed general relationship between cycling volumes and safety; one that has thus far eluded comprehensive explanation in the cycling safety literature.

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