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Safety effects of permanent running lights for bicycles: A controlled experiment

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ABSTRACT

Making the use of daytime running lights mandatory for motor vehicles is generally documented to have had a positive impact upon traffic safety. Improving traffic safety for bicyclists is a focal point in the road traffic safety work in Denmark. In 2004 and 2005 a controlled experiment including 3845 cyclists was carried out in Odense, Denmark in order to examine, if permanent running lights mounted to bicycles would improve traffic safety for cyclists. The permanent running lights were mounted to 1845 bicycles and the accident rate was recorded through 12 months for this treatment group and 2000 other bicyclists, the latter serving as a control group without bicycle running lights. The safety effect of the running lights is analysed by comparing incidence rates – number of bicycle accidents recorded per man-month – for the treatment group and the control group. The incidence rate, including all recorded bicycle accidents with personal injury to the participating cyclist, is 19% lower for cyclists with permanent running lights mounted; indicating that the permanent bicycle running light significantly improves traffic safety for cyclists. The study shows that use of permanent bicycle running lights reduces the occurrence of multi-party accidents involving cyclists significantly. In the study the bicycle accidents were recorded trough self-reporting on the Internet. Possible shortcomings and problems related to this accident recording are discussed and analysed.

1. Background

By October 1st 1990 it was made mandatory for car users to use daytime running lights in Denmark. The safety effects of this legislation were documented through simple before–after studies by Hansen (1993, 1995). It was concluded that the introduction of daytime running lights had reduced the number of accidents – especially accidents involving more than one party. In 1996, Elvik (1996) conducted a meta-analysis estimating the mean effect of introducing daytime running lights to motorized vehicles. The mean effect was estimated to a 3–12% reduction in the occurrence of multi-party daytime accidents. In the "Handbook of traffic safety measures" (Elvik et al., 2009), the effect of making daytime running lights mandatory for motorized vehicles is estimated to 5–10% reduction in daytime multi-party accidents, and it is documented that the effect varies between different types of accidents.

The Danish Road Safety Commission formulates objectives and strategies for the Danish road safety work. For several years, the improvement of road safety for cyclists has been singled out as an area of special priority by the commission (Danish Road Safety Commission, 2001). Bicyclists have been declared a high risk group. In the beginning of the last decade, when this project was initiated, the number of cyclists killed in road traffic in Denmark amounted to 50–60 persons per year; the total number of injured cyclists recorded by the police amounted to 1500–1750 persons per year (Danmarks Statistik, 2003). In terms of accident risks the number of cyclists killed and seriously injured per kilometre travelled is more than 9 times higher than the number of car-users killed or seriously injured per travelled kilometre (Brems and Munch, 2008). More over, accidents involving cyclists are in general more severe than accidents not involving cyclists (Madsen, 2005). The safety problems related to cyclists are unfortunately even bigger than the official statistics based on police recordings indicate. This is due to a severe underreporting of accidents involving cyclists. Comparisons between police recordings and hospital recordings of people injured in road traffic accidents shows that only 15% of the total road traffic injuries are in fact recorded by the police. When it comes to injured cyclists only 6% of the injuries are recorded by the police (Danmarks Statistik, 2009). Consequently, the number of injured cyclists equals the number of injured car-users on a yearly basis in Denmark even though the total number of passenger-kilometres for cars is more than 20 times higher than for bicycles (Statistics Denmark, 2009).

Faced with climatic changes and in order to improve public health it has been and still is a national Danish priority to change modal-split and specifically move trips from car to bike. Given the

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higher risks related to transport by bike, the task of identifying measures that can effectively improve traffic safety for bicyclists is of special interest in Danish road safety research. One theory as to why the accident risk is higher for bicyclists is that cyclists are less visible in traffic. In that context studies by Williams and Hoffmann (1979), Thomson (1980) and Wulf et al. (1989) indicate that poor visibility may explain why the accident rates are especially high for moped users and motorcyclists. In-depth studies of accidents involving cyclists made by the Danish Road Traffic Accident Investigation Board indicate that this too may be the case for cyclists (Havarikommission for Vejtrafikulykker, 2008).

1.1. Running lights for bicycles; hypothesis of effect

In order to improve the visibility of mopeds and motorcycles, the use of daytime running lights had already been made mandatory in Denmark several years before daytime running lights was made mandatory for cars. According to Elvik et al. (2009), the average effect of introducing mandatory use of daytime running lights for mopeds and motorcycles is a 7% reduction in multiparty daytime accidents involving motorcycles and mopeds.

In the wake of the positive effects of introducing daytime running lights for motor vehicles, the possibility of introducing a running light for cyclists was discussed. The idea was that positive safety effects were likely for two reasons: (I) A permanent running light for bicycles would improve the visibility of bicyclists during daytime, where cyclists normally do not use their conventional bicycle lights. (II) With a bicycle running light permanently fixed to the bike, the problem of cyclists forgetting their conventional bicycle light when it is dark or in the twilight period would be eliminated. Consequently introducing a permanent bicycle running light should in general lead to an improvement of the visibility and hence the safety of bicyclists during daytime, twilight and night time hours. As visibility should be improved, the key hypothesis is that the use of bicycle running lights will reduce the occurrence of multiparty accidents involving cyclists.

1.2. Bicycle running lights technology

The idea of introducing a permanent bicycle lights for cyclists was for several years hampered by the lack of a convincing technical solution. However, in 2002 the Traffic Research Group at Aalborg University and the Municipality of Odense; the latter in the capacity of being the national cycling city of Denmark, were introduced to a new type of bicycle light; manufactured by the Danish company Reelight, which had the potential to serve as a permanent running light for bicycles. The light is based upon the electro-dynamic induction principle. Two magnets are fixed to the each of the spokes of both wheels and the lights are mounted to the front and the rear wheel fork. When the magnets passes the light an electric current is induced, which makes the lights flash, when the wheels are rolling. Both the front and rear light is equipped with two diodes. As opposed to the classical dynamo set; the new magnet lights are silent and more or less free of friction. In comparison to battery lights; the magnet light does not require any batteries and the light is on the moment, the wheels are rolling. Photometric information on the lights is available in Table 1.

As the magnet lights are fixed permanently to the bike, are battery-free and requires little maintenance; problems of forgetting the lights and/or batteries being flat should be eliminated. Since the lights are on, when the wheels are rolling, the hypothesis is that such permanent driving light will improve the visibility of cyclists under all circumstances thus reducing their accident risk. However, there are downsides to the design of the running lights. First of all, they only flash, when the magnets pass the light; consequently they would not flash, when the bike was not moving e.g. at intersections. Secondly the lights were placed at low positions on the forks; depending on the size of the bike up to 0.4 m above the ground, thus reducing the visibility of the lights in comparison to most traditional battery operated bicycle lights, where the front light is typically mounted on the handle bar.

Table 1
Photometric intensity in candela at selected angles for the bicycle running light used in the project. Positive values denote angles to the right hand side of the light seen from the light.

Vertical angle 0°	Horizontal angle				
	−80°	−20°	0°	20°	80°
Front light outer diode	0.02	0.22	4.43	3.74	0.05
Front light inner diode	0.05	0.59	5.50	2.15	0.05
Rear light outer diode	0.02	0.23	2.76	0.85	0.08
Rear light inner diode	0.07	0.46	3.56	0.83	0.05

2. Experimental design

At the time of introduction, the magnetic lights were in fact illegal as the use of flashing front lights was prohibited in Denmark. In combination with the downsides related to the design; Danish authorities would not approve the running lights until the safety effects of the lights had been examined. The Municipality of Odense and the Traffic Research Group were therefore granted permission to perform a test of the bicycle running lights in Odense with the aim of documenting positive as well as negative safety effects related to the bicycle running lights.

Many road safety evaluation studies are carried out as observational before–after studies. This is generally also the case for earlier studies of the safety effects of daytime running lights for motor vehicles. However, Elvik (1993, 1996) states that observational before–after studies may not provide sufficient control for confounding factors that may have affected the outcome of the evaluation. In comparison controlled experiments are deemed to provide a better control for confounding factors in studies of this type, see e.g. Hauer (1997). Consequently, such study design was adopted in the evaluation of the safety effects of bicycle running lights.

2.1. The controlled experiment

The basic concept of the controlled experiment is to create a minimum of two experimental groups; one group that receives treatment (the treatment group) and one group that does not receive treatment (control group). Ideally the two groups must be identical with respect to extraneous factors influencing the outcome of interest, so that if none of the groups were treated the outcome recorded in time T for both groups would be the same. Consequently the effect of the treatment can be found by comparing the outcome of interest in time T for the treatment group and the control group. In order to obtain the desired control for confounding factors, the experimental units must however be allocated to the treatment and the control group at random; i.e. through randomization (Rothman et al., 2008).

2.2. Self-reporting of accidents

In the given case the outcome of interest is accidents by bike for both the treatment and the control group. Ideally the police should record all accidents by bike, but as described above only 5–10% of all injured cyclists are recorded by the police. Hence, if the study was to be based upon police recordings of bicycle accidents involving persons from the treatment and the control group, both experimental groups would have to be very large in order to safely evaluate