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Emotional reactions to cycle helmet use

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ABSTRACT

It has been suggested that the safety benefits of bicycle helmets are limited by *risk compensation*. The current article tests if previous helmet use influences the response to helmets as a safety intervention. This was investigated in a field experiment where pace and psychophysiological load were measured. We found that after having removed their helmets, routine helmet users cycled more slowly and demonstrated increased psychophysiological load. However, for non-users there was no significant change in either cycling behaviour or psychophysiological load. We discuss the implications of these results for a hypothesis of risk compensation in response to helmet use. We also show that heart rate variability is a promising measure of psychophysiological load in real-world cycling, at least in situations where there is limited physical demand.

1. Introduction

Do bicycle helmets have safety benefits? While case–control studies show injury reducing effects of bicycle helmets (Thompson et al., 2000; Attewell et al., 2001) evidence from countries that have introduced helmet laws indicate no reductions in head injuries over and above those observed for other injuries (Robinson, 2006, 2007). One explanation for that lack of helmet law effects is the population shift hypothesis, which holds that such laws generally reduce the number of cyclists, and that the cyclists remaining after the law is introduced are those who take the most risks. In line with this idea, a recent study found that helmet use is greater among a subpopulation of cyclists who to tend cycle aggressively and use safety equipment as part of their cycling identity (Fyhri et al., 2012).

An alternative explanation for the lack of helmet effect on injury levels is that of risk compensation, which holds that any reduction in perceived risk effected by helmet will be compensated for by the wearer, who may for example cycle faster or take more risks (Robinson, 2006; Adams and Hillman, 2001). This explanation also finds a certain empirical support, with one study finding that children running over an obstacle course were less cautious when wearing a helmet and a wrist-guard (Morrongiello et al., 2007). However, there is to date no evidence of risk compensation by cyclists in response to bicycle helmet wearing. The present paper attempts to address the theory of risk compensation in a field experiment with cyclists.

1.1. Risk compensation

The concept of risk compensation is often used in the domain of *driver behaviour* research, where it describes how perceived risk influences driving behaviour. Related to this is Wilde's (Wilde, 1994) *target risk theory* (more commonly known as risk homeostasis theory). Such models predict that the driver's behaviour is motivated by the goal of achieving a certain outcome related to risk level. For Wilde's model this outcome is a targeted risk level that differs between individuals, but that is fairly static within society as a whole. By weighting potential risk benefits, risk costs, safety benefits and safety costs the individual seeks to achieve risk homeostasis at a level that by definition is greater than zero. In another well established model, Näätänen and Summala's *zero risk theory* (Summala, 1988), the desired outcome is zero risk, i.e. drivers monitor risks, adapt their behaviour and pace their driving speeds according to a perception where the level of risk of an accident is experienced as zero.

Within the tradition of driver behaviour research, risk perception is rarely measured as such, it is only inferred from observed behaviour or accident rates. This contrasts with research on *risk perception* where the aim is to gain a further understanding the components of risk perception, but where behavioural outcomes are rarely measured (af Wåhlberg, 2001).

It has been claimed that support for or against risk compensation needs to be gathered using a research strategy based in both driver behaviour and risk perception traditions. In other words there is a

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need to measure risk perceptions *and* link them to any changes in associated safety behaviours (Phillips et al., 2011).

1.2. Measuring risk

Measuring behaviour is relatively straightforward. In the case of cyclists, it can be assumed that change in cycling pace as controlled by the pedals and the brakes, will be the main indicator of any risk compensation that manifests itself in cyclist behaviour. The greater challenge, however, lies in being able to measure any accompanying changes in perceived risk.

Perceived risk is only experienced subjectively. As such it can either be measured explicitly, by asking the subject to report on his or her own perceptions, or implicitly, by measuring the effects of perceived risk on physiological (e.g. heart rate) or behavioural outcomes. While explicit measures may be more valid, they are less objective, and thus less reliable. For this reason it is considered best to take both explicit and implicit measures and take corresponding changes in those measures as evidence of perceptions. Since when measuring risk compensation we are already looking to observe what potentially is a behavioural outcome of perceived risk (i.e. cycling pace), it would be important to consolidate self-reports of perceived risk with a measure of accompanying psychophysiological changes. Importantly, such an approach would also enable the detection of changes in the emotional component of perceived risk, which several authors claim have been overlooked by previous research (Näätanen and Summala, 1976; Zajonc, 1980a; Summala, 1985; Finucane et al., 2000a).

The role of emotions in making judgements and evaluating risk has long been promoted (Zajonc, 1980b; Finucane et al., 2000b). It is also accounted for by theorists in models of time-limited car driving, as well as cycling and other control of self-movement (Näätänen and Summala, 1976). The notion of "emotional heuristics" proposes that safety margins and emotional risk work as heuristics in driving as well as in dynamic decision making in hazardous situations (Summala, 1985). More recently, Vaa expanded on attempts to include emotions as a guiding principle in risk monitoring by road users (Vaa, 2003). Despite these accounts, there are few attempts to account for emotion as a major component of risk perceived by road users in traffic using objectively measured emotional reactions (Mesken, 2002).

Psychophysiological measures have often been used as indicators of cognitive and emotional challenge (Myrtek et al., 2005). One indicator used to measure emotions in car driving is heart rate variability (HRV), which describes the variability in R–R intervals (effectively the time between two successive heart beats) (Mesken, 2002).

The present study builds on a previous experimental study, which showed that when not wearing a helmet, routine helmet users reported higher experienced risk (explicit measure) and cycled more slowly, but that there were no such differences when helmet use was varied for cyclists unaccustomed to their use (Phillips et al., 2011). These results were consistent with the notion that regular helmet users compensate for a reduction in experienced risk by increasing the riskiness of their cycling. Although HRV was used as an implicit measure of perceived risk in this study, there were no significant changes in this measure accompanying the change in explicitly reported risk perception (Phillips et al., 2011). One explanation for this is that there was inadequate control of the variation in physiological load due to pedalling, which may have obfuscated any change in psychological challenge measured by HRV. The interference from varied physiological challenge also made it difficult to use the preferred *sd1/sd2* measure of HRV, which reflects the variation in successive R–R intervals and variation in heart rate over the longer term. Rather, HRV was measured using *pNN10* (the percentage of successive R–R intervals exceeding 10 ms), which made it difficult to control for changes in heart rate over the longer term.

1.3. Aim

The main goal of this study was to test the hypothesis that behavioural change due to the introduction of bicycle helmets only occurs among cyclists *who have become accustomed to wearing a helmet*. A secondary aim was to see if reductions in psychophysiological load experienced when wearing a helmet could be observed objectively if there are no variations in physical load due to pedalling, and where a more appropriate measure of HRV is used. In order to control for self selection effects typical for voluntary safety devices such as helmets (McGuire and Smith, 2000; Lajunen and Rasanen, 2004), a controlled experimental design was used (Streff and Geller, 1988).

2. Method

2.1. Procedure

A field experiment was carried out at two sites in Oslo in October 2009. The first test strip was a cycle path (Makrellbekken; 0.9 km), the second a cycle lane (Kongsveien; 1.4 km). The test sites were chosen because they sloped gently downhill, allowing participants to freewheel, and because there was little traffic, which made it unlikely that pedestrians or cars would affect cycling behaviour.

Participants were recruited from nearby colleges. They were taken by car to the top of the hill they were to cycle down. They were fitted with a heart rate monitor and asked to sit and rest for 2 min while a baseline measure of their heart rate was recorded. Test bicycles fitted with a speedometer were provided. The participant was then instructed begin pedalling downhill. In order to control for physical load, participants were instructed to stop pedalling after a short standardised distance (0.1 km) at the start of each run. The point at which they had to stop cycling was marked with a sign.

In an attempt to increase the difference in measures between the helmet-on and -off conditions, all participants were instructed to cycle using one-hand in both conditions.

2.2. Instruments

Heart rate and raw R–R interval data was recorded using a Polar RS800cx wrist watch computer with associated heart rate sensor mounted on a chest strap. The raw R–R data was used to generate sd1, sd2 and pNN values. Speed was measured by a calibrated Polar Speedometer 2.0 mounted onto the front wheel of each of two test bikes. Participants did not use their own bikes. The size of bicycle and seat level was adjusted to suit the height of the participants. Pace data (min/km) was recorded by the Polar watch computer and the data analysed using the ProTrainer5 software. Each participant was asked to wear their own helmet either in the first or second round of cycling. If they did not arrive with a helmet they were loaned one. Psychophysiological measures (sd1/sd2) only from the freewheeling period were used in the analyses. An increased ratio of sd1/sd2 implies a decreased psychophysiological load.

2.3. Participants

The participants were 27 college students aged 16–46 (mean age 22.1, std. dev 6.7). Only four of the participants were male. Nine of the participants were regular bicycle users (cycling more