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Reading cyclist intentions: Can a lead cyclist's behaviour be predicted?

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ABSTRACT

As a cyclist, it is essential to make inferences about the intentions of other road users in order to anticipate their behaviour. There are official ways for cyclists to communicate their intentions to other road users, such as using their arms to point in the intended direction of travel. However, in everyday traffic cyclists often do not use such active forms of communication. Therefore, other visual cues have to be used to anticipate (critical) encounters or events. During this study, 108 participants completed a video internet survey in which they predicted the intentions of a lead cyclist based on visible behaviour preceding a turning manoeuvre. When the lead cyclist approached the intersection, each video was stopped just before the cyclist initiated turning. Based on visual cues, the participants had to select which direction they thought the cyclist would go. After entering their prediction, they were asked how certain they were about their prediction and on which visible behaviour(s) each prediction was based. The results show that it is very hard to predict the direction of a turning cyclist based on visual cues before the turning manoeuvre is initiated. Exploratory regression analyses revealed that observable behaviours such as head movements and cycling speed were related to prediction accuracy. These results may be used to support cyclists in traffic interactions.

1. Introduction

Although the health benefits of cycling (Oja et al., 2011) and its positive effects on the environment are well-known, cyclists are very vulnerable in case of accidents. In the Netherlands, 32% of all fatal traffic accidents concerned cyclists (CBS, 2014). Non-fatal cycling accidents typically lead to injuries to the head, face or neck, traumatic brain injuries, spine and back injuries, damage to the torso and injuries to the upper- and lower extremities (Siman-Tov et al., 2012; Juhra et al., 2012; De Geus et al., 2012). Personal factors associated with accident involvement are age (Bíl et al., 2010; Boufous et al., 2012; Schepers, 2012; Siman-Tov et al., 2012; Kaplan et al., 2014; Martínez-Ruiz et al., 2014; Martínez-Ruiz et al., 2015), experience (Schepers, 2012; Poulos et al., 2015) and alcohol and drug use (Twisk and Reurings, 2013; Kaplan et al., 2014). Furthermore, environmental factors related to increased risk and injuries include sharing the road with motorised traffic (Kaplan et al., 2014), involvement of other road users (Heesch et al., 2011), high speed limits (Boufous et al., 2012; Kaplan et al., 2014), cycling in the dark (Boufous et al., 2012; Twisk and Reurings, 2013) slippery roads or paths (Kaplan et al., 2014), curves (Boufous et al., 2012) and poorly visible road elements (Schepers and Den Brinker, 2011). Cyclists are especially at risk in rural areas (Boufous et al., 2012), near intersections (Dozza and Werneke, 2014) and on designated cycling infrastructure (Schleinitz et al., 2015).

In the Netherlands, the majority of cycling accidents are cyclist-only accidents (Schepers, 2013), although conclusive statistical evidence is lacking due to an underreporting of bicycle crashes (Wegman et al., 2012; Schepers, 2013). Frequent types of cyclist-only accidents are a loss of balance, colliding with an obstacle, or entering the verge (Schepers and Klein Wolt, 2012). However, a considerable amount of cyclist-only accidents are preceded by interaction with another road user (Davidse et al., 2014a). For example, a cyclist misjudging the intentions of another cyclist can lead to a crash (Davidse et al., 2014a,b), suggesting a lack of situation awareness (Endsley, 1995). To limit or prevent these accidents, it is important that cyclists are aware of the presence of other road users and able to make accurate inferences about their intentions. The goal of this study is therefore to assess whether cyclists are indeed capable of predicting the intentions of other cyclists, or whether they would benefit from external support such as technical support systems.

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1.1. Intentions, expectations and situation awareness

According to the Situation Awareness (SA) theory, one cannot reach its destination through traffic safely by merely perceiving the current state of the environment (Endsley, 1995). In order to prevent accidents, it is crucial to make inferences about oncoming events. SA is achieved in three levels, each describing a different step from perceiving individual elements (level 1), combining these into one holistic representation (level 2) to predicting oncoming events involving these elements (level 3) (Endsley, 1995).

Cyclists are supposed to use their arms to communicate their intention, as these cues are easily perceived by other road users (Walker, 2005). Informal signals of intention, such as maintaining a certain position on the road, trailing a foot, or seeking eye contact can be used for SA assessment level 1as well. Furthermore, car drivers may infer whether a cyclist will behave predictably from the cyclist's physical appearance, and adjust their overtaking accordingly (Walker, 2007). For example, Walker (2007) found that car drivers maintain a greater overtaking distance to cyclists who seem inexperienced, and therefore unpredictable (e.g. children), compared to cyclists who seem experienced. Directing the attention to the cyclists' face first might not always be possible nor be the most efficient strategy to assess their intentions, and it may result in a prolonged processing and reaction time (Walker and Brosnan, 2007). Car drivers respond more quickly and accurately when they expect a car in front to make a turn based on the indicator (Muhrer and Volrath, 2010). These are merely a few examples of different cues which can be used during SA assessment level 1 (Endsley, 1995). Apart from perceived behaviour by other road users, locational cues are used for predictions in traffic as well. For example, road users' expectation of the category of rural road they are facing is based on how far apart both driving directions physically are (Stelling-Konczak et al., 2011). Martens and Fox (2007) found that the more familiar car drivers were with the location they were passing, the less they looked at relevant traffic signs. However, these experiences can also have negative effects, as drivers tend not to look for signs at locations where they do not expect any, potentially leading to missing critical information (Borowsky et al., 2008).

During the second level of SA, all perceived and (rated as) relevant cues are combined into one holistic comprehension of the current situation (Endsley, 1995). Cognitive processing time is required to form this holistic image. The third level of SA assessment concerns making inferences about the future state of the current situation (Endsley, 1995). In other words: a car driver, cyclist or pedestrian (or any other) will predict the intentions of other traffic participants, in order to make a decision on how to anticipate and possibly evade a potential conflict. Therefore, correct expectations facilitate a quick response, but incorrect expectations are potentially hazardous. For example, an important factor leading to bicycle-car collisions is a cyclist having the incorrect expectation that a car driver will yield (Räsänen and Summala, 1998).

1.2. Cyclist intention prediction

In the current study it was assessed whether cyclists are able to predict the direction a preceding cyclist is going to choose, based on perceived informal signals (i.e. absence of the formal arm indication). As SA is not a continuous concept, it is the question whether cyclists are able to predict other cyclists' intention based on behaviour preceding the actual turning manoeuvre. Hemeren et al. (2014) found that the oncoming direction a cyclist will choose can be predicted by looking at the lateral position, head turns and speed, for two directions on a T section, i.e. cyclists going straight or turning left.

It was hypothesized that predictions for any intended direction of travel are more accurate than chance, in accordance to the results by Hemeren et al. (2014). As anticipating the intentions of other cyclists is essential, it was argued that models for driver behaviour might also (partially) explain cyclist behaviour. According to the Task-Capability Interface model, the amount of success for the prediction task depends on the cyclists' capability and the demands of the task (Fuller, 2011; Fuller et al., 2008). The cyclists' capability is determined by their physiological characteristics, cycling experience, cycling competence, and human factor variables (Fuller, 2011; Fuller et al., 2008). The current physical environment, behaviour of other road users, properties of the bicycle and current cycling speed contribute to the overall task demand (Fuller, 2011; Fuller et al., 2008). The second hypothesis was that experienced cyclists are better able to predict the intentions of other cyclists than less experienced cyclists.

2. Method

An online survey was created using Qualtrics, in which 24 trials were presented in which participants were asked to predict the oncoming turn of a cyclist, based on a video made in real traffic from the perspective of a cyclist. All questions were asked in Dutch. All participants were offered a financial compensation by using a lottery system: among all submissions, two gift vouchers (€15 value) were randomly allotted. This study has been approved by The Ethical Committee of Psychology, University of Groningen.

2.1. Participants

A total of 158 participants started the survey, of which 108 answered all questions (68% completion rate). The mean age of all participants was 39.7 years (SD: 16.0), 63% were female and the majority was living in the Netherlands (N = 104). A small number came from Germany (N = 4). The most used type of bicycle was the regular bicycle (N = 87), followed by the electric bicycle (N = 11) and the touring bicycle (N = 6). A racing bicycle, a mountain bike, a carrier cycle and a fixed gear bicycle were used by one participant each.

2.2. Design

The study was designed as a within subjects questionnaire containing 24 trials, in which the independent variable was defined as the correct direction of travel of a lead cyclist (three levels: left, straight and right directions) and the three dependent variables were defined as prediction correctness, prediction certainty and selected cues on which each prediction was based.

2.3. Materials

A total of 24 video stimuli trials were created, plus one practice trial. These video stimuli consisted of video fragments recorded using a Contour + 2™ digital action camera with GPS, mounted on the front of a bicycle. The camera was set at 720p quality video settings (170° range of vision). The videos were recorded in real traffic; cyclists were followed until they reached a crossing and either turned left, right, or continued cycling straight on. The filmed cyclists were recorded inconspicuously and were unaware of the fact that they were being recorded, not to influence their cycling behaviour in terms of (over)acting. On four locations in the city of Groningen, footage was selected where cyclists did not use their arms to show their intentions to other road users. Furthermore, care was taken that the filmed cyclists did not have to give right of way to other road users and that no cars were present during the turning manoeuvre. Additional selections based on cue presence