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Hazard perception in young cyclists and adult cyclists

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ABSTRACT

Child bicyclists are at greater risk to get involved in a traffic accident. Although hazard perception tests between inexperienced and experienced car drivers revealed significant differences in perceptual-cognitive skills, a similar test for bicyclists is not yet existent. Therefore this study aimed to compare visual search patterns and reaction times of child bicyclists and adult bicyclists utilizing a hazard perception test for cyclists. Seventy-five children and forty-one adults were presented with eleven video clips filmed from the perspective of the bicyclist. The participants were required to press a response button whenever they detected a hazardous situation. Children were found to have significantly delayed reaction times and time until the first fixation on the latent covert hazards compared to adults. The inefficient visual search patterns in children may be attributed to an immature visual system. However, the finding that children fixated later on the hazards and only responded to the covert latent hazards when they became salient indicate difficulties with identifying possible hazards. Altogether, the findings of this study suggest that children's situation awareness is dependent upon experience too, and not just maturation. Therefore, implications for training young bicyclists will be discussed.

1. Introduction

Bicycling is a virtually free and enjoyable way of transportation. In Flanders 13% of all trips is made by bicycle and cycling represents the most common mode to commute to school for children and young adults (Janssens et al., 2012). Besides the health benefits associated with cycling to school or work, such as improved fitness, reduced risk for colon cancer or cardiovascular mortality, cycling also has the potential to decrease traffic congestion and air quality degradation (de Hartog et al., 2010; Oja et al., 2011). Moreover, in accordance with the European guidelines, cycling is a promising way to meet international guidelines for daily activity (60 min/day of moderate or vigorous physical activity for school-aged youth and 30 min/day for adults) (European Communities, 2006; Oja et al., 2011; Shephard, 2008).

Unfortunately, increased bicycle-usage has also led to more traffic casualties where especially children (9–12 year old) and older cyclists (>65 year old) are at risk (Carpentier and Nuyttens 2013; Juhra et al., 2012; Maring and van Schagen 1990; Ormel et al., 2009; Schepers and Wolt 2012). In Europe, 2017 cyclists were killed in traffic accidents, representing 7.8% of all road accident fatalities (European CARE report 2015). Moreover, 9–14 year old children represent almost 10%, and 14–19 year old children represent 11% of all the bicycle accidents in Flanders (Carpentier and Nuyttens 2013). Therefore, the causes underlying accident involvement in young cyclists, i.e. the influence of extrinsic factors (e.g. environmental characteristics, distance to work or school, bicycle facilities,. . .) and intrinsic factors (cycling skills, cognitive skills, attitudes,. . .) in relation to bicycle safety have been studied (Chihak et al., 2010; Ducheyne et al., 2013; Grechkin et al., 2013; Maring and van Schagen 1990; Møller and Hels 2008; Plumert et al., 2004, 2011; Trapp et al., 2011; Vansteenkiste et al., 2014; Zeuwts et al., 2014).

For instance, safe cycling requires the development of sufficient motor and cognitive abilities (Briem et al., 2004). On the motor side, learning to control and ride the bicycle on closed roads or playgrounds can be considered the essential first step, which is often mastered under adult supervision (Ducheyne et al., 2013). However, on the cognitive side, the transition from playground to traffic also requires additional anticipatory and decision-making skills to adequately anticipate or respond to other traffic. These skills are found to undergo changes until late childhood as a result of experience and development (Plumert et al., 2011; Thelen and Smith 1994). In support of this, a number of studies have shown that children appeared to have more difficulties with coordinating their actions in relation to other moving vehicles, which resulted

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in delayed onset of movement, larger variability in time to spare and less time to spare before contact with oncoming traffic (Chihak et al., 2010; Grechkin et al., 2013; Plumert et al., 2004, 2011). This evidence stems road crossing studies (using a bicycling simulator), where participants are presented with a number of intersections with continuous traffic. Still, safe cycling requires not only gap interception and go-no-go decisions for road crossing, but also the anticipation of hazardous situations in traffic, such as a car directly turning in front of the bicyclist or people stepping out of the bus. Anticipating dangerous situations is referred to as hazard perception, and is defined as the ability to read and detect dangerous situations unfolding on the road ahead, a process that enables early anticipation (Wetton et al., 2010; Wetton et al., 2011).

Traditionally, hazard perception is studied by presenting individuals with video clips filmed from the driver's perspective. Each clip contains at least one dangerous traffic situation that requires imminent action. Herein, participants' eye movements and reaction time to the hazardous situation are of interest. Vlakveld (2014) distinguished two types of dangerous traffic situations: overt latent hazards and covert latent hazards. Overt latent hazards refer to other visible road users who might start to act dangerously, while covert latent hazards refer to places from where a possible road user might appear who is not yet visible through an obstructed view.

When novice and experienced car drivers are presented with the hazard perception test, novices are found to overlook more traffic conflicts, show less extensive scanning patterns and have more difficulties detecting the foreshadowing elements or precursors for hazardous situations. This results in slower response times to hazards compared to more experienced drivers (Huestegge et al., 2010; Wetton et al., 2011). Moreover, learner drivers have been shown to make less anticipatory eye glances on covert latent hazards, which implies that novice drivers lack the ability to perceive and predict dangerous traffic situations (Borowsky et al., 2010; Underwood et al., 2002; Vlakveld 2011).

The documentation of hazard perception in children, including its development and underlying factors, is an important step towards safer traffic participation. In pedestrians, children's lack of road crossing experience limits their attentiveness and ability to anticipate possible hazards (Meir et al., 2015a,b, 2013; Rosenbloom et al., 2015). Furthermore, Meyer et al. (2014) presented two groups of children between 8 and 12 years, 13–17 years of age and an adult group with a hazard perception test for drivers to explore the relationship between age and hazard perception in children. Compared to the adult group, children demonstrated longer hazard perception latencies and lower response rates for situations containing hazardous behaviour caused by other vulnerable road users. This might be explained by a more egocentric view which suggests that children are less likely to identify with other road users (Meir et al., 2015b, 2013; Meyer et al., 2014), hence children lack the ability to predict how a situation might develop over time to anticipate the forthcoming events. However, these findings are limited since the video clips presented in this experiment were made from the perspective of a car driver, which is an experience children lack, and no clear distinction between covert and overt hazards was made.

The ability to predict and to anticipate traffic situations is closely related to the concept of situation awareness (SA) which consists of three interrelated levels (Endsley 1995). First the driver perceives a hazardous situation (perception). Then, the situation is interpreted (comprehension), and finally, the driver predicts how the situation will develop (projection). These three levels of SA are based on mental models or schemata, i.e. long-term memory structures that contain prototypical situations. Decision-making then involves pattern recognition or matching of situations with these mental models. Experience and training contributes to the formation of sophisticated and extensive mental models and will speed-up pattern matching, thus decision-making. Therefore it can be concluded that novice drivers lack an accurate internal representation of the context-dependent nature of hazardous situations. (Borowsky et al., 2010; Meir et al., 2013). As poor hazard perception skills in novice car drivers were shown to be related to elevated crash risk, in England and Australia a hazard perception test was successfully incorporated in the theory exam for learner drivers (Hosking et al., 2010; Wetton et al., 2011).

To conclude, the concepts reported above mostly concern studies in pedestrians and car driving while, despite an overrepresentation of young cyclists in accidents, research regarding gaze and hazard perception in cyclists is limited. Therefore the main aim of this study is to compare visual search patterns and reaction times between young cyclists and adult cyclists using a hazard perception test consisting of video clips from the perspective of a cyclist. We will document the visual search patterns of child and adult bicycle users by means of eye tracking methodology. Having access to the visual information on a potential hazard is a prerequisite that forms the basis of the first level of Endsley's (1995) situational awareness. It is expected that the lack of experience in children will result in missing more hazards and/or perceiving these hazards later than adults. In addition, reaction times to hazardous situations are expected to be longer in children for the same reason.

2. Methods

2.1. Development of the hazard perception test for cyclists

First, a collection of video clips (n = 365; mean duration ± 35 s) was created, including at least one hazardous event in each clip. All video clips were filmed from the perspective of a cyclist with a GoPro Hero2 camera (30 Hz, full HD and 170° Field Of View) mounted onto a helmet and were gathered in the cities and surroundings of Antwerp and Ghent. Film clips were analysed and edited with Kinovea. Each clip contained a run up time to appearance of the hazard of at least five seconds and lasted at least five seconds after that event. In addition, each clip was stabilized to minimize vibrations due to the state of the bicycle path or head movements using 'Mercalli V2′ (ProDad).

Subsequently, the experimenters rated each clip for image quality, the role of changing traffic signals, temporal proximity to other conflicts, and the existence of evasive action taken by the camera in response to the traffic conflict according to the criteria of Wetton et al., 2011. Film clips that passed this first inspection by the experimenters were then rated by a panel of three traffic experts specialized in hazard perception or research in cycling. First, the experts indicated what hazard(s) were appearing in the clip and how dangerous they perceived the hazard on a five point scale (1 = not dangerous, 5 = very dangerous). Second, experts classified the events as an acute hazard, a covert latent hazard, or an overt latent hazard (Vlakveld 2011). An acute hazard reflects a situation in which a reflexive response is required on a sudden hazard, for example a child that suddenly enters the street from behind a car. Possible hazards that do not develop into an imminent threat are referred to as latent hazards. Covert latent hazards then are potential hazards where other road users are hidden from view such as a truck blocking view on a pedestrian crossing, while overt latent hazards refers to visible road users who might start to act dangerously.

Next, for each video clip the presence of the anticipatory cue was scored on a five point scale according to Wetton et al. (2011) (1 = no anticipatory cue; 2 = early anticipation of a traffic conflict requires attention to obvious cues; 3 = early anticipation of a traffic conflict requires attention to slightly subtle cues; 4 = early anticipation of a traffic conflict requires attention to quite subtle cues, 5 = early