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The implications of low quality bicycle paths on gaze behavior of cyclists: A field test

Pieter Vansteenkiste *, Linus Zeuwts, Greet Cardon, Renaat Philippaerts, Matthieu Lenoir

Department of Movement and Sports Sciences, Ghent University, Watersportlaan 2, 9000 Ghent, Belgium

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ABSTRACT

Unlike for car driving and walking, the visual behavior during cycling is poorly documented. The aim of this experiment was to explore the visual behavior of adult bicycle users ‘in situ’ and to investigate to what extent the surface quality affects this behavior. Therefore cycling speed, gaze distribution and gaze location of five participants were analyzed on a high and a low quality bicycle track. Although there was no difference in cycling speed between the low and the high quality cycling path, there was an apparent shift of attention from distant environmental regions to more proximate road properties on the low quality track. These findings suggest that low quality bicycle tracks may affect the alertness and responsiveness of cyclists to environmental hazards.

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1. Introduction

Human locomotion is primarily guided and controlled by visual information (Patla, 1997). The visual channel provides input for planning one’s trajectory, for on-line control, and for anticipation to specific events. Especially in traffic, not noticing possible hazards can have disastrous consequences. Therefore the determinants of visual search and hazard perception are often the subject of traffic research (Chapman, Underwood, & Roberts, 2002; Crundall et al., 2012; Mourant & Rockwell, 1970; Recarte & Nunes, 2003). The effects of age, alcohol, traffic density, billboards, etc. on visual attention in traffic all have been described during past years (Borowsky, Oron-Gilad, & Parmet, 2009; Deery & Love, 1996; Edquist, Rudin-Brown, & Lenné, 2012; Horswill, Helman, Ardiles, & Wann, 2005; Shinoda, Hayhoe, & Shrivastava, 2001; The Effects of Commercial Electronic Variable Message Signs (CEVMS) on Driver Attention, 2009; Young & Regan, 2007). The majority of these studies, however, focused on car driving. The visual attention of cyclists on the other hand, is poorly documented, even though the number of bicycle users is increasing and, unfortunately, the number of bicycle accidents has increased as well (de Hartog et al., 2010; Juhra et al., 2012). Therefore, more insight in the visual behavior of cyclists could be beneficial for traffic education and infrastructural planning.

For car driving, the two-level model of steering (Donges, 1978; Land & Horwood, 1995; Schieber & Schlorholtz, 2009) is a well documented and generally accepted model for gaze behavior. According to this model, car drivers watch distant road features foveally for guidance and anticipation while the close regions are attended peripherally for lane keeping. This theory has been proven to be useful in various car driving situations (Salvucci & Gray, 2004) but could only partly explain the visual behavior of cyclists as it does not take environmental conditions into account (Vansteenkiste, Cardon, D’Hondt, Philippaerts, & Lenoir, 2013). However, the assumption that both the near and the far region are necessary for efficient steering still seemed valid. These regions provide visual information for compensatory closed-loop and anticipatory open-loop steering

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* Corresponding author. Tel.: +32 (0) 9 264 86 83.

E-mail addresses: pieter.vansteenkiste@ugent.be (P. Vansteenkiste), linus.zeuwts@ugent.be (L. Zeuwts), greet.cardon@ugent.be (G. Cardon), renaat.philippaerts@ugent.be (R. Philippaerts), matthieu.lenoir@ugent.be (M. Lenoir).

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control. Although foveal gaze towards the far region and peripheral perception of the near region has repeatedly been put forward as a safe gaze strategy for car driving, some researchers suggest that the compensatory and anticipatory steering mechanisms can be used in a more flexible way. Therefore a weighted use of these mechanisms has been suggested (Frissen & Mars, 2013; Kountouriotis, Floyd, Gardner, Merat, & Wilkie, 2012; Vansteenkiste, Cardon, D'Hondt, Philippaerts, & Lenoir, 2013).

There are several important differences between car driving and cycling that induce different visual requirements (Schepers & den Brinker, 2011). Unlike car drivers, cyclists have an almost unrestricted visual field, travel at lower speeds and are more subject to environmental conditions as weather and road quality. In addition, cyclists have to maintain their balance while cars are stable on their own. From this point of view cyclists' visual behavior might resemble more to that of pedestrians, although pedestrians travel at even lower speeds and are not limited by the capabilities of a vehicle.

Pedestrians only spend a limited amount of their visual attention to the pathway and a large part of their attention is spent watching the scenery (Foulsham, Walker, & Kingstone, 2011; Pelz & Rothkopf, 2007). When walking on an irregular surface however, gaze is directed significantly more to the travel path itself (Marigold & Patla, 2007; Pelz & Rothkopf, 2007). Although gaze is necessary for on-line visual control of human locomotion (Hollands, Marple-Horvat, Henkes, & Rowan, 1995; Patla & Greig, 2006; Turano, Geruschat, Baker, Stahl, & Shapiro, 2001) it seems that it is rarely directed to the ground on a flat, obstacle-free path. The two-level model as applied for car driving, however, does not predict gaze behavior when attentional demand is low and does not reckon with changing environmental constraints. Therefore, the model is not suitable for the visual behavior during walking and cycling.

The aim of current experiment is to investigate the gaze behavior of cyclists 'in situ' on high quality and low quality cycling tracks. It is expected that the higher task complexity on a low quality cycling track will lead to a higher percentage of gaze in the functional approach space (the space immediately surrounding one's body; Laurent & Thomson, 1991) of the cyclist and to less irrelevant fixations (Vansteenkiste, Cardon, D'Hondt, Philippaerts, & Lenoir, 2013).

2. Methods

2.1. Participants

Ten participants (22–24 years of age) took part in the study and signed the informed consent. All participants were students of the department movement and sports sciences from Ghent University. Four participants were left out since their Eye-Tracking Ratio (% of time eye movements was actually measured) was less than 80% and one participant was left out because of the busy traffic situation during the test. The five remaining participants had a good pre and post calibration, and were tested during a similar traffic situation. All participants used their bicycle at daily basis for transportation and had normal or corrected-to normal vision.

2.2. Apparatus

Eye movements and gaze location were recorded using the IviewX Head mounted Eye tracking Device (SMI, Teltow GER). The system with a 1° accuracy was mounted on a baseball cap and recorded the left eye movements with an infrared-sensitive camera at 50 Hz using pupil position and corneal reflex. Scene video was recorded at 25 Hz by a camera with 3.6 mm lens, placed next to the eye-tracking camera. Scene video had a horizontal and vertical field of view of approximately 33°. The two cameras were connected to a notebook (Lenovo X201; 1.4 kg) which was worn in a backpack and both scene video and eye tracking recordings were saved using SMI's software IViewX (see Fig. 1).

2.3. Protocol

After giving informed consent, participants were asked to put on the eye tracker and secure it with a strap. A five-point calibration was performed indoors and the participant was then asked to follow the test leader to the bicycle rack. The saddle of the city bike, rented from the university bicycle service, was adjusted to the participants height and the participant was asked to follow the test leader for a familiarization trial. For the actual test, participants were asked to cycle the same route as the familiarization trial at preferred speed until the test leaders, who cycled behind, instructed them to stop. A calibration check was performed before both high and low quality cycling path by instructing the participant to watch certain objects in the environment. After the test, a final indoor calibration check was done and the data were saved. Since sunlight disturbed the infrared-signal of the eye tracking system, all tests were performed in overcast weather.

2.4. Cycling route

Cycling route consisted of a 4 km tour in the city of Ghent which included a similar low quality (LQ) and a high quality (HQ) cycling track on the sides of a river. Both tracks were straight and were neighbored by a bush and a river on the one side and by trees and a car road at the other side (see Fig. 2). The HQ track was a recently renewed cycling path of 2 m in width and had a brick surface. The LQ track was 1 m 30 wide and consisted of large tiles that had moved or were lacking at some

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