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Driver's emotional state and detection of vulnerable road users: Towards a better understanding of how emotions affect drivers' perception using cardiac and ocular metrics

Alex Lafont [a,*], Joceline Rogé [a], Daniel Ndiaye [b], Jean-Michel Boucheix [c]

[a] Univ Lyon, IFSTTAR, TS2, LESCOT, F-69675 Lyon, France
[b] Université Paris-Est, COSYS, LEPSIS, IFSTTAR, F-77447 Marne-la-Vallée, France
[c] LEAD-CNRS, University of Bourgogne Franche-Comté, F-21065 Dijon, France

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ABSTRACT

Traditionally, anger has been considered to have a detrimental effect on driving. However, recent studies suggest that this statement should be qualified, especially where vulnerable road user detection is concerned. One primary factor which may determine anger's effect on a driver's attention is its intensity. In the present study, different intensities of anger were elicited via film clips, then performances in vulnerable road user detection (i.e., of cyclists) were assessed while participants drove a car in a simulated environment. Cardiac and ocular measurements and self-reported data were used in order to accurately assess emotional state and attention management throughout the experiment. Results suggested that participants resorted to reappraisal strategies when they were exposed to the emotional film clips. This phenomenon did not directly affect cyclist detection performances, but evidence of different visual scanning strategies between groups emerged. The contribution of cardiac and ocular measurements to emotional assessment and the advantages of appraisal approaches of emotion were also discussed.

1. Introduction

1.1. Context

Nowadays, many wheeled vehicles share the same space, and recent statistics have highlighted a human failure in managing the numerous interactions between road users. In 2015, the number of deaths on French roads increased for the second time in a row, by 1.7% compared to 2014. More specifically, pedestrians and cyclists, who are considered to be vulnerable road users (VRU), represented 18% of deaths in 2015, just behind motorists (52%) and motorcyclists (22%) (The French Road Safety Observatory, 2016). The same report also shows that the main causes of accidents involving pedestrians and cyclists are collisions with other road users, mostly motorists (69% and 52% respectively). In addition to the traditional factors involved in a crash (e.g., speed, inappropriate drinking), a lack of VRU visibility has also been reported (The French Road Safety Observatory, 2016). Consequently, the aim of the present research was to investigate the cognitive processes

* Corresponding author.
E-mail addresses: alex.lafont@ifsttar.fr (A. Lafont), joceline.roge@ifsttar.fr (J. Rogé), daniel.ndiaye@ifsttar.fr (D. Ndiaye), jean-michel.boucheix@u-bourgogne.fr (J.-M. Boucheix).

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which affect the way drivers detect cyclists, whose presence on the streets of French cities is on the increase (Bouaoun, Haddak, & Amoros, 2015). As attention management is required to detect some stimuli while carrying out a second task (Wickens, 2002), the exploration of the online processes which draw an individual's attention to a VRU during driving, especially when drivers are asked to detect VRUs, appears worthy of interest. In this context, conspicuity, which is the inherent ability of the stimuli to attract an individual's attention (Engel, 1971) emerges as an intriguing concept.

1.2. Conspicuity and attention in driving

"Two main types of attention are commonly distinguished in the literature: bottom-up or *stimulus*-driven and top-down or *goal-oriented* attention" (Nikolla, Edgar, Catherwood, & Matthews, 2018). Bottom-up attention is determined by the physical characteristics of the information attended to, whereas top-down attention is guided by the observer's goals.

The earliest studies investigating conspicuity focused on the physical characteristics (e.g., shape, brightness, color, size) that make stimuli salient from their surroundings (Hancock, Wulf, Thom, & Fassnacht, 1990; Wulf, Hancock, & Rahimi, 1989). When this is the case, attention is mainly guided by bottom-up processes and is linked to the concept of sensory conspicuity.

More recent studies, notably related to research in the driving field, have shown that the focus of attention can also be influenced by expectations, objectives and knowledge relating to a stimulus (Hole, Tyrrell, & Langham, 1996; Magazzu, Comelli, & Marinoni, 2006; Rogé et al., 2017; Rogé, Douissembekov, & Vienne, 2012). When this is the case, top-down processes associated with the concept of cognitive conspicuity, are involved in perception. According to Rogé, El Zufari, Vienne, and Ndiaye (2015), other components such as the driver's emotional state might also play a role in driving activity, especially VRU detection abilities. Therefore, the study of emotions could lead to a better understanding of situations in which motorists have to detect VRUs.

1.3. Emotion and attention in driving

Previous studies have shown that emotion can affect a driver's attention management while driving. According to Ellis and Moore (2005), negative emotions are likely to elicit thoughts which are unrelated to driving activity. This phenomenon tends to decrease overall attentional resources. This in turn leads to inattention toward key activities (which are essential to ensure safe driving), for instance the detection of other road users (Regan, Hallett, & Gordon, 2011). Several studies which are consistent with this idea, have demonstrated that negative emotions can impair driving. Pêcher, Lemercier, and Cellier (2011), for example, showed that sadness was associated with degradation of performance due to irrelevant thoughts such as rumination and self-focus while driving. According to Jeon, Walker, and Yim (2014), fear (assessed through Likert-type scales) can reduce drivers' attentional focus. Nesbit, Conger, and Conger (2007) highlighted a link between anger and aggressive driving. Additionally, Garrity and Demick (2001), showed that anger, assessed using the NEO Personality Inventory (NEO-PI-R)[1] and the Profile of Mood States (POMS),[2] led to an overall negative driving behavior. According to Jeon, Walker, and Gable (2015), anger assessed via Likert-type scales could also trigger dangerous modulations in driving style. Stephens, Trawley, Madigan, and Groeger (2013) used an impeding vehicle and close rear traffic to elicit anger in participants who had to drive in a simulator in order to specifically study road user detection abilities. Using the Profile of Mood States Short Bilingual Version (POMS SBV)[3] to assess emotions, they observed that anger-provoked drivers spent a considerably smaller proportion of time initially looking at less apparent pedestrians or emerging vehicle events than control drivers. They also took longer to make corrective actions to avoid potential collisions. Anger-provoked drivers tend to resort to a more superficial processing of potential hazards, and consequently underestimate the inherent risk of certain driving situations.

Contrary to these studies which underscore the detrimental effects of negative emotions – especially anger – during driving, other studies highlight the positive effects of anger on driving activity. Techer, Jallais, Fort, and Corson (2015) used the Attention Network Test–Interactions (ANT-I) paradigm[4] which is a single task allowing the assessment of different attentional networks at the same time. They used ANT-I after eliciting anger through autobiographical recall procedure and checking the efficiency of their emotional induction via Affect Grid[5] and Brief Mood Introspection Scale (BMIS).[6] They found a positive impact of anger on the alerting network which is dedicated to the preparation and sustainment of alertness when a high priority signal needs to be processed. According to Posner and Petersen (1990) this network is one of three independent networks of attention (i.e., alerting, orienting, and executive control). The authors concluded that anger could broaden the scope of the attentional focus via the alerting network.

Rogé et al. (2015) presented safety messages in order to improve the perception of VRU vulnerability during driving. They assessed emotional state using an adapted version of the Geneva Emotional Wheel (GEM)[7] throughout the experiment. They observed that processing safety messages increased the number of negative emotions felt by drivers. Among these, the intensity

[1] Costa and McCrae (1992).
[2] McNair, Lorr, and Droppleman (1992).
[3] Cheung and Lam (2005).
[4] See Callejas, Lupianez, Funes, and Tudela (2005).
[5] Russell, Weiss, and Mendelsohn (1989).
[6] Mayer and Gaschke (1988).
[7] Scherer (2005).