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ANGER AND DRIVING: TOWARDS THE ADAPTATION OF ADAS

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ABSTRACT: Anger is a commonly reported emotion in driving. It can lead to many behavioural modifications. Like other negative emotions, anger may promote attentional failures in driving which are attributable to mind-wandering. Besides positive expected impacts, advanced driving assistance systems (ADAS), can also increase cognitive underload and reduce available attentional resources. Consequently, the detrimental effects of negative emotions may get even more threatening to road safety when driving with ADAS. A better comprehension of emotions in driving would allow an adaptation of ADAS to reach an optimal level of performance.

6 INTRODUCTION

This paper briefly summarises current concerns about anger and advanced driving assistance systems (ADAS) and the main solutions considered by researchers.

7 ANGER AND DRIVING

Anger is a frequently reported emotion while driving (1,2). Its impact on driving is not necessarily detrimental. Conjointly with a negative effect on the reactivity to traffic speed changes, it may improve the detection of pedestrians (11). However, anger increases the propensity of risk taking and number of infractions (3–7). It also adversely impacts the longitudinal and lateral control of the vehicle (8–10). Concerning the attentional dimension of driving, anger promotes a more superficial processing of the environment and a reduction of the attentional breadth (12), leading to stereotypical judgements, slower reaction to unexpected hazards, and a reduction in the situation awareness (5,13,14). According to Jeon and colleagues (8), the reduction of situational awareness may be the main factor explaining the effect of anger on excessive speeds. Additionally, anger promotes the emergence of ruminations (15) which means that the attentional resources of the drivers will often be directed towards internal thoughts unrelated to driving. Consequently, anger appears as a

complex issue for road safety because of its various effects on behaviour and cognition during the driving task.

8 NEGATIVE EMOTIONS AND ATTENTIONAL RESSOURCES WHILE DRIVING WITH ADAS

8.1 *Negative emotions and attentional dynamic*

The allocation of attentional resources on self-generated thoughts is commonly designated as “Mind-wandering”. Epidemiological studies about mind-wandering seem to be consistent about the hazardousness of this attentional state. For example, amongst a population of patients admitted in an emergency department due to a car crash, reported mind-wandering was the best predictor of the accident responsibility (16). Detrimental effects of mind-wandering on road safety may be explained because it is accompanied by perceptual decoupling, which means that attentional processes are not the reflect of sensory input (13).

Mind-wandering seems to be particularly associated with negative moods (13,17). This is probably one of the reasons explaining the correlation between the occurrence of negative life events such as divorces or separations, and the prevalence of accidents (18). Altogether, studies suggest that negative emotions may be a threat to road safety because of the engendered attentional perturbations. Based on this statement, it seems clear that interaction between emotions and other sources of attentional perturbation should be taken seriously while designing future driving assistance systems.

8.2 *Impact of ADAS on attentional resources*

So far, most driving assistances focused on the task complexity reduction so as to increase available attentional resources in case of emergency situations, thus facilitating crash avoidance (19). Often, they opted for an automation of driving sub-tasks, which means that the vehicle was able to perform several tasks previously performed by the driver (20). This can lead to cognitive underload. Unfortunately, cognitive underload is as detrimental to the driving performance as cognitive overload. This counter-intuitive issue could be explained by considering that the quantity of available attentional resources is partly function of the task demands (21). However, for a benefit from informative ADAS such

as forward collision warnings, attentional resources have to be available to process information given by the system (22).

Considering the impact of negative emotions on attentional resources in driving, the use of ADAS may not be as profitable as expected. Future studies should investigate about the way emotions interact with ADAS while driving.

8.3 *Impact of Emotions while driving with ADAS*

On this topic, Techer and colleagues (in preparation) assessed the impact of an angry state on driving performance and attention when driving on car simulator with a forward collision warning system during a monotonous driving task. Reaction times, several behavioural metrics and electrophysiological data were recorded. Results revealed that an anger state impaired lateral control and impacted the nature of self-generated thoughts. Event-related potentials revealed that the nature of self-generated thoughts modified the attentional processing of target stimuli. This study contributes to a better comprehension of the influence of an anger state on attentional processing while driving with ADAS. It is important to keep studying how emotional states impact the attention and driving performance in order to prepare the introduction of future driving automation systems.

9 REDUCING THE DETRIMENTAL EFFECTS OF EMOTIONS ON DRIVING PERFORMANCE

Intuitively, two types of actions have been considered to reduce the effects of emotions on driving performance.

9.1 *Emotion regulation*

On one hand, if a particular emotional state is a threat to road safety, a possible action might be to encourage drivers and help them to recover a more neutral mood. Most of the propositions about emotion regulation are based on the “process model” of emotion regulation (23). Since it is not always possible to change the driving environment, cognitive “reappraisal-down” is believed to be more appropriate strategy in order to prevent the apparition of irritability (24). This strategy consists of convincing the driver that the frustrating event which occurred was unintentional and less hazardous than perceived. However, for an

increased efficiency, this method requires that the reappraisal message is displayed during a short time before or after the critical event. Emotion regulation have been found to be efficient to improve driving performance, avoid or reduce negative moods, and even reduce perceived workload (8,24). Another possible strategy of emotion regulation is to improve driver's comfort, like creating an enjoyable atmosphere through coloured lights or playing music appreciated by the driver when he is in a bad mood. However, this implies that in-vehicle systems are able to discriminate different emotions.

9.2 *Situational awareness improvement*

On the other hand, an important proportion of driving errors such as speeding may be accountable to an impaired situational awareness (8). Thus, systems might provide useful information about critical events in order to raise drivers' situational awareness, and thereby allow them to cope more efficiently with hazardous situations. Variables such as alerting systems reliability or timing of alert may impact the ADAS efficiency (25). Thus, it is conceivable that when attention is disrupted by emotional state, the optimal timing of alert may change. Therefore, future ADAS may need to be adapted to cope with a particular emotional state's weaknesses or strengths. For example, a shorter delay between critical events and alerts would allow an earlier reaction to hazards through an improved situational awareness. This type of intervention can be applied for negative as much as positive states. However, each emotional state may impair a specific dimension of the driving performance. Ideally, future systems may only provide information corresponding to the weaknesses of driver's current state. Again, this kind of intervention requires that the system is aware of driver's emotional state.

Emotional regulation and situational awareness improvement strategies may also be complementary for ADAS efficiency improvement.

9.3 *Complementary interventions*

Jeon et al. (8) decided to evaluate the usefulness of an in-vehicle agent to improve driving performance of drivers accumulating integral and incidental anger induction. The in-vehicle agent using a speech-based interface provided either situational awareness or emotion regulation prompts. Both types of

intervention efficiently improved driving performance and situational awareness, but the situational awareness agent was evaluated as more useful and friendly. Moreover, the in-vehicle agent reduced perceived workload for both groups. Further analyses revealed that this perceived workload reduction was due to scores decreases in different sub-dimensions of the perceived workload scale, which could be useful to adapt the agent to driver's specificities. Those two kinds of interventions seem to be complementary in order to adapt to drivers' specificities and current states.

However, despite promising experimental results, several improvements might be important for the conception of future driving assistance systems.

10 MAJOR IMPROVEMENT FOR FUTURE ADAS

10.1 Specificities of various emotional states

In driving, anger, happiness, and fear do not impact the driving performance and the attention in a same manner (9,26). Different moods may also positively affect a number of attentional variables. For example, previous research revealed that anger improves the pedestrian detection (11). Apart from a driving context, anger also increases the alerting network efficiency (27). Consequently, future systems should provide appropriate information in order to cope with the particular attentional needs of the driver, while taking advantage of the positive side of emotional states.

Moreover, according to the driver's current mood, the system should adjust the conditions of information transmission. For example, in the case of a speech-based interface, the characteristics of the system's voice may play an important role in the driver-car cooperation. Happy drivers seem to take a better advantage of an energetic speech system, while angry drivers will better cooperate with a more subdued system (28). Critical information presented in a style adapted to drivers' mood would promote human-car cooperation which may help reaching an optimal level of performance.

However, emotional states, unlike personality traits, are able to change during the driving task. Therefore, another major issue is to be able to monitor in real time the emotional state of the driver. This issue may be reached by taking into account physiological and behavioural measures.

10.2 Online detection of internal states

According to Lazarus (26), each emotional state contains an action tendency which goes along with a specific pattern of physiological activation. Consistently with this idea, merging a set of physiological variables seems to be an appropriate method towards the inference of driver's internal state. Several studies investigated about the physiological response associated with emotional states using variables such as heart rate, respiration, skin conductance or body temperature (1,5,27). For example, fear and anger, which are two negative and highly arousing emotions, seems to be distinguishable on the basis of the physiological patterns provoked (27). Physiological patterns have also been identified for mind-wandering using electroencephalography methods (28), revealing that perceptual decoupling occurring in mind-wandering is observable at a cortical level.

Taken together, the identification of emotional states and possible mind-wandering associated may be the first step towards an adaptation of ADAS.

11 FUTURE ISSUES

With the development of autonomous vehicles, technology will completely redefine the driver's role from an operator to a supervisor required to take over the car for emergency purposes. In the occurring of an urgent takeover, drivers should have an optimal situation awareness and enough cognitive resources to deal with the emergency manoeuvre. Thus, the effects of emotions on attention in driving will remain an important concern for road safety.

According to existing literature, four major axis have to be investigated in order to prevent potential threats for future road safety.

- Understand how various discrete emotional states affect driving performance and attentional processing of a driving situation.
- Further investigate about the impact of mind-wandering considering the nature of self-generated thoughts.
- Develop accurate real time monitoring of internal states including mind-wandering.
- Prepare future adaptive assistance systems able to identify critical information in the driving environment and deliver it in the more

appropriate conditions corresponding to the driver current state.

- Investigate about optimal thresholds of alerting systems according to each emotional state in order to promote situational awareness.

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