Sorry, I'm Late; I'm Not in the Mood: Negative Emotions Lengthen Driving Time

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Abstract. A considerable amount of research has shown that anger degenerates driving performance [e.g., 1, 2, 3], but little research has empirically shown other affective effects on driving. To investigate angry and sad effects on driving, we conducted a driving simulation study with induced affective states. In cognitive psychology, there is the "sadder but wiser" phenomenon, but given that driving is a complex, dynamic task that engages not only basic cognitive processes, but also other critical elements such as decision making, action selection, and motor control, it might result in different outcomes. Thirty-two participants were induced into sad, angry, or neutral affective states and asked to complete a driving task using a medium fidelity driving simulator. Measures included driving performance, subjective mood ratings, and a NASA-TLX workload index. Results showed that participants in the angry and sad conditions took significantly more time to complete the driving task compared to the neutral condition.

Keywords: Aggressive driving · Anger · Driving simulation research · Emotions · Road rage · Sadder but wiser

1 Introduction

Driving is a complex, dynamic task that requires the use of high amount of attentional resources. Drivers must employ basic cognitive processes, along with information processing mechanisms such as visual search, risk perception, decision making, action selection, and motor control [4, 5]. While the cognitive and behavioral mechanisms involved with driving have received a fair amount of attention, research on the affective effects on driving is fairly modern. Until recently, research on the affective, or "emotional" effects on human performance was kept apart from the more definable and measureable variables associated with performance and action. Further investigation found that nearly all actions and decisions engaged the emotional system, and the impact of those emotions is not negligible [6]. Experiencing an emotional state influences both higher level cognitive processing of information and lower level physiological responses [7].

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Advancements in affect detection methods such as physiological measures have allowed researchers to better understand the underlying mechanisms of affective states so that emotional behavior can be further studied.

Previous research on affective effects on driving primarily studied the differences between positive and negative emotions. While much of this research found differences between the two affective states, the distinction between states within the same valence (for example, anger and sadness) was not always made. The circumplex model of experiencing emotions classifies affect by their valence and their activation. Valence describes whether it is positive or negative, and activation describes the level of arousal [8]. More recently, though, research has shown that not all similar valence emotions lead to the same type of behavior and performance, and not all tasks are created equal [17, 18]. A study was conducted in order to discern what affective states are most critical to complex tasks such as driving. Results of the driving-related affective study showed that anger, fear, and happiness were the most emergent affective states related to driving [14]. Research also supports that those in a positive mood are more likely to be more cautious when faced with risky decisions [7].

While happiness may have its own effects on driving, it is more common to hear about safety issues emerging from negative affective states such as anger, fear, or sadness. Angry driving, or "road rage", is a prevalent problem when it comes to emotion-related driving. Some research has even provided evidence that angry driving may be more dangerous than drunk driving [21]. Anger is considered a high-arousal emotion, and the effects of an angry affective state include lowered concentration on the road in addition to dangerous actions such as speeding, passing, etc. A recent driving simulator study on angry, fearful, and neutral drivers showed that drivers who were induced into an angry state had significantly more errors in lane keeping and following traffic rules compared to their counterparts in a neutral state. In addition, they showed significantly more aggressive driving traits than the neutral and fearful conditions [17]. This research supports the hypothesis that angry driving may be more dangerous than other affective states.

Sadness is considered a negative, low-arousal emotional state. According to previous research, drivers who are experiencing sadness may be more analytical and detail oriented when processing information, but may lead to inattention [5]. Other affect researchers have widely shown that sadness increases systematic information processing, while happiness decreases it [9–11]. This tendency has similarly been reported in memory [12] or judgment [13], which is typically deemed the 'sadder but wiser' phenomenon. Based on this notion, we posed a simple research question, "Is this wise tendency of sadness applied to a more complicated task, such as driving?" In other words, are sad drivers better drivers than other types of emotional drivers? While sadness and anger are both considered negative emotions, research shows that it is not just the valence (positive or negative), but specific emotional states that lead to different performance while performing tasks.

This research aimed to look at the differences in driving performance between participants induced into an angry or sad affective state. Measures of performance were taken using a driving simulator, and written personal experiences were utilized for affect induction.

2 Method

Thirty-two young drivers (5 Female; *Mean Age* = 20, *SD* = 1.6; angry 11, sad 11, and neutral 10) participated in this study. Participants reported that they have a valid driver's license and more than two years of driving experience (*M* = 4.4 years, *SD* = 1.6).

We used a medium-fidelity NADS MiniSim driving simulator (Fig. 1). A driving scenario was created using the iSAT software, which included ten hazardous events (see Table 1) across an urban road and a highway.

Fig. 1. After affect induction procedure, all participants drove the same predefined route that includes hazardous events, using the NADS MiniSim.

Table 1. Hazardous events in the driving scenario

Predictable Hazard Events
Event 1. Car crosses over center line into driver's lane
Event 2. Motorcycle pulls into driver's lane
Event 3. Traffic signal suddenly changes into yellow in the intersection
Event 4. Car U-turns in front of driver
Event 5. Boy runs out from behind a parked car
Event 6. Car pulls into road ahead of driver
Event 7. Truck suddenly appears in highway entrance
Event 8. Construction and lane merge
Event 9. Two deer cross road
Event 10. Car entering highway cuts off driver

Before inducing an affective state, participants were asked to rate their current affect using a seven-point Likert scale. The affective states included nine adjectives: fearful, happy, angry, depressed (sad), confused, embarrassed, urgent, bored, and relieved [14]. Then, participants went through the simulator sickness screening protocol. Participants who had not shown evidence of simulator sickness continued into the actual experimental task. They had 12 min to write a description of a past emotional experience [e.g., 15] associated with either anger or sadness. Participants were urged to refer to two sample paragraphs in the instruction sheet to help them write their own paragraphs [2]. An experimenter instructed them to remember the memory as clearly as possible and to emotionally revisit the experience again while they wrote. Participants in a neutral condition wrote their mundane events of the previous day. After describing the emotional experiences, participants completed ratings on their present affective states. Then, they were instructed to drive as they would drive in the real world, following any traffic and safety rules. During this time, they experienced the ten hazardous events described below. After the drive, participants completed the final affective state rating and the electronic version of NASA-TLX [16] to provide measurements of perceived workload. Finally, participants filled out a short questionnaire for demographic information.

3 Results

Figure 2 shows the mean rating of affective states at three times. We conducted paired-samples t-tests. Anger-score after induction (M = 3.4, SD = 1.6) was significantly higher than before induction (M = 1.8, SD = 1.2), $t(10) = -2.5$, $p < .05$. After the experiment, anger-score decreased (M = 2.5, SD = 1.9) and returned to the level before

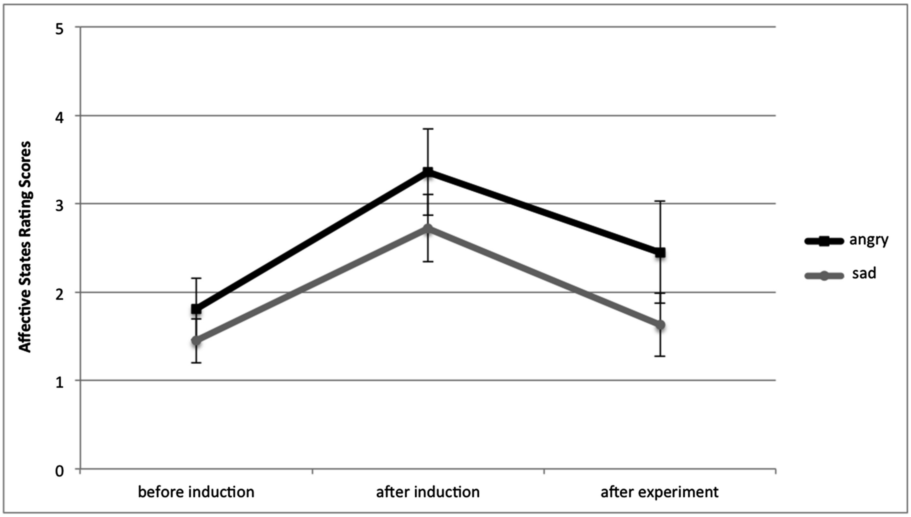

Fig. 2. Affective states rating scores across rating timings. The scores significantly increased after affect induction. After the experiment, affect scores returned to the level before induction. Error bars indicate standard errors of the means.

induction. Likewise, sadness-score after induction (*M* = 2.7, *SD* = 1.3) was significantly higher than before induction (*M* = 1.5, *SD* = 0.8), $t(10) = -3.8$, $p = .003$. Also, sadness-score after the experiment (*M* = 2.5, *SD* = 1.5) returned to the level before induction. In sum, affect rating scores increased after the inducing procedure and decreased while driving.

To compare driving time in each affective condition, a one-way ANOVA was conducted. There was a main effect of affective state, $F(2, 19) = 4.6$, $p < .05$. A LSD post hoc analysis showed that sadness (*M* = 792.9 s, *SD* = 48.9) and anger (*M* = 793.3 s, *SD* = 45.7) took significantly longer driving time than neutral (*M* = 724.9 s, *SD* = 55.5) (*p*s < .05) (Fig. 3).

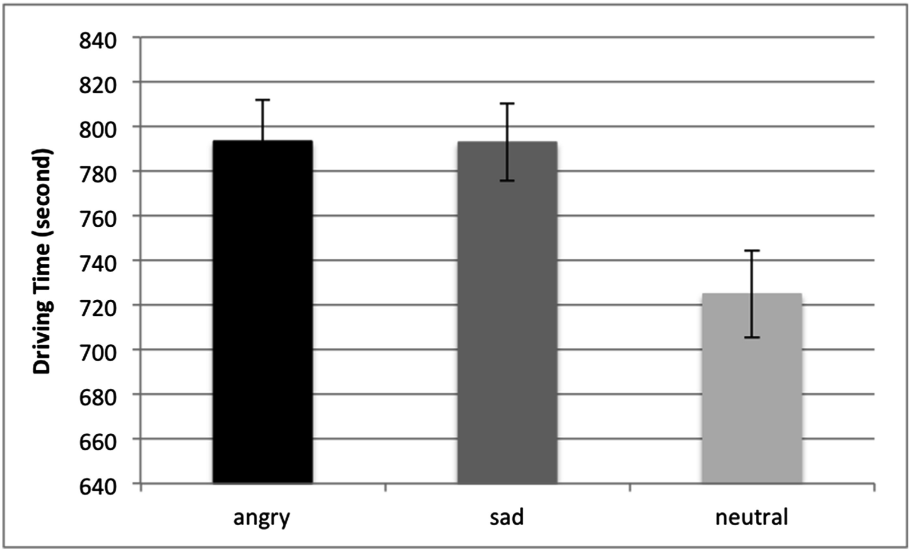

Fig. 3. Driving time across affect conditions. It took significantly longer in the both negative affect conditions than the neutral condition. Error bars indicate standard errors of the means.

There was no difference among driving performance variables (e.g., max speed, average speed, speed standard deviation, lane departure, lane departure percentage, collisions). However, in lane departure and lane departure percentage, sadness and anger showed higher number than neutral, which implicates that driving time differences might come from the differences of lane deviation. Therefore, we can cautiously infer that negative affective states might prevent drivers from keeping within their lane.

The analysis also revealed no difference in perceived workload among affective states. Anger showed numerically highest workload (*M* = 55.5, *SD* = 14.8), followed by neutral (*M* = 52.9, *SD* = 19.5) and sadness (*M* = 49.7, *SD* = 25.9). Even though participants in the negative affective states took longer time than those in the neutral condition, they did not seem to perceive higher workload. This result supports that emotional effects might be independent of perceived workload [17, 18] and thus, we need a different approach to measuring and solving affective issues. To estimate a driver's affective states more accurately and intervene accordingly, we plan to integrate a number of physiological measures and affect detection systems.

4 Discussion

This research aimed to look at differences between sad and angry drivers. While we did not find significant differences between the two in driving performance, we did find that both sad and angry drivers made numerically more lane departures and took significantly longer to complete the driving task than participants in the neutral condition.

This supports hypotheses that negative valence emotional states may cause more inattention (more lane departures) than those of neutral or positive valence. The differences in time to complete the task between participants in the neutral state and those in the sad and angry states are a consistent result with our previous study [4].

While this particular research found that written personal experiences designed to induce a specific emotion effectively changed the participants' subjective mood scores, there are a variety of ways in which affect induction can be done in an experimental environment (e.g., watch movies, listen to music, etc.). The subjective mood scores did change according to their intentional moods, but it is difficult to say how those induced emotions compare to those experienced in a real world environment. Emotions are, in their essence, quick to change and can be experienced at different levels of intensity.

With the vast amount of in-vehicle technologies that are being released on the market, there is a good case to make for the utility of an affect detection and mitigation system. The development of an affect detection system that could recognize a driver's current affective state, and further, help mitigate the negative effects on performance could save lives. Currently, there are multiple types of affect detection systems. Facial expression and facial electromyography, autonomic activity measures such as heart rate, blood pressure, respiration, temperature, pupil dilation, and skin conductivity, and voice all show promise as ways to detect a user's affective state [7]. Some, such as facial electromyography, may be too intrusive to a complex, visually intensive task such as driving. Other measures, like heart rate, skin conductivity, or facial expression detection could easily be incorporated into an in-vehicle affect detection system without being too intrusive. Future research, then, should investigate the potential of these measures in effectively recognizing the emotional state of the driver. An affect detection system that is unreliable could potentially make matters worse by providing the wrong information to an affect mitigation system.

In terms of affect mitigation, there are a variety of ways and modalities in which affective states can be mediated. Finding the ways in which we can use those in a vehicle effectively may be more challenging. One example could be using auditory displays; either music [19] or speech-based systems [20].

While this research is primarily aimed at differences between negative valence emotions (anger and sadness), it does not mean that future research should push aside positive valence emotions.

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