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The need for speed? The relationships between driver traits and speed choices during a naturalistic drive

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Abstract

Questionnaire based studies and those using driving simulators have provided convincing data that drivers prone to becoming angry drive faster. In contrast, anxious drivers tend to be more cautious in their driving style. Only a few studies have examined this in real traffic conditions, and these have often relied on an experimenter or instructor being present in the vehicle, which may confound the results. The aim of the current study was to examine the relationships between anxiety and anger traits, driver mood and speed and braking behavior while driving in real traffic conditions without an observer present in the vehicle. A total of 19 drivers (males = 12, mean age = 30.84, ± 7.88 years) holding a valid, full Victorian driver license, participated in the study. Drivers drove an instrumented vehicle along a predetermined 38km route in the south-eastern suburbs of Melbourne. Mood (tension, sadness, anger, vigor, confusion and happiness) was measured before and after the drive and anger and anxiety propensities were also obtained. Drivers were also asked to think aloud during the drive, and verbal assessments of the driving situation were recorded. Overall, trait propensities for anger and anxiety were low, and this was evidenced by low levels of negative mood states both before and after the drive and no significant changes in these moods across the drive. However, despite the low propensities for anger and anxiety while driving, anger and anxiety shared relationships with speed and braking behaviors. Over the entire drive, drivers prone to anxiety tended to exhibit more braking behavior, but no differences in average or variation of speed emerged. In contrast, trait anger propensities were unrelated to driver behavior; however, drivers who had slower speeds throughout the drive tended to have increased anger at the end of the drive and also tended to discuss speed more as they got closer to the end of the drive.

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Keywords: Anger; Anxiety; Traits; Naturalistic driving; Speed choices

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1. Introduction

Relationships between anger and anxiety with driving performance are well established in the literature. For example, a number of studies have examined trait predispositions for anger and anxiety and assessed the relationships these have with driver behaviour[1-5]. This has been largely done in questionnaire based studies[1, 3, 5], although there are now several published simulator-based studies that have replicated the relationships[2, 4, 6]. In these instances, drivers who tend to be more anxious have better speed compliance[6] and "generally stressed" drivers also exhibit more cautious behaviors in a driving simulator[7]. In contrast, trait driving anger is related to faster and more erratic speeds in a driving simulator[6].

Drivers prone to anger and anxiety also tend to experience more state anger and anxiety while driving[1, 2, 4] and this state affect has also been related to driver performance[6, 8]. In simulator based studies, drivers with higher levels of state anxiety have more interaction with driving controls, such as the steering and the accelerator pedal[6]. In an extreme example of anxiety and driving performance, Briggs, et al. [9] measured the driving performance of drivers with arachnophobia when they were discussing spiders. During these conversations, drivers had a higher heart-rate, a more narrowed visual scanning pattern of the driving scene and made more errors on the driving simulation. Heightened states of anger and angry mood have been related to faster speed choices[8], slower hazard detection[10], and a larger number of go decisions at intersections displaying yellow traffic signals[11].

While a number of researchers have considered only state or trait affect in their studies[1, 3, 5, 8, 11], others have measured both[2, 4, 6]. When both trait and state are considered, as is to be expected, drivers with angry or anxious dispositions tend to display higher levels of these while driving[2, 6]. However, Stephens and Groeger [6] suggest that the influence of trait anger is situation specific. In their simulator-based study, drivers higher in trait anger reported more anger in non-provoking situations. However, trait driving anger was unrelated to the anger ratings in situations pre-determined to be anger-provoking. Similar findings have also been reported by Underwood, et al. [12] from their naturalistic driver diary study. In this study, trait anger levels were unrelated to anger resulting from a near miss or crash, but were related to anger from seemingly non-provoking situations.

The diary study by Underwood, et al. [12] is one of the few published studies that examines trait and state anger and driver behavior in real traffic conditions. In this study, 100 drivers from the UK were asked to complete a driving diary over a two week period. Across this period, and after each driving episode, drivers recorded their level of anger and noted any near crashes for that drive. This was one of the first on-road studies specifically investigating the relationships between state anger and near crashes, with the results highlighting reciprocal relationships between these two factors. More recently, Mesken, et al. [13] had 44 drivers in the Netherlands drive a predetermined route in real traffic conditions, while accompanied by an experimenter and a driving instructor. During the drive, at three minute intervals, or more frequently if there was a specific driving event, drivers were asked to disclose their leading emotion and rate its intensity. Drivers chose one of anger, anxiousness or happiness each time. The results confirmed that drivers prone to anxiety had more intense anxiety while driving, while drivers prone to anger made more frequent ratings of anger. Further, anger ratings were associated with faster speeds and less speed limit compliance, whereas anxiety was unrelated to speed behavior.

The studies performed in real traffic conditions[12, 13] largely support findings from the more controlled simulator based studies[4, 6, 10] showing relationships between anger and anxiety traits, states and driving behavior. However, there are some limitations that span both methodologies. In all cases, drivers were aware of the responses being sought. For example, in the work by Stephens and Groeger[6, 10], drivers made continual ratings of their anger levels while driving, thereby being primed to evaluate situations from the perspective of how anger provoking each was. Further, while Mesken, et al. [13] found that anxious drivers had more anxiety while driving and drivers who tended to become angered reported more anger during the drive, these trait-state relationships may have also been primed by the responses being sought. By way of example, if drivers are only asked about how anxious or angry they are feeling, then it is reasonable to conclude that anxious drivers would focus on anxiety-provoking situations and those with angry dispositions would focus on the anger-provoking elements of the situation. The driver diary study by Underwood, et al. [12] suffers from a similar limitation. While drivers did not rate their anger during the drive, they were aware that at the end of each drive they would be. Coupled with this, studies conducted in a driving simulator laboratory environment suffer from the problem of the experimenter being present at all times, even if not visible. The Mesken, et al. [13] study in real traffic conditions also had an experimenter in the vehicle

and a driving instructor. Their presence may have influenced both the ratings of emotion as well as driver behavior, as drivers may have sought to behave in a way consistent with perceived observer expectations and may have exhibited less extreme emotions.

The aim of the current study was therefore to build on the earlier work cited above by examining the relationships between anxiety and anger traits, current anger and anxiety levels and driving behavior. This was done in real traffic conditions using an instrumented vehicle to record behavior and without an observer present in the vehicle. To further build on the current knowledge in this area, drivers were also asked to "think aloud" while driving, providing a running commentary on how they were evaluating the driving task.

2. Method

2.1. Participants

A total of 19 drivers holding a valid full Victorian driver license participated in the study. Participants ranged in age from 22 to 47 years (M = 30.84 ± 8.02) and had been licensed for between 2 and 30 years (M = 12.78 ± 8.23) and drove for an average of 1 to 100 hours each week (M = 16.00 ± 23.50). Participants reported that 70% of their weekly travel was for private purposes.

2.2. Materials

Both state and trait mood measures were given to participants. Current mood was measured before and after the on-road drive. Seven moods were assessed. These included six mood categories defined in the Profile of Mood States[14]: Tense/Anxious, Sad/Depressed, Angry/Annoyed, Tired/Fatigued, Energetic/Active, Confused/Uncertain. Happy/Joyful was also included. Participants marked a line denoting a 0-100 scale (0 = not at all; 100 = extremely) according to their current level of each mood.

Trait anxiety was measured using the Trait Anxiety Inventory (TAI)[15]. The scale contains 20 short statements that individuals may use to describe themselves. For example, "I am happy"; "I feel inadequate". Participants rate each statement on a four-point Likert scale (1 = almost never, 4 = almost always) indicating how true each statement is in relation to how they generally feel. Nine items are reverse coded so that high scores on the TAI reflect higher levels of trait anxiety. The TAI has shown good test-retest reliability (α = 0.80)[16].

The 14-item Driving Anger Scale (DAS) was used to provide an overall measure of driving anger[17]. The scale presents 14 different situations and asks participants to rate how angry each situation makes them feel on a five-point Likert scale (1 = not at all, 5 = very much). Item scores are combined to form a total DAS, with higher scores indicting greater propensities to become angered while driving. The DAS-short form has demonstrated good internal consistency (α = 0.80)[17]. The validity of the DAS has been shown through correlations with state anger and trait anger measures[17].

2.3. Verbal Protocol Analysis

Drivers were asked to "think aloud" while driving by making a continuous dialogue of their internal thoughts related to their journey. Drivers were instructed that VPA includes general thoughts about where the driver is placing their vehicle and why; thoughts about the road environment, road condition and any road signs or billboards they observe. In addition, any road signals, other road users the encounter and specifically what these road users are doing, how that relates to the driver and what the driver is doing about it. Drivers received training in VPA on a desktop simulator which took approximately 30 minutes. VPA has been found to be an effective tool in measurement of situation awareness of drivers[18], with no adverse consequences on task performance[19].

2.4. On-Road Test Vehicle (ORTeV)

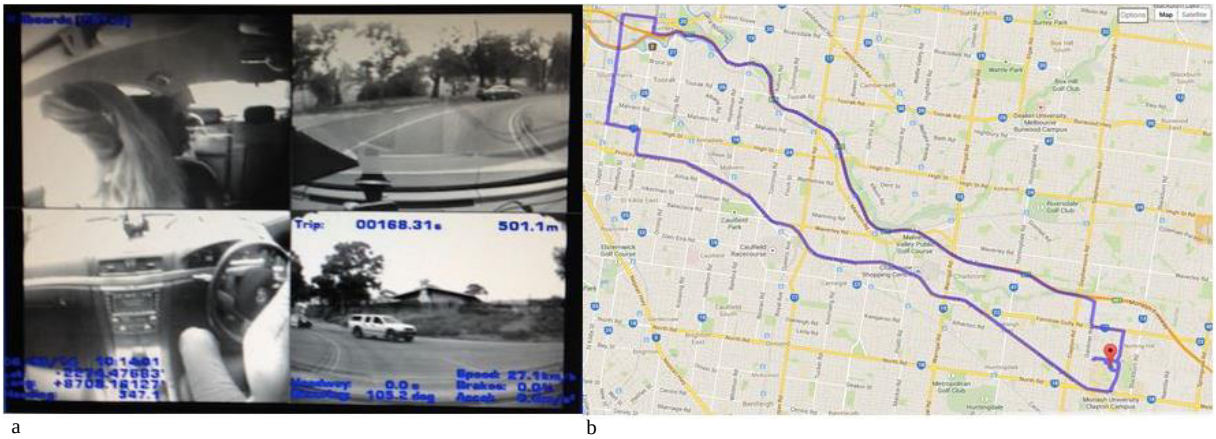
Driving data were collected in the Monash University Injury Research Centre On-road Test Vehicle (ORTeV). This is an instrumented Holden Calais sedan with an automatic transmission. The ORTeV simultaneously collects vehicle-related data and captures images of the driving scene and driver interaction with the vehicle. A discrete V-Box data logger records vehicle speed, GPS location, longitudinal acceleration and deceleration, steering angle and total distance travelled. Four unobtrusively mounted cameras capture forward and rear roadway views, each spanning 90 degrees. Video data of the driver's facial expressions and their interactions with the cockpit are also recorded and audio data from inside the vehicle are captured via small ceiling mounted microphones. A smart phone was mounted on windscreen to the left of the driver, above the center fascia. This provided voice-guided navigation instructions to drivers throughout the driving route. A tracking program installed on the phone also streamed real time GPS data to the experimenters, allowing online monitoring of the driver's progression on the driving route.

2.5. Predetermined driving route

Drivers drove a pre-determined route that took approximately 50 minutes to complete. The route encompassed sections of freeway driving (80km/h to 100km/h); busy retail areas (40km/h to 60km/h) and arterial roads (70km/h to 80km/h). Testing was limited to non-peak/school times. Fig. 1 displays the different sections of the route. All drivers completed the route in a counter-clockwise direction, first encountering the freeway, then the shopping strip then the arterial roads. Extensive piloting of the route was performed to ensure ease of navigation for the drivers.

2.6. Procedure

Ethical approval for the study was obtained from the Monash University Human Research Ethics Committee. Participants attended a single two-hour session that began and ended at the Monash University Accident Research Centre simulator laboratory. Upon arrival, participants were briefed about the study and provided informed consent. Next, they provided demographic information (license history, amount driven per week), were trained in VPA and completed a pre-drive mood checklist. Participants were then escorted to the test vehicle and drove accompanied around the Monash campus to become familiar with the ORTeV and gain further practice in VPA. Once the participant felt comfortable, the experimenter left the vehicle and the participant drove the route unaccompanied while the experimenter tracked the participant's progress online. Upon completion of the drive, the participant returned to the simulator laboratory where they completed a post drive mood check-list, answered some questions about their driving experiences (not discussed in this paper) and completed the trait anxiety and anger scales. Participants were gifted 50AUD for their time and expenses.



a b

Fig. 1. Camera images in ORTeV (a); driving route with the different sections outlined (b).

2.7. Data handling

Prior to analysis all variables were checked for normality. Skewness and Kurtosis of average speed (km/h) were within the acceptable range. However, the remaining driving variables were positively skewed and thus analyzed with non-parametric tests.

3. Results

3.1. Trait tendencies

Overall, drivers displayed low to moderate levels of anxiety and anger traits. The average trait anxiety score for the group was 34.36 (± 7.01) out of a possible 80. The trait driving anger average was 37.53 (± 9.07) out of a possible 70, suggesting moderate levels of anger propensities. Although low, these anger and anxiety traits from the current sample were similar to previously published means using an Australian sample (TAI: M = 36.94 ± 10.93)[20]; (DAS: M = 38.74 ± 14.60)[20].

3.2. Current mood

Wilcoxon signed-rank tests were conducted to assess whether drivers' mood changed significantly across the duration of the drive. Neither anger nor anxiety showed a reliable change (see Table 1). This is to be expected given the low propensities for both in the sample. However, drivers become reliably more tired, less energetic and less happy across the drive.

Table 1. Mood change across the drive.

Mood (1 – 100)	Pre-drive M (SD)	Post-drive M (SD)	
Tense/ Anxious	25.11 (23.54)	19.05 (22.48)	Z = -1.14, p = .25
Sad / Depressed	8.21 (13.24)	5.21 (7.39)	Z = -.77, p = .44
Angry / Annoyed	6.37 (12.89)	7.32 (15.11)	Z = -.57, p = .57
Tired / Fatigued	20.26 (20.53)	42.47 (25.11)	Z = -3.07, p <.01
Energetic / Active	54.68 (17.31)	39.84 (22.27)	Z = -2.96, p <.01
Confused / Uncertain	10.32 (13.26)	8.58 (12.32)	Z= -.70, p = .48
Happy / Joyful	65.90 (18.50)	57.37 (19.78)	Z = -2.11, p <.05

Spearman correlations were conducted to identify any relationships between traits and mood change across the drive. Only two reliable relationships emerged and these were in an unexpected direction. Drivers who became less angry, and those who became more happy across the drive reported higher propensities for anger while driving (r = -.50, p < .05 and r = .52, p < .05, respectively).

3.3. State and trait mood and driving behavior

Spearman correlation coefficients were calculated to determine whether trait and state mood while driving was related to speed across the drive. When speed and braking were considered over the whole drive, mood change, not mood propensities, was related to driver speed. For example, drivers who drove at slower average speeds tended to report increases in angry mood (r = -.47, p < .05) and decreases in feeling energetic (r =.48, p < .05). In contrast, no relationships between mood change and average braking behavior were found. However, drivers higher in trait anxiety tended to brake more often (r =.46, p < .05) during the drive.

To investigate these relationships further, behavior was considered separately across sections of the freeway (~6km), retail (~4km) and arterial roads (~10km). The sections of road that involved navigating to each were not included in the analysis (~18km). This allowed a more controlled analysis of relatively straight sections of drive. The relationship between anxiety tendencies and braking behavior was only apparent during the freeway section of

the drive. In this section, drivers more prone to anxiety tended to brake more often. However, average speed was unrelated to trait anxiety levels. This finding suggests that anxiety prone drivers displayed a more unsure driving style in the fastest speed zone. Neither trait anger nor anger change was significantly related to speed or braking when these were considered within the separate driving environments. However, interestingly, a relationship was found between change in happiness and speed in the arterial section of the drive ($r = .46$, $p < .05$) and change in energy and speed ($r = .49$, $p < .05$) indicating that drivers who had slower speeds in this section of the drive reported more decreases in happiness and energy across the drive. Further, drivers who had less variation in their braking also reported more increases in tiredness ($r = -.51$, $p < .05$).

3.4. Verbal protocols – thinking aloud while driving

Key themes were identified for when drivers were in each of the three types of driving environment. The key themes that emerged on the freeway were statements related to speed (i.e. the speed limit or the driver's current speed) and the behavior of other vehicles (trucks, cars in other lanes). In the retail area, the main theme was the behavior of other road users. These included pedestrians, trams and cars that were parking on the side of the road. For the arterial section of the road, the focus was on the speed limit and the status of the traffic lights. For each section, the proportions of comments made about each of the key themes in relation to all comments were calculated for each participant. Spearman correlations showed no relationships between driver traits or mood changes and mentions of other road users on the freeway (all $p > .05$). However, as the drive progressed more relationships emerged between traits, mood and what drivers mentioned. In the retail area, which was the densest driving environment, drivers who had higher levels of trait anxiety made fewer references specific to other road users ($r = -.51$, $p < .05$), but rather had a broader assessment of the driving situation. In the arterial section of road, drivers more prone to anger focused more on speed ($r = .53$, $p < .05$) than other elements of the drive, while those who became angrier across the drive had less focus on the state of traffic lights. These findings are particularly interesting as they show that in the sample, drivers were focused on elements of the task such as speed and the behavior of other road users and this was largely unrelated to trait or mood tendencies unless the situation became salient for the current emotion. By way of example, trait anxiety was only related to broader evaluations in the densest part of the drive, when workload of the drivers was high. Anger was only related to the type of assessments made at the end of the drive, when drivers who had their speed restricted more, became more angry and therefore focused more on the speed they and other road users were doing.

4. Discussion

The aim of the study reported above was to examine the relationships trait and state moods have with driver behavior. A naturalistic protocol was adopted, where drivers drove a predetermined route, unaccompanied and while verbalizing their thought processes as they drove. Previous research has suggested that drivers with higher levels of anxiety or anger traits tend to become more anxious or angry as they drive[13]. However, the results of the current study were unable to support this. Anxiety traits were unrelated to mood change and an unexpected direction was observed for the relationship between trait driving anger and change in angry mood. In the current sample, drivers with lower trait propensities for anger had more of an increase in anger across the drive. It should be noted however, that angry mood did not change across the drive.

The findings that angry mood did not change across the drive are consistent with previous research[12]. Underwood, et al. [12] found that drivers only reported becoming angry while driving one out of every five driving occasions. Likewise, in a simulator-based study of drivers in Ireland, Stephens, et al. [21] found only small increases in angry mood ($M = 2.50$ on the anger scale of the POMS) after manipulating anger through a frustrating simulated driving experience. The average age of the anger-provoked drivers in their study ($M = 32.91 \pm 12.92$) is comparable to the current study ($M = 30.84 \pm 8.02$) and both are higher than the sample used by Underwood and colleagues ($M = 23$, SD not reported). It is widely acknowledged that trait and state anger levels decline with age[1, 2, 17] and as such, the age of the sample may explain the lower levels of trait anger, and consequently the lack of anger change across the drive.

While drivers did not report an increase in anger across the drive, happiness levels reliably decreased. It may be that for this sample, happiness was a more sensitive mood change measure. Drivers may have found it easier to report declines in happiness, than increases in anger in this study given that they were not primed about a specific emotion. Very little published research has investigated the influence of happiness on driving. Mesken, et al. [13] found that drivers reported less happiness than anxiety or anger while driving, however, it may be that when asked to make dynamic assessments of the driving situation, anger and anxiety become more prevalent because they are directly associated with a driving event, while happiness is more general. Indeed, Mesken and colleagues found that anger and anxiety ratings, but not happiness ratings, were associated with specific driving events. Further in their study, happiness was unrelated to driver behavior. In contrast, in the current study, decreases in happiness displayed similar relationships with behavior, as did increases in anger. When relationships were found, more negative affect was related to slower speeds, particularly toward the end of the drive.

It is particularly interesting to observe the different relationships that emerged across the duration of the drive. At the beginning of the drive and on the freeway, which has the fastest speed zone, drivers more prone to anxiety used their brake pedal more than drivers less prone to anxiety. However, their overall average, or variation of speed did not differ. This suggests that in the more demanding driving environment, anxious drivers displayed more unsure driving behavior. Interestingly, during the freeway drive all drivers focused on critical elements of the driving situation, which included the current speed limit and the behavior of other drivers. Thus, evaluation of the freeway environment was unrelated to mood tendencies, or changes in mood. As drivers progressed to the busier retail areas, drivers more prone to anxiety had less focus on specific elements of the situation, such as the behavior of other road users. Therefore suggesting they were unable to focus as much of their attention on the more critical elements of the driving situation. In this area, speed and braking behaviors did not differ according to state or trait moods. This is most likely due to the slow speed zone, presence of road-works and complexity of the driving environment which allowed little room for behavior to differ. In the final section of the drive, the arterial road, trait factors shared no reliable relationships with behavior or the verbal protocols, but mood changes did. In these instances, drivers who had increases in negative mood, evidenced by decreased happiness and energy, also had slower speeds in the final section of the drive and focused more on speed in their verbal protocols. Although no causal factors can be concluded, the direction of the relationships that emerged suggests that changes in mood resulted from the driving conditions and these changes were gradual, so that it was not until close to the end of the drive those relationships between mood and behavior were found. Overall, increases in angry mood across the drive were associated with slower speeds, a finding that corresponds with previous research into the causes of anger[6, 13, 17].

As mentioned above, a counter-intuitive relationship was found between trait driving anger and changes in negative mood across the drive. In the current study, drivers higher in trait anger tended to become less angry and more happy across the drive. The study was limited in sample size and sample demographic and these limitations may have contributed to this finding. For example, there may be participation bias in the sample, where only drivers who feel confident in their "safe" driving abilities participated in the study. Further, trait measures were taken at the end of the study, to avoid any priming effect, and it may be that drivers who felt they had a particularly enjoyable drive overcompensated when answering the trait questions. In other words, drivers who may get angered while driving did not get angered in this instance and therefore answered the trait questionnaire in line with their state, not trait, emotion. If this is the case, then further research should consider the order in which questionnaires are presented to drivers. Likewise, if this is the case, then the reason why drivers who tend to become angered while driving did not become angered should be explored further. One possible explanation might lie within the verbal protocol methodology. This has been found to be an effective method of tapping in to drivers' situational awareness as they drive and with little influence on their driving behaviour[19]. However, it may be in the current sample that the act of focusing on safety critical elements of the driving environment (by verbalizing them) distracted drivers from making the type of assessments that would lead to increased angry mood or increased anxiety. Indeed, Stephens and Groeger [6] found that drivers who were asked to focus on the difficulty and danger of a situation adopted a more cautious driving style than those who were asked to focus on how anger provoking a situation was. Therefore, this may be a rather serendipitous finding worthy of further research.

In conclusion, few relationships were found with driver's trait and state moods; however, when they emerged trait anxiety was related to more braking behavior in high demand driving situations. In contrast, state anger was related to slower driving speeds and more focus on speed in the verbal protocols.

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