THE EFFECTS OF MOOD VALENCE AND AROUSAL ON CAR FOLLOWING; EVIDENCE FROM DRIVING BEHAVIOUR AND EYE TRACKING

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ABSTRACT

The choice of time headway is individual and highly depends on the perceived likelihood of a rear-end collision. This study investigated whether this perception is dependent on drivers' mood and cognitive load. Drivers were asked to follow a lead vehicle in one of four moods (neutral, happy, sad, and angry) and under three cognitive loads (none, non-driving related load, and driving related load). Time headways were measured along with eye tracking data and physiological measurements of electro-dermal activity and heart rate. The relationship between cognitive load, visual search patterns, mood, and time headway was modelled. The results indicate that those in a sad mood followed at longer time headways than those in other moods However, the positive effect of these changes is moderated by the reduction of attentional shift, in the form of longer eye fixations. In addition, it was found that cognitive load can act as attentional mediator for those in the sad mood but as a distractor for other drivers.

Keywords: *time headway, driver's mood, cognitive load, attentional shift, driving safety*

1. INTRODUCTION

Drivers have to keep a safe distance to a car in front to account for the possibility of sudden braking. Choosing an inappropriate distance can have severe consequences. For example, in the UK, close car following has been associated with 7023 accidents in 2015, 469 of which were fatal or serious (Department for Transport, 2015). One of the parameters defining a safe distance is time headway (TH). TH is a measurement of time between cars in which the front of a following car would reach the back of a lead car without changes in their speed (Evans, 1991). An alternative TH has been proposed as being the safe upper limit of safe interaction; this time varies from 1.5-3.5 seconds in good road and traffic conditions (Pasanen & Salmivaara, 1993; Piao & McDonald, 2003; Vogel, 2003; Wasielewski, 1979). Shorter TH leaves less time to respond to a potential hazard. This response is dependent on drivers' mood, cognitive load, and their ability to switch attention from object to object (Crundall, Chapman, Phelps, & Underwood, 2003; Lee, Lee, & Ng Boyle, 2007; Zimasa, Jamson, & Henson, 2017). For example, Tasca (2000) found that aggressive drivers are more likely to tailgate, and Green (2000) found that under cognitive load, the drivers' stopping distance increases. The interaction between mood and load and their effect on following behaviour has been under researched however.

Eye movement measures are reliable indicators of attentional shift (Underwood, Chapman, Berger, & Crundall, 2003; Velichkovsky et al., 2003). Previous research has shown that sad drivers are slower in attentional shift than happy and neutral drivers as indicated by longer hazard response times and eye fixation durations (Zimasa et al., 2017). However, the impacts of positive and negative mood valence and high and low arousal impacts on TH choice are unknown.

The current study addresses both these shortcomings by comparing changes in TH from baseline, as a reference point of a normal or usual driving style, to the driving style which occurs as a result of drivers' mood change. It was hypothesized that the higher arousal moods would result in shorter THs. The lower arousal moods would elicit different behaviours; sad mood would result in slower attentional shift expressed by longer fixation durations and longer TH. The neutral mood should not bring any changes in TH and eye fixation durations.

2. METHODOLOGY

2.1. Material/Apparatus

The study was performed the University of Leeds driving simulator (UoLDS), with highly immersive dynamic motion system and high level of fidelity. UoLDS is based on a 2005 Jaguar S-type vehicle, equipped with fully operational controls, rear view and side mirrors, real steering wheel with force feedback and pedals. The vehicle is placed inside a dome with spherical screen projection of 3x1920x1200 to the front and 1024x768 in the peripheral and rear view. The view is displayed in the rear and side mirrors with visual field angle of 42°. Seeing Machines face LAB v5 eye-tracker was used for recording eye movements. The eye tracker was fixed in the driving simulator car's front panel and allowed the recording of gazes with accuracy of ±1° at 60 Hz. Physiological measurements were collected via the Empatika E4, a wearable wireless multi-sensor device. This is non-invasive, small (4cm x 4cm), and lightweight (25 grams) device. Measurements are taken using 4 sensors efficiently combined into wristband.

Prior to and after the experiment participants were asked to fill in a mood assessment grid to determine their mood valence and arousal (Figure 1)

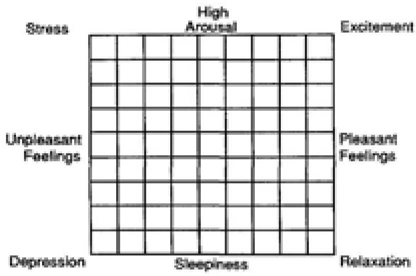


Figure 1: Self-assessment grid (Russell, Weiss, & Mendelsohn, 1989).

Mood was induced via music (Table 1) and supplemented with appropriate mental imagery (Västfjäll, 2002).

Table 1: Music used for different Mood inductions.

Mood	Music
Sad	1) Chopin (1839). Opus 28,/#6, from Preludes, Played by Alessandra Ammara, piano 2) Prokofiev (1938). Russia Under Mongolian Yoke from Alexander Nevsky
Happy	1) Delibs (1870), Mazurka from Coppelia 2) Bach (1721). Brandenburg Concerto #2
Neutral	1) Chopin Waltz No. 12 in F minor, Op. 70, No.2 2) Chopin Waltz No. 11 in G flat, Op. posth, 70 No. 1
Angry	1) Mussorgsky (1867) – Night on Bald Mountain, played by symphonic orchestra. 2) Hoist (1918). – The Planets – Mars, the Bringer of War

2.2. Design

A 3x4 mixed design was employed with Mood as the between subject's factor with four levels (neutral, happy, sad, angry), and Load as a within subjects factor with three levels (no-load (NONE), non-driving related load (NDRL), and driving related load (DRL). A baseline drive was performed before each experimental drive to establish drivers' usual driving styles and to be able to capture changes triggered by different moods. Within every Mood condition there were three drives under different Load conditions. The drives consisted of 8 events and a car following task. Due to spacial limitations, only the car following task will be discussed here.

2.3. The car following task

The car following task was developed by (Brookhuis, Waard, & Mulder, 1994) and adapted to driving simulator by (Ward, Manser, de Waard, Kuge, & Boer, 2003). The participant follows a lead car on a single carriageway. The lead car varies its speed between 50 and 60 mph in an approximate sinusoidal cycle with a frequency of about 0.03 Hz. The instructions are to drive and consistently keeping the safest and the most convenient distance.

2.4. Cognitive load

In no-load condition no questions were asked during the drive. In the DRL condition, driving related questions were asked, and in NDRL, non-driving related questions were asked. An example of a DRL question was "Is it safe to overtake these parked cars?", whilst a NDRL would be "Do you have a dog?" The order of the questions was counterbalanced between the conditions, so that all the participants had all the questions, but in different orders. All together there were 4 questions asked in each load condition.

2.5. Participants

The participants were recruited using the University of Leeds simulator participant pool as well as personal contacts. The inclusion criteria were driving experience no less than 3 years and driving no less than 5000 miles per a year. There were 40 participants (26 males), mean age 38.48 (SD 12.29), range 48. As a gesture of appreciation all participants were given £20.

2.6. Procedure

After filling in consent forms and pre-study questionnaires, participants had to perform a practice drive to familiarize themselves with the task. After the practice drive participants performed a baseline drive with instructions "drive as you would normally do". The same instructions were given for the experimental drives. Following the baseline drive, they were asked to sit as still as possible and relax for 4 minutes to elicit baseline physiological measurements. After this, 5-minute musical excerpts were played (80 dB volume) and the second set of physiological data was collected to record changes. Next, participants were asked to perform three more experimental drives during which cognitive load was manipulated. The questions were asked through the hands-free communication system in the vehicle at a volume of 65dB, so being not too loud, but could be heard regardless of music, as the music was still played with lower volume (60 dB).

3. ANALYSIS AND RESULTS

3.1. Mood induction

The pre-study self-assessment questionnaires showed that there was no significant difference in the mood valence and arousal between different participant groups, indicating that all the participants were in the similar mood and similarly aroused before the study; valence, F (3, 35) = 0.55, p = 0.65, arousal, F (3, 35) = 0.11, p = 0.95. However, the post-study questionnaires showed significant difference in participants' mood valence, F (3, 35) = 7.43, $p <$ 0.05. Post-hoc tests showed that the differences were between the positive valence (happy, neutral) and negative valence (sad, angry) conditions, (p < 0.05). There also was a significant difference in arousal between the groups. Post hoc tests revealed differences between the low (sad, neutral) and high arousal groups (happy, angry), all p < 0.05. The results demonstrate the effectiveness of the mood induction.

3.2. Physiological data

Electro-dermal activity (EDA) and heart rate (HR) data were analysed to determine whether there were changes in arousal levels between the conditions. There was a significant difference between the EDA in the different Mood conditions X^2 (3) = 21.76, p < 0.001, with mean ranks of 29.55 for Sad, 12 for Happy, 25.83 for Neutral, and 10.5 for Angry conditions. Pairwise comparisons using the Dunn-Bonferroni correction showed that significant differences were between the low (neutral, sad) and high (happy, angry) arousal conditions (Figure 2).

Condition1 – Condition 2	Test statistic	Significance
Angry-Happy	0.46	1
Angry-Neutral	11.82	0.004**
Angry-Sad	12.8	0.002**
Happy-Neutral	10.89	0.006**
Happy-Sad	9.02	0.02**
Neutral-Sad	4.34	0.22

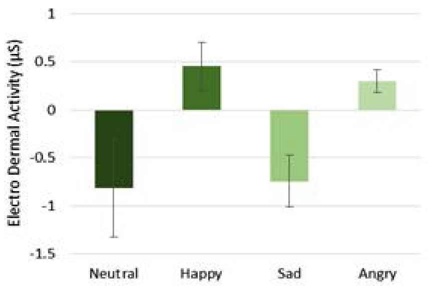


Figure 2: Kruskal-Wallis test statistics for EDA differences between the Mood conditions (left), and graph representing EDA measured in microsiemens (right). Error bars represent standard errors

There was a significant difference in HR between the Mood conditions X^2 (3) = 23.2, p < 0.001, with mean ranks of 24 for the sad, 12.9 for the happy, 29.63 for the neutral, and 7.5 for the angry conditions. Follow up pairwise comparisons using the Dunn-Bonferroni approach showed significant differences between the low (neutral, sad) and high (happy, angry) arousal conditions (Figure 3).

Condition1– Condition 2	Test	Significance
Angry-Happy	5.4	1
Angry-Neutral	22.13	0.00**
Angry-Sad	16.5	0.006**
Happy-Neutral	-16.73	0.005**
Happy-Sad	11.1	0.11
Neutral-Sad	-5.63	1

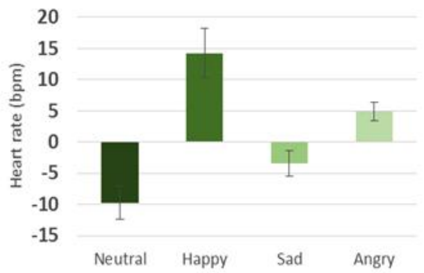


Figure 3: Kruskal-Wallis test statistics for HR differences between the Mood conditions (left), and graph representing HR measured in beats per minute (right). Error bars represent standard errors

3.3. Eye tracking data

Fixation durations in the baseline drive were subtracted from the corresponding Mood condition data. There was a significant main effect of Load, *F* (1.71, 61.52) = 9.23, $p < 0.01$. Within-subjects' contrasts revealed significant differences between the NONE (mean difference 0.15 sec) and NDRL (mean difference 0.07 sec), and between the NDRL and DRL (mean difference 0.03 sec). There was a significant main effect of Mood, *F* (3, 36) = 4.75, $p < 0.01$. Pairwise comparisons revealed that the differences were between the sad (mean -0.02 sec) and happy (mean 0.07 sec), the sad and neutral (mean 0.08 sec), and a marginally significant difference between the angry (mean 0.02 sec) and neutral conditions ($p = 0.056$). The biggest changes were in the sad mood, where fixation durations increased compared to the baseline.

There also was a significant interaction, *F* (5.13, 61.52) = 3.86, $p < 0.01$. Within subjects' contrast showed that the significance was between the NONE (mean -0.08 sec) and NDRL (mean 0.03 sec) in the sad mood (Figure 4)

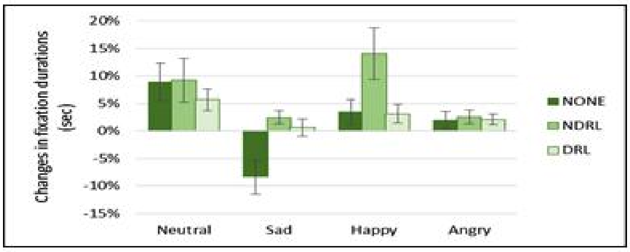


Figure 4: Changes in the fixation duration between the baselines and the corresponding Mood conditions, measured in seconds. Error bars represent standard errors.

3.4. Time Headway (TH)

For the analysis of TH, repeated measures ANOVA was used with the between subject factor Mood (four levels: neutral, happy, sad, angry) and the within subject factor Load (three levels: NONE, DRL and NDRL). For the within subject effect, a Greenhouse-Geisser correction was used, if the assumption of sphericity was violated. THs longer than 6 seconds were excluded from the analysis (Vogel, 2002). The data were divided into 6-time segments; 0 to 1 second, 1 to 2, 3 to 4, 4 to 5, and 5 to 6. The time was calculated without including the last second. For example, from 0 to less than 1 (with 1 not included), from 1 to less than 2 (with 2 not included), and so on. For each time segment, the proportion of time participants drove in each time segment as a proportion of all time was calculated and compared across conditions. Finally, the proportions in each Mood condition was subtracted from the corresponding baseline. For example, time segment 1-2 seconds in the sad mood was subtracted from the baseline of the sad mood.

There were no significant differences in the TH of 0-1, 2-3, 4-5, and 5-6 time segments in any of the conditions. There was a significant effect of Mood on TH in the 1-2 seconds time segment, F = 3.72, p < 0.05. Pairwise comparisons showed that these differences were

between the sad and all the other moods ($p < 0.05$), demonstrating that, regardless of Load, the happy, neutral, and angry drivers preferred this time headway significantly more compared to the sad drivers.

In the time segment of 3-4 seconds there was a significant main effect of Load, F (1.59, 55.48) = 3.5, $p < 0.05$. Pairwise comparisons showed that this was due to the effect of NDRL, $p < 0.05$, indicating that regardless of Mood, when asked non-driving related questions, drivers preferred to spend less time at this TH. There was also a significant main effect of Mood in this time segment, F (3, 35) = 3.22, $p < 0.05$. Pairwise comparisons showed that this difference was between the sad and the angry moods, with the sad drivers spending significantly more time at this TH. There were no significant interactions between Mood and Load in this segment (Table 2, Figure 5).

Mood/Load	Time (Sec)	Neutral	Happy	Sad	Angry
NONE	1-2	0.26(0.21)	0.24(0.19)	0.05(0.09)	0.26(0.24)
	3-4	0.26(0.21)	0.29(0.22)	0.33(0.18)	0.14(0.16)
NDRL	1-2	0.25(0.21)	0.3(0.29)	0.1(0.14)	0.41(0.29)
	3-4	0.19(0.17)	0.18(0.19)	0.25(0.14)	0.11(0.13)
DRL	1-2	0.32(0.25)	0.19(0.28)	0.04(0.05)	0.3(0.29)
	3-4	0.19(0.19)	0.18(0.19)	0.4(0.16)	0.14(0.14)

Table 2: Means and standard deviations (in brackets) for TH in Mood and Load conditions. Non-significant results are not included.

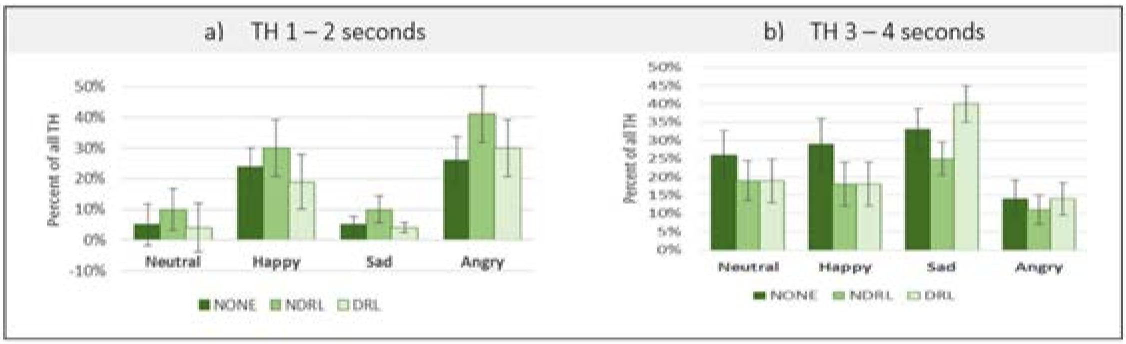


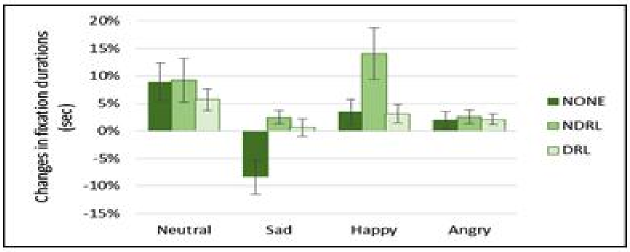
Figure 5: Percent time spent in different time headway segments by Mood and Load. Error bars represent standard errors.

The comparison of changes between the conditions and their corresponding baselines showed that there were no significant differences in the TH changes from baseline in the time segments 0-1 second, 1-2 seconds and 2-3 seconds. Figure 6 shows that the sad drivers reduced the time spent in 0-1, 1-2, 4-5, and 5-6 time segments, did not change time in the 2-3 seconds segment and increased time spent in the 3-4 segment. Neutral, happy, and angry drivers decreased time spent in the 2-3 seconds segment, and angry drivers decreased time in the 4-5 and 5-6 seconds segment as well. However, these changes are not significant.

There was a significant main effect of Load in the 3-4 second time segment, F (1.59, 57.27) = 3.95, $p < 0.05$. Pairwise comparisons showed that this difference was between the NDRL and other Loads, $p < 0.05$, indicating that regardless of Mood, drivers reduced the time spent in this segment in the NDRL condition (mean = -0.02, SE = 0.03) compared to the DRL (mean = 0.31, SE = 0.03) and NONE (mean = 0.06, SE = 0.06) conditions. There was a significant main effect of Mood, F (3, 36) = 3.2, $p < 0.05$. Pairwise comparisons showed that this effect was between the angry and all other moods, $p < 0.05$, indicating that drivers in the angry mood spent significantly less time in this time segment compared to their normal driving. There were no significant interactions (Table 3 and Figure 6).

Table 3: Means and standard deviations (in brackets) for changes in TH from the corresponding baselines to the Mood and Load conditions.

There also was a significant interaction, F (5.13, 61.52) = 3.86, $p < 0.01$. Within subjects' contrast showed that the significance was between the NONE (mean -0.08 sec) and NDRL (mean 0.03 sec) in the sad mood (Figure 4)



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Mood/Load	Time (Sec)	Neutral	Happy	Sad	Angry
NONE	1-2	0.26(0.21)	0.24(0.19)	0.05(0.09)	0.26(0.24)
	3-4	0.26(0.21)	0.29(0.22)	0.33(0.18)	0.14(0.16)
NDRL	1-2	0.25(0.21)	0.3(0.29)	0.1(0.14)	0.41(0.29)
	3-4	0.19(0.17)	0.18(0.19)	0.25(0.14)	0.11(0.13)
DRL	1-2	0.32(0.25)	0.19(0.28)	0.04(0.05)	0.3(0.29)
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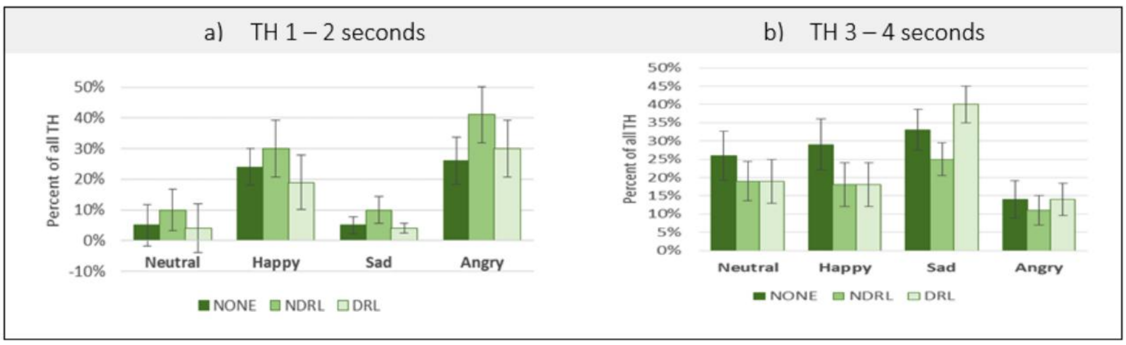

Figure 5: Percent time spent in different time headway segments by Mood and Load. Error bars represent standard errors.

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Table 3: Means and standard deviations (in brackets) for changes in TH from the corresponding baselines to the Mood and Load conditions.

Mood / Load	Time (seconds)	Neutral-Baseline	Happy- Baseline	Sad- Baseline	Angry- Baseline
NONE	3-4	0.09(0.17)	0.14(0.15)	0.09(0.23)	-0.08(0.16)
NDRL	3-4	0.01(0.12)	0.02(0.1)	0.11(022)	-0.11(0.22)
DRL	3-4	0.02(0.14)	0.03(0.14)	0.16(0.24)	-0.08(0.15)

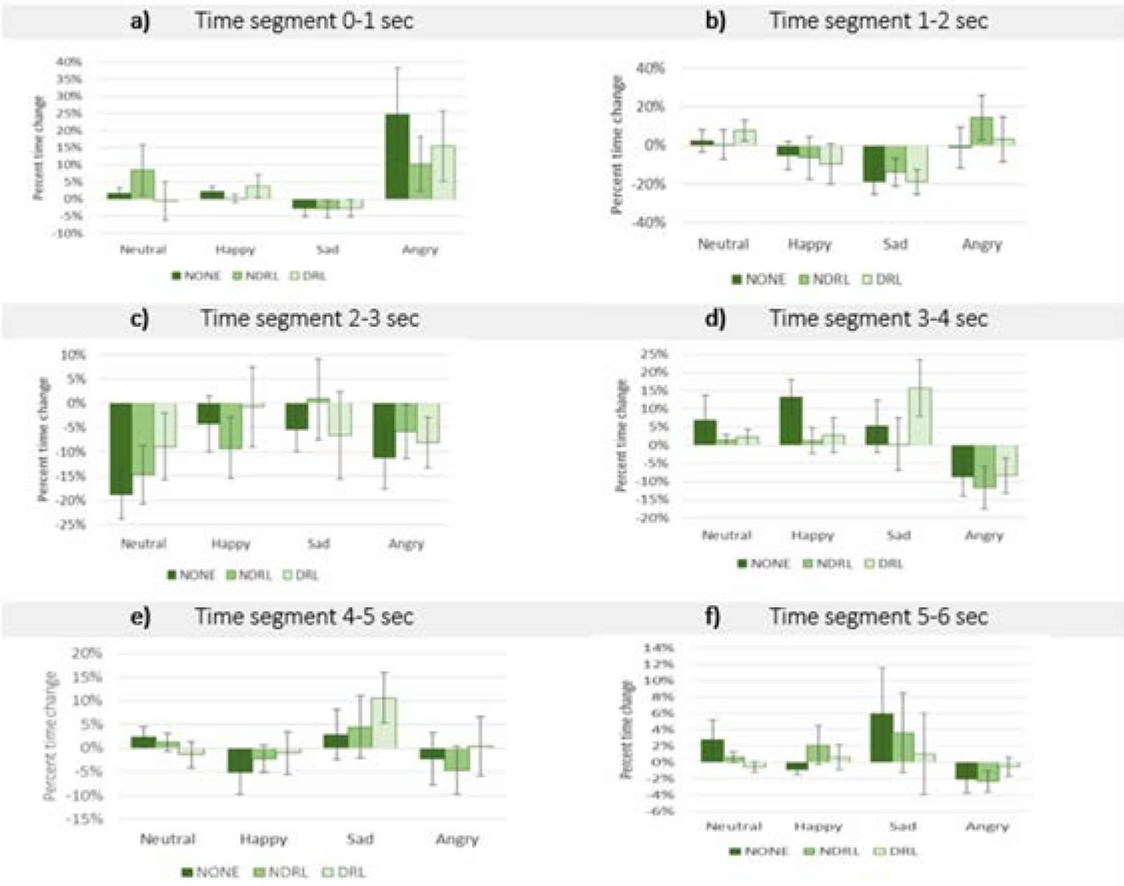

Figure 6: Changes in percent time spent in different time segments between the baselines and corresponding Mood and Load conditions. Error bars represent standard errors.

4. DISCUSSION

The present research has investigated how different moods and cognitive load affect car following as expressed by time headway. It was hypothesized that angry drivers would choose shorter following times (Tasca, 2000). It also was hypothesized that if following time can be accounted for by arousal, happy drivers following distance should be like that of the angry drivers. Sad drivers, instead would increase the car following distance due to a compensatory mechanism and the internal nature of the sad mood (Zimasa et al., 2017). The drivers in the neutral mood should not be affected by the arousal and due to no changes in the mood valence, their car following distance should not change from the baseline.

The results of the mood induction show that the participants' mood was indeed changed in accordance with the experimental manipulations. The physiological data also supports this conclusion, as the high arousal moods showed significantly higher EDA and HR compared to the low arousal conditions.

The time headway results fully support the hypotheses. Angry drivers increased their TH in 0-1 and 1-2 segments, which are the most safety-critical, and in some countries (i.e. Sweden) are not acceptable (Vogel, 2003). Happy drivers were not so consistent in their safety preferences. Some increase in the less safe 1-2 seconds segment was recorded along with an increase in the safer 3-4 seconds segment. This shows that there are some differences in choosing safety distance between high arousal moods. Positive valence in this case moderates a negative effect of arousal. The significant decrease of time spent in the 3-4 seconds segment and increase in under 3 seconds segments for the angry drivers show that they are less concerned with possible consequences of driving too close to the car in front.

The sad drivers preferred travelling at 3-4 seconds headway significantly more often than the angry drivers, and at 1-2 seconds headway significantly less than drivers in all the other moods, thereby increasing their safety gap. However, the increase in their eye fixation durations show that the positive effect of this change reduces due to a slower switch of their attention and therefore less efficient road monitoring (Underwood et al., 2003; Zimasa et al., 2017). The biggest changes in time headway for low arousal moods were observed in the 2-3 seconds segment, indicating the importance of drivers' arousal in their perception of a safe following distance. However, the changes in low arousal were mediated by the positive valence and affected only the sad drivers.

The type of the cognitive load had a significant effect on drivers chosen following distance as well. When non-driving related questions asked, drivers found it more difficult to maintain their chosen safety gap, showing about a 20% increase in time spent at less than 2 seconds TH and a significant decrease in the safer 3-4 seconds segment. The ability to switch attention was also affected by the type of cognitive load, showing the best attentional alteration when no-load was applied. Driving related questions appeared to have the strongest effect on the drivers' environmental search abilities. However, the cognitive load not always has a negative effect, NDRL helps to improve drivers' attentional shift in the sad mood.

Conclusions and suggestions for further research. Drivers' mood valence and arousal have a significant effect on driving safety. High arousal lowers drivers' perception of danger. Low arousal reduces drivers' attentional ability. However, positive valence mediates the effect of the arousal by conveying more awareness of hazards and improving drivers' ability to search the surrounding environment. The type of cognitive load has a similar effect on driving safety, showing the best safety results when no load is applied. NDRL lowers drivers' perception of danger and attentional shifts and driving related load lowers attentional shift as well. The reasons of attentional improvement in the sad mood when NDRL is applied are not clear. It could be that NDRL switches drivers' attention away from internal state and makes them more aware about external environment. However, this is the question for further research.

REFERENCES

Brookhuis, K., Waard, D. d., & Mulder, B. (1994). Measuring driving performance by car-following in traffic. *Ergonomics, 37*(3), 427-434.

Crundall, D., Chapman, P., Phelps, N., & Underwood, G. (2003). Eye movements and hazard perception in police pursuit and emergency response driving. *Journal of Experimental Psychology: Applied, 9*(3), 163.

Department for Transport. (2015). Reported Road Causalities Great Britain: 2015, Annual Report, Moving Britain Ahead. Retrieved from https://www.gov.uk/government

Evans, L. (1991). *Traffic safety and the driver*: Science Serving Society.

Green, M. (2000). "How long does it take to stop?" Methodological analysis of driver perception-brake times. *Transportation human factors, 2*(3), 195-216.

Lee, Y.-C., Lee, J. D., & Ng Boyle, L. (2007). Visual attention in driving: The effects of cognitive load and visual disruption. *Human Factors, 49*(4), 721-733.

Pasanen, E., & Salmivaara, H. (1993). Driving speeds and pedestrian safety in the City of Helsinki. *Traffic Engineering and Control, 34*(6), 308-310.

Piao, J., & McDonald, M. (2003). *Low speed car following behaviour from floating vehicle data.*
Paper presented at the Intelligent Vehicles Symposium, 2003. Proceedings. IEEE.

Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect grid: a single-item scale of pleasure and arousal. *Journal of personality and social psychology, 57*(3), 493.

Tasca, L. (2000). *A review of the literature on aggressive driving research*: Ontario Advisory Group on Safe Driving Secretariat, Road User Safety Branch, Ontario Ministry of Transportation Ontario, Canada.

Underwood, G., Chapman, P., Berger, Z., & Crundall, D. (2003). Driving experience, attentional focusing, and the recall of recently inspected events. *Transportation Research Part F: Traffic Psychology and Behaviour, 6*(4), 289-304. doi:10.1016/j.trf.2003.09.002

Västfjäll, D. (2002). Emotion induction through music: A review of the musical mood induction procedure. *Musicae Scientiae, 5*(1 suppl), 173-211.

Velichkovsky, B. M., Rothert, A., Miniotas, D., Dornhofer, S. M., Joos, M., & Pannasch, S. (2003). Visual fixations as a rapid indicator of hazard perception. *NATO SCIENCE SERIES SUB SERIES I LIFE AND BEHAVIOURAL SCIENCES, 355*, 313-322.

Vogel, K. (2002). What characterizes a "free vehicle" in an urban area? *Transportation research part F: traffic psychology and behaviour, 5*(1), 15-29.

Vogel, K. (2003). A comparison of headway and time to collision as safety indicators. *Accident Analysis & Prevention, 35*(3), 427-433.

Ward, N. J., Manser, M. P., de Waard, D., Kuge, N., & Boer, E. (2003). *Quantifying Car following Performance as a Metric for Primary and Secondary (Distraction) Task Load: Part A— Modification of Task Parameters.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.

Wasielewski, P. (1979). Car-following headways on freeways interpreted by the semi-Poisson headway distribution model. *Transportation Science, 13*(1), 36-55.

Zimasa, T., Jamson, S., & Henson, B. (2017). Are happy drivers safer drivers? Evidence from hazard response times and eye tracking data. *Transportation research part F: traffic psychology and behaviour, 46*, 14-23.