

## **Information Collection Request Supporting Statement: Section B In-Vehicle Drowsiness Detection and Alerting**

NHTSA is seeking approval to collect information from licensed drivers to determine their eligibility to participate in a study to evaluate the effectiveness of in-vehicle countermeasures for driver drowsiness during four hour drives, using a high-fidelity driving simulator.

Drowsy driving poses a significant safety risk. The development and refinement of driver state detection systems promises the ability to detect drowsiness and prevent crashes. However, while various approaches to driver state detection show promise (e.g. Lee et al. 2013; Schwarz et al. 2015), the problem of how the vehicle should respond remains unanswered. The participant sample will consist of 120 younger (age 21-30) male drivers, the group at highest risk for fatal drowsy driving crashes.

The objective of this study is to compare the impact of in-vehicle drowsiness countermeasures in a driving simulator. Participation will involve a phone and simulator screening session and an overnight study drive where participants will be exposed to one of three drowsiness countermeasure conditions. Participants will also complete self-ratings of drowsiness and preference for the in-vehicle drowsiness countermeasures.

This study will add to the state of knowledge by systematically comparing the effect of different in-vehicle drowsiness countermeasures on driver performance and decision making in a high-fidelity driving simulator. The current plan is for the contractor to produce a draft technical report in 2019 with publication of a final technical report in 2020. Results may also be presented at international meetings of researchers from industry and academia, as well as in peer-reviewed scientific publications.

### **B.1. Describe the potential respondent universe and any sampling or other respondent selection to be used.**

Respondents will be younger male drivers, age 21-30, in Eastern Iowa willing to drive to the University of Iowa Research Park to participate in a driving simulation study. The National Advanced Driving Simulator (NADS) currently has a registry of approximately 7000 individuals who have already expressed interest in participating in driving research studies. Young male drivers who have expressed an interest in participating will be contacted via email sent out to potentially eligible individuals (meet initial age and gender criteria via registry query). Individuals will be randomly selected from this pool and randomly assigned to one of three between-subjects countermeasure conditions. If insufficient interest exists from that group, advertisements will be posted to increase the pool of potential subjects.

A statistical power analysis was performed for sample size estimation based on data from Gaspar and colleagues (2017)<sup>1</sup> comparing the difference in lane departures per minute for drivers who did and did not receive drowsiness mitigation (a warning icon). The effect size in this study was considered to be relatively large ( $\eta^2 = 0.12$ ). With  $\alpha = 0.05$  and power = 0.80, the projected sample size needed with this effect is approximately  $N = 74$  for this between group

<sup>1</sup> Gaspar, J. G., Brown, T. L., Schwarz, C. W., Lee, J. D., Kang, J., & Higgins, J. S. (2017). Evaluating driver drowsiness countermeasures. *Traffic Injury Prevention, 18*(sup1), S58-S63.

comparison. The current study involves drives approximately four times as long, with potentially many more lane departure events. Therefore, our proposed sample of N = 75 drivers should be sufficient to detect differences in driving performance resulting from drowsiness countermeasures.

## **B.2. Describe the procedures for the collection of information.**

Individuals who have expressed an interest in participating in this study will be contacted by phone. Potential participants will complete a phone screening (FORMS 1441) to determine their eligibility to participate in the study.

For those eligible to participate in the study, a research team member will make appointments for a screening session and answer any questions participants may have about the study. During the screening session, potential participants will come to the National Advanced Driving Simulator where a research team member will review study procedures and obtain signatures on an informed consent agreement approved by the University of Iowa Institutional Review Board (FORM 1443). Participants will then complete a short drive in the driving simulator to evaluate simulator sickness and complete a wellness survey (FORM 1444) to evaluate symptoms. Drivers who show symptoms of simulator sickness will be excluded from further participation and compensated for their time.

The final sample will consist of 75 young male drivers between the ages of 21 and 30. The 75 consented participants will complete a screening visit lasting one hour and a study visit lasting nine hours. Prior to the study visit, participants will be asked to wear an activity monitor and to complete a food and activity log (FORM 1445) to confirm that they are awake by 8 AM the day of the visit and do not sleep during the day or consume caffeine after 1 PM. Participants will arrive at the lab at 11 PM, complete a sleep and food intake survey (FORM 1446) and remain awake until starting the study drive at 2 AM. During this time, participants will complete subjective sleep questionnaires (FORM 1447) every thirty minutes. Participants will then drive the simulator for four hours, from 2 AM to 6 AM, to assess the effectiveness of drowsiness countermeasures. During the drives, participants will have the option to stop to rest. During rest breaks, participants will complete the subjective drowsiness survey (FORM 1448) to evaluate drowsiness. Following the drive, participants will complete a questionnaire (FORM 1449A, B, or C depending on the countermeasure condition to which participants are randomly assigned) to understand their acceptance, trust, and perceptions of the drowsiness countermeasure they experienced in the study drive. Transportation will be provided to and from the driving study visits.

## **B.3. Describe methods to maximize response rates.**

Participation in the study is voluntary; however, response rate will be maximized by contacting and enrolling only individuals who have previously expressed interest in driving research. Participants will be offered \$150 as compensation for completing all study procedures. Pay will be pro-rated at \$15/hour. Compensation will be \$15 for the screening visit and \$135 for the study visit. However, participants are told they will start with base pay of \$85 and can earn \$1 per minute for each minute they finish the drive under 3.25 hours (up to \$50). They will also be told they can lose this entire \$85 for any road departures or crashes. In reality, everyone will

earn the \$135 for completing the visit (otherwise pay is pro-rated as mentioned). This incentive is necessary to keep participants engaged in the drowsy driving task for enough time to obtain the necessary data.

Our experience indicates that anything less than the proposed \$150 total compensation would likely result in failure to recruit enough participants to provide adequate statistical power. Our payment structure was based off the structure used in a previous NHTSA study, Driver Monitoring of Inattention and Impairment Using Vehicle Equipment (DrIIVE Phase 2). This study examined the effects of a system to detect and mitigate the effects of drowsiness and provides much of the framework for the current study. This study compensated \$10 for screening, \$100 for the first study visit, and \$140 for the final study visit. Our study has less visits, so our overall pay reflects the screening and final visits (\$150).

**B.4. Describe any tests of procedures or methods to be undertaken.**

The instruments planned for this study have been used extensively in prior studies and refined for ease of completion and question comprehension. The data from the simulator will be reduced to provide summary measures of driving performance. Survey responses will be summarized and used to examine driver preferences toward drowsiness countermeasures and lane departure warnings. To compare drowsiness countermeasures, we will evaluate between-group differences in the number and duration of breaks, as well as overall driving performance (e.g., number of total lane departures). Questionnaire data will be collected electronically via Qualtrics (<https://uiowa.qualtrics.com>). Video simulator data are recorded and backed up automatically. Computer programs (MatLab and R) will be used to reduce simulator data to summary measures (e.g., means, standard deviations) and to perform statistical analyses and generate results figures.

Appropriate statistical tests will be used to compare between-group differences.

Analyses will be restricted to data from the forms and driving data collected by the simulator. No para data will be collected or analyzed.

Research Question	Data	What it measures	Analysis method	Groups Compared
Are there group (LDW, mitigation, control) differences in lane departures? Does LDW reduce lane departures? Does mitigation enhance this effect?	Number of lane departures divided by the total minutes of driving time to account for differences in driving time. This measure provides the lane departures per minute for each participant.	Rate of lane departures; Source: simulator data	Between subjects ANOVA	Lane departure warning (LDW), drowsiness mitigation with LDW (mitigation), and control (no warning or mitigation)

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Are there group differences in the severity of lane departures?	The average maximum lateral exceedance area for drowsy lane departures, defined above	Severity of lane departures; Source: simulator data	Between subjects ANOVA	LDW, mitigation, control
Are there group differences in response time to lane departures?	Steering reversal time, calculated as the time from one tire crossing a lane line to the first instance of steering reversal. Averaged across all drowsy lane departures, as defined above	How quickly drivers respond to a drowsy lane departure; Source: simulator data	Between subjects ANOVA	LDW, mitigation, control
Does drowsiness mitigation reduce drowsy eyelid closures?	Percent eye closure (PERCLOS) calculated from the eye tracker data.	The percent of time drivers eyes are closed or mostly closed, as an objective index of drowsiness; Source: simulator data	Between subjects ANOVA	LDW, mitigation, control
Does drowsiness mitigation increase the likelihood of taking rest breaks?	The number of rest breaks divided by the total time in the experiment	How frequently drivers stop to rest; Source: simulator data	Between subjects ANOVA	LDW, mitigation, control
Does drowsiness mitigation increase the length of rest breaks?	The average duration of rest breaks	How long drivers stopped to rest; Source: simulator data	Between subjects ANOVA	LDW, mitigation, control
Does drowsiness mitigation reduce subjective drowsiness?	Stanford Sleepiness Scale scores collected at the start and end of drive	Self-ratings of drowsiness at different points in time; Source: Form 1447	Mixed ANOVA with drowsiness countermeasure as a between-subjects factor and time point (pre-drive, post-drive) as a within-subjects factor	LDW, mitigation, control
Did drivers consider the drowsiness mitigation when	Number of drivers citing the drowsiness	The percentage of total rest breaks where the	Descriptive statistics	LDW, mitigation,

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deciding to stop to rest?	mitigation in their responses to, "Please describe why you chose to stop," for drivers in the drowsy mitigation group.	mitigation influenced driver decisions; Source: Form 1448		control
How drowsy did drivers feel when they stopped to rest?	The average SSS score during rest breaks	The level of subjective drowsiness when drivers started a rest break; Source: Form 1448	Descriptive statistics	LDW, mitigation, control
Do drowsy drivers find lane departure warnings and drowsiness mitigation annoying?	Responses to questions on the post-drive survey	Subjective Likert-scale rating of annoyance; Sources: Forms 1449B and 1449C	Descriptive statistics	LDW, Mitigation
Are drivers likely to use lane departure warnings and drowsiness mitigation?	Responses to questions on the post-drive survey	Subjective ratings of how likely it is that drivers would activate these technologies in their own vehicle; Sources: Forms 1449B and 1449C	Descriptive statistics	LDW, Mitigation
Do drivers perceive LDW and drowsiness mitigation as useful?	Responses to questions on the post-drive survey	Subjective beliefs about the ability of technology to prevent a drowsy driving crash; Sources: Forms 1449B and 1449C	Descriptive statistics	LDW, Mitigation
Might drowsy drivers over-rely on drowsiness mitigation technology?	Responses to question on the post-drive survey	Subjective rating of how much more likely drivers would be to drive drowsy with drowsiness mitigation; Source: Form 1449C	Descriptive statistics	Mitigation
Did the experimental	Responses to question on the	Subjective rating of how much the	Descriptive statistics	LDW,

incentive structure replicate the tradeoff between wanting to get home quickly versus driving safely?	post-drive survey	experiment Source: Forms 1449B and 1449C		mitigation
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**B.5. Provide the name and telephone number of individuals consulted on statistical aspects of the design**

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