

Department of Transportation
National Highway Traffic Safety Administration
Supporting Statements: Part B
Crash Avoidance Warning System Human-Machine Interface (HMI) Research
OMB Control Number: 2127- XXX

B. JUSTIFICATION

B1. Describe the potential respondent universe and any sampling or other respondent selection to be used.

The target population or the study universe are U.S. drivers with in the age range of 25-55 years. In driving research, drivers 25-55 years old are typically considered to be “middle-aged drivers.” This age range is referred to as the “bottom of the bathtub curve” as it is known to have homogenous low crash risk across the range of years. Drivers younger and older than this range tend to have higher crash risk (these higher end values give the curve the bathtub shape). While the target age range is drivers aged 25-55, ages 56-65 are included in the stated age range to provide for the possibility that difficulties are encountered in finding enough drivers in the 25-55 age range. E.g., if a study targets owners of a particular vehicle that has a high price, often the owners tend to be older (e.g., 56-65) so the target age range would need to encompass the typical age of owners. Listing an upper age of 65 years gives flexibility to ensure recruitment of the needed number of participants.

Drivers participating in this research will be recruited from the Columbus, OH regional area. Regarding the generalizability of data from Ohio-based drivers, drivers’ responses to vehicle crash avoidance warnings are not considered behaviors that would tend to vary with geographical location. A driver’s quick, automatic self-preservation response to a potential crash situation happens very quickly and logically would not be affected by societal differences across areas of the U.S. As such, while the sampling frame is the drivers in the West Central Ohio area, it is assumed that the recruited individuals represent the U.S. driving population in terms of factors related to vehicle HMI. The respondent universe includes individuals solicited through print and online newspaper advertisements in the West Central Ohio area. It is planned that participants will be recruited from an area covering an approximately 60-mile radius surrounding the test site. The sample will be recruited from the sampling frame meeting the specific criteria.

To better understand the impact of crash avoidance (CA) HMI design on driver behavior, this research will focus on middle-aged drivers. However, research has shown that drivers of varying ages perceive and respond to visual and auditory warnings differently, which can impact their interaction with in-vehicle systems. Due to age-related changes in color perception, older drivers may experience difficulties perceiving certain colors or distinguishing between similar hues¹. Conversely, younger drivers often respond more quickly to visual warnings due to quicker reaction times and better peripheral vision². Additionally, hearing ability tends to decline with age, potentially affecting the efficacy of auditory warnings for

¹ van Leeuwen, J.E.P., McDougall, A., Mylonas, D. et al. Pupil responses to colorfulness are selectively reduced in healthy older adults. Sci Rep 13, 22139 (2023). <https://doi.org/10.1038/s41598-023-48513-7>

older drivers.

Despite these potential age-related differences in drivers' perception of and response to warnings, research in HMI typically begins with a focus on a homogenous middle-aged population to establish baseline interactions and usability since they often represent the largest segment of the driving population. Starting with a more homogeneous group helps control for confounding variables, making it easier to isolate the effects of the CA HMI design itself before introducing the complexities of age-related factors. Middle-aged drivers generally exhibit fewer age-related sensory or cognitive impairments, allowing researchers to establish normative data on CA HMI effectiveness. Focusing on this group allows researchers to identify and address fundamental CA HMI design issues before tackling the more complex variations introduced by age-related sensory and cognitive changes. As the need arises, future research can expand to include age-related factors to ensure that interfaces are accessible and effective for all age groups.

Participant screening criteria satisfaction will be determined using a standard set of demographics, driving behavior, and general health questions. Specific questions were developed and reviewed through their use in multiple studies to ensure their wording is clear and only the minimum relevant information is obtained for the purposes of assessing individuals' suitability for study participation. No health information will be stored; only a net response indicating whether a candidate participant "meets criteria" will be retained. Participant contact information will be securely retained only for the duration of the study and used to schedule facility visits and provide appointment reminders. Contact information will be securely (i.e., access controlled and password-protected computer hard drive) stored separately from study data and destroyed after study completion.

No statistical methods will be used in selecting study participants, rather this sample will be a convenience sample with further criteria. Study participants will be selected based on a set of criteria that serve to ensure that participants will be generally representative of average U.S. drivers, have no recent criminal convictions, and hold no biases that may impact study results. The criteria state that participants must:

- a. Be aged 25-65 years (inclusive)
- b. For drivers of light passenger vehicles: Hold a valid U.S. driver's license and drive at least 11,000 miles annually in light passenger vehicles
- c. For drivers of heavy trucks: Hold a valid U.S. commercial driver's license and drive at least 11,000 miles annually in a commercial truck
- d. Have no more than 2 points on current driving record
- e. Have no criminal convictions in the past 3 years including criminal driving offenses
- f. Have no uncorrected vision or hearing problems
- g. Be in good general health, able to drive continuously and safely for a period of 2 hours without the need for assistive devices
- h. Self-report that they are able to read, write, speak, and understand English
- i. Be willing to drive to NHTSA's Vehicle Research and Test Center and spend up to approximately 3 hours participating in a research study

² Fildes B, Charlton J, Muir C, Koppel S. Driving responses of older and younger drivers in a driving simulator. *Annu Proc Assoc Adv Automot Med*. 2007;51:559-72. PMID: 18184513; PMCID: PMC3217503.

The contractor's insurance company requires the question regarding the participant's driving record to ensure there is a liability insurance policy in place for testing. The question regarding criminal record serves to ensure no recent criminal convictions (to increase the likelihood that participants will follow research staff's instructions and maintain safety for research staff and the instrumented government-owned test vehicles). The website used to administer the questions records responses to individual vehicle and driving-related questions, while recording only a summary indications (i.e., yes or no) of whether an individual has any criminal convictions and meets the health question requirements. If the respondent replies, 'yes,' to the question about recent criminal convictions, a "thank you for completing the questionnaire" message will be displayed and no responses to the *Candidate Screening Questions* will be saved.

For all driver samples, we will attempt to balance sex (as listed on the candidate participant's birth certificate) to the extent possible based on availability of candidate participants.

B2. Describe the procedures for the collection of information.

No such statistical methods (e.g., stratification) will be employed.

Candidate participants who view and choose to respond to a study recruitment advertisement will complete the Interest Response Form (hosted online on a secure website). Individuals, whose responses to the Interest Response Form meet initial study participation criteria (described above), will be contacted via e-mail and asked to complete the Candidate Screening Questions, which will be accessible via a secure website. Individuals, whose responses to the Candidate Screening Questions meet study participation criteria, will be scheduled for study participation according to their availability. Interest Response Form and Candidate Screening Questions data will only be used for the purposes of identifying suitable study participants and will not be used in any other way.

For driving experiment data collection scheduled participants will be randomly assigned to groups corresponding to study conditions being tested. Study conditions would be the different HMI characteristics examined for a particular crash avoidance system type (e.g., for a particular system type, multiple visual warning symbols could be examined). Study Data Collection will include passive observation and recording of the participant's driving behavior, eye glance behavior, and use of crash avoidance warning systems. This data collection is necessary for assessing the relative effectiveness of the crash avoidance warning system HMI characteristics. Participants will be asked to drive a government-owned instrumented motor vehicle on a test track, public road, or in a simulated environment (i.e., driving simulator). Participants' driving and eye glance behavior will be observed and recorded. Participants may be presented with a crash-imminent scenario stimulus. Participants' crash avoidance response to the event (e.g., their brake response times) will be recorded for later analysis concerning research questions addressing the safety impacts of crash avoidance warning system HMI characteristics tested. Data collected will be combined across all participants in each test condition. Statistical analyses (e.g., ANOVA) will be performed to assess effects of the factors varied.

Stationary laboratory measurements relating to crash avoidance warning signal characteristics

may also be performed for the crash avoidance system types examined. For the stationary measurements, participants will sit in a stationary vehicle in a laboratory and measurements will be made of their eye midpoint location. This location, along with the location of the center point of the visual warning signal being examined, will be used to calculate the individual's visual angle when looking at crash avoidance warning system HMI visual signal(s) information. This information will be used to understand where drivers' lines of sight intersect different instrument panel and in-vehicle locations.

After all Study Data Collection is completed, participants will complete the Post-Drive Questionnaire to gather participants' opinions and preferences regarding the tested HMI characteristics. Participants' responses to scale-based questions will be combined for analysis. Responses to open-ended questions will be qualitatively summarized and described in the technical report without reference to individual participants.

B3. Describe methods to maximize response rates.

Study recruitment will be accomplished using print (newspaper or flyer) or online study recruitment advertisements, and/or mailed invitations to registered Ohio owners of specific vehicle models. Individuals interested in participation will respond to the advertisement by visiting a secure website containing a brief study description. Along with the study description, a web link will be provided that interested candidate participants can follow to begin the screening process.

Study participation likelihood will be increased by the provision of monetary compensation at an hourly rate, as well as mileage reimbursement for travel to and from the test site. Monetary compensation is consistent with normal experimental practice and should encourage study participation. We anticipate payment to both light vehicle and heavy truck drivers at an anticipated hourly rate of approximately \$65.00.

B4. Describe any tests of procedures or methods to be undertaken.

Participants in stationary HMI visual angle measurement testing will sit in a stationary vehicle, and measurements will be taken using a coordinate measuring machine for use in calculating their visual angle to different landmarks on the vehicle's instrument panel and crash avoidance HMI. This may be repeated across different vehicle types. The objective is to understand where crash avoidance warning system HMI placed at different visual angle measurements fall across multiple vehicles for the general public. This information could be used to assert required locations for visual warning components of crash avoidance warning system HMIs.

For testing involving driving an instrumented vehicle, all crash avoidance warning system HMI characteristics will utilize the same data collection approach. Vehicles will be equipped with varying crash avoidance warning system HMI characteristics. Participants will be randomly assigned randomly to the order of crash avoidance warning system HMI characteristics. Participants will be asked to drive a government-owned instrumented vehicle on a test track, public road, or in a simulated environment (i.e., driving simulator). Participants' driving behavior will be observed and recorded and they may be presented with a crash-imminent condition stimulus, and their crash avoidance response (i.e., onset of braking and steering inputs)

times will be measured as a function of visual warning location (e.g., down-angle) or other HMI characteristics. This will be repeated until all conditions are evaluated.

Anticipated research questions being investigated in driver behavior observation experimental data collection are described below.

1. Driver Behavior and Crash Avoidance Response

- How do crash avoidance warning HMI characteristics affect drivers' behavior (e.g., following distance, clearance to other vehicles during a lane change)?
- How do crash avoidance warning HMI characteristics affect drivers' crash avoidance response time in a crash-imminent event?
- How do crash avoidance warning HMI characteristics affect drivers' crash avoidance response type (e.g., apply brakes, steer the vehicle, both brake and steer, or either brake nor steer) in a crash-imminent event?
- Does drivers' crash avoidance response time differ across different visual angle placements of the visual component of the crash avoidance warning HMI?
- How do crash avoidance warning HMI characteristics for a particular crash avoidance warning system (e.g., forward, rear, or lateral crash avoidance) affect drivers' likelihood of avoiding a crash?

Several dependent measures will be analyzed to evaluate whether there are differences in driver crash avoidance response across the HMI characteristics. Dependent measures related to drivers' crash avoidance response will include the type of avoidance maneuver taken as a function of crash avoidance warning system HMI, signal reaction time, time to collision (TTC) to the vehicle that initiated the need for crash avoidance (if applicable) when the participants initiate the avoidance maneuver, and the scenario outcome (i.e., crash or crash avoidance).

Data will be aggregated for all participants according to crash avoidance warning system type (forward, rear, or lateral crash avoidance) and each dependent variable's mean, median, and standard deviation will be calculated. Separate analyses will be performed for each system. Separate paired samples t-tests, if appropriate per the distribution of data, will be performed within each crash avoidance warning system HMI characteristic to assess whether each response time-dependent measure differs.

2. Eye Glance Behavior

- Where does the driver look when presented with crash avoidance warning signal?
- How does the eye glance behavior differ across different visual angle placements of visual component of the crash avoidance warning?

Eye glance behavior will be recorded and metrics calculated to evaluate whether differences exist in eye glance behavior in response to presented crash avoidance HMI warnings and alerts across conditions. Specifically, the response time from the visual signal onset to the driver looking at the visual warning signal and initial crash avoidance response.

Data will be aggregated for all participants, and each dependent variable's mean, median, and standard deviation will be calculated. Separate analyses will be performed for each system. Separate paired samples t-tests will be performed within each crash avoidance warning system HMI characteristic.

3. Post-Drive Questionnaire

- Do drivers' subjective impressions of general use, comfort, and visibility differ across crash avoidance HMI characteristics tested?

A post-drive questionnaire will assess participants' subjective ratings about the crash avoidance warning system HMI characteristics. Questions will be asked concerning the crash avoidance warning system HMI characteristics, degree of comfort with system use, and perceptions of safety associated with system use, and effectiveness of the HMI in supporting crash avoidance. Participants' responses to scale-based questions will be combined for analysis. Responses to open-ended questions will be qualitatively summarized and described in the technical report without reference to individual participants. Data will be aggregated for all participants, and the mean, median, and standard deviation of ratings will be calculated for use, trust, and safety.

B5. Provide the name and telephone number of individuals consulted on statistical aspects of the design.

Elizabeth Mazzae, MSE, USDOT NHTSA, 937-666-4511

Alexandria Rossi-Alvarez, PhD, USDOT NHTSA, 937-666-3322

Kelly Satterfield, PhD, USDOT NHTSA, 937-666-3247

Scott Baldwin, MSE, Transportation Research Center, Inc., 937-666-4511

Isabella Skuce, MS, Transportation Research Center, Inc., 937-666-4511

Samantha Walker, MS, Transportation Research Center, Inc., 937-666-4511
