Department of Transportation
National Highway Traffic Safety Administration
Supporting Statements: Part B
Distraction: Modern Voice Command Interfaces OMB Control Number: 2127- (XXXX)

Abstract:[1]

The National Highway Traffic Safety Administration (NHTSA) is proposing new research involving the collection of information from the public to understand the effects of voice command interfaces (VCIs) on driver performance, distraction, and cognitive workload via a driving simulator study. VCIs allow drivers to verbally request actions (e.g., send a text) or information (e.g., what is the weather forecast for today), which can be initiated with either a spoken phrase (e.g. "Hey Google") or button presses. This study will compare VCI use to visual-manual interface use, particularly during safety-critical driving situations. A visual-manual interface refers to any system where a user interacts by looking at something (visual) and manipulating it with their hands (manual). Driver performance, distraction, and cognitive workload will be assessed using data collected from a driving simulator, eye-tracker, electrocardiogram (ECG), and tactile detection response task (TDRT). The overall objective of this information collection request is to advance the state of knowledge regarding the use of VCIs in vehicles by comparing common tasks executed across different VCI systems, and across different input methods (VCI vs visual-manual input).

Westat is the contractor leading this effort, and they will be working with a partner, Dynamic Research Inc. (DRI). All procedures will be approved by the Institutional Review Board (IRB) at Dynamic Research Inc. (DRI). Data collection will involve human-subjects operating DRI's driving simulator and will begin upon receipt of PRA clearance and final approval from DRI's IRB. DRI's driving simulator provides a safe and controlled environment for testing production vehicles. Its modular design allows for easy swapping between different vehicle makes and models, facilitating comprehensive evaluations. The research involves a single study session, during which participants from the general population will complete a series of drives in a driving simulator. Driver's interactions with six VCI systems will be evaluated (e.g., Apple CarPlay, Android Auto, Google Built-In, three OEM systems) across four vehicles. Participants will be recruited based on which vehicle and system they use when they drive (e.g. Android Auto in a Honda Accord) and complete their session using that same vehicle (or very similar vehicle) and system. Participation is voluntary with monetary honorarium provided to participants.

Vehicles and their available systems as well as the VCI capabilities may change year-to-year. Therefore, the specific vehicles and OEM systems will be selected after PRA approval and will be based on an annual technology scan assessing changes in VCI capabilities in production vehicles. Note, none of the elements of the study affecting participant burden (e.g., number of drives or tasks performed) will be changed.

Participants will complete a series of nine drives (in one vehicle), consisting of a familiarization drive, seven drives where they will complete secondary tasks, and one drive involving a safety

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critical event. The familiarization drive will occur first, serving as practice for participants to drive the simulator. The order of the seven task drives will be counterbalanced to control for order effects. The Safety-Critical Event (SCE) drive will occur last due to potential behavior changes after drivers experience a possible crash due to the SCE.

The familiarization drive is designed to help participants get accustomed to driving in the simulator. Although participants will be assigned to the system/vehicle that matches their own vehicle, the control of the vehicle may feel different from real-world driving, so it will take participants some time to acclimate. Therefore, before any data is collected, participants will complete a drive to gain familiarity and reduce any potential practice or learning effects.

The seven task drives will be comprised of six standardized task drives. The six standardized task drives will consist of three common task drives, where participants will perform common in-vehicle secondary tasks (e.g., navigation, music streaming, phone calls) while driving. Each common task will be performed once using VCI technology and once using traditional visual-manual interaction. The unique task drive will assess advanced vehicle-to-infrastructure features specific to that particular vehicle or system.

The final drive will be a Safety-Critical Event (SCE) drive, involving a simulated dangerous driving situation. During this drive, participants will be engaged in a navigation task to induce distraction. The task will be interrupted by a sudden, covered-to-revealed road obstruction that requires an immediate response.

B. JUSTIFICATION

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

No statistical methods will be used in selecting study participants. The respondent universe consists of individuals from the greater Torrance, CA area who represent the average U.S. driver, are generally healthy and who use one of the chosen study vehicles and voice command interfaces of interest. More specifically, individuals must meet the following criteria:

1. Must be 18-70 years old
2. Normal or corrected-to-normal hearing
3. Vision requirements – must meet criteria in either i or ii
    a. (i) Must meet one of the following criteria:
        - No Prescription glasses needed to drive OR
        - Wear contact lenses while driving
    b. (ii) Must meet both of the following criteria:
        - Prescription glasses with SPH values between -6 and +6 diopters AND
        - Prescription glasses with CYL values between -1.5 and +1.5
4. Fluent in reading and speaking in English

5. Valid driver's license
6. Regularly drive one of the following vehicles
    a. [*Vehicles to be chosen after PRA*]
7. Regularly use one of the following systems
    a. [*Systems to be chosen after PRA*]
8. Not experienced motion sickness in a driving simulator previously
9. Drive at least 3000 miles per year
10. Ability to abstain from alcohol, marijuana, and illicit substances for the 12 hours prior to session
11. No special driving equipment needed
12. No medical conditions that might impact driving (i.e., heart condition, back or neck pain, recent back or neck pain treatment, disorders, disability or seizures)
13. No sedative or psychotropic medications (antidepressants, anti-anxiety medications, stimulants, antipsychotics, or mood stabilizers)
14. Not pregnant
15. No mascara or fake eyelashes can be worn to the session
16. Have valid Social Security Number or Tax Identification Number

Participant commute is not anticipated to exceed 30 miles from Dynamic Research Inc.'s facility in Torrance, California. Due to the specific nature of this recruitment, we anticipate recruiting both from DRI's participant database of approximately 2000 drivers, and through social media. Participants in DRI's database have previously agreed to receive communication about upcoming studies.

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

The data collection will be a mixed design, with between-subjects effects of system (six systems) and within-subjects effects of task (three common tasks), task modality (VCI and visual-manual) and time (before, during and after). Participants will complete a series of nine drives (in one vehicle), consisting of a familiarization drive, seven drives where they will complete secondary tasks, and one drive involving a safety critical event (SCE). The secondary task drives will consist of three common tasks identified by the annual technology scan that will be completed once via VCI and once via the infotainment screen. The unique tasks will not be shared among the systems, so the six systems being assessed will correspond with six unique tasks. The SCE drive will compare the effect of visual-manual task execution with VCI task execution during a dangerous driving situation.

The vehicles chosen for the information collection will be determined by the annual technology scan, and one of the criteria for participants will be the type of vehicle and VCI system they regularly use. Participants will complete the drives in the DRI driving simulator, using a vehicle and VCI system comparable to what they regularly use.

This research will be conducted within a fixed-base driving simulator located at the DRI facility. Four vehicles will be installed and instrumented within the simulator for this research. Given the potential for technological advancements during the PRA approval process, the final four vehicles will be selected post-approval, based on insights from an annual technology scan that examines recent trends in VCI capabilities in production vehicles. For the research effort, we will assess six systems (e.g., Android Auto, Apple CarPlay, Google Built-In, Amazon Alexa, three OEM specific systems). As noted previously, the systems will also be selected after PRA approval so that they reflect the most current technology. The final sample will include 144 valid data sets: 24 participants per VCI system. Eligible participants will be limited to those who regularly use one of the selected VCI systems.

Based on recent studies, we anticipate some participant attrition before reaching our final dataset of 144.

- Screener Completion: We expect approximately 1330 individuals to complete the screener.

- Eligibility and Contacting Participants: From those eligible and meeting demographic criteria, we anticipate contacting approximately 198 individuals. This accounts for an expected 10 percent attrition rate between screener completion and session attendance.

- Simulator Sickness: We anticipate that approximately 10 percent of participants may experience simulator sickness and be unable to complete the experiment. To account for this, we plan to schedule 178 participants (for 160 to complete the session).

- Data Invalidity: We anticipate that an additional 10 percent of data may be invalid due to equipment malfunctions or participant non-compliance. Therefore, we plan to recruit 160 participants to achieve a final dataset of 144, allowing for the potential exclusion of invalid data.

We propose a two-fold approach to recruitment: (1) DRI's participant database; (2) social media posts. We anticipate 330 potential participants from DRI's participant database will complete the eligibility questionnaire, while approximately 1000 potential participants will complete the eligibility questionnaire from social media. All communication and forms will be approved by the DRI IRB.

Eligibility screening will be completed through an online questionnaire (NHTSA Form 2071: Eligibility Questionnaire) hosted by Voxco, a secure online survey administration platform. Form display and branching logic will ensure respondents see the minimal number of questions required to determine eligibility by ending the questionnaire early if criteria are not met at different points in time. The components include (1) a PRA statement informing participants about the rules governing federally funded research; (2) a privacy notice of data collected and used per California state laws; (3) consent for eligibility questionnaire and study introduction and description to inform participants about the study specific data to be collected; (4) eligibility questionnaire to identify participants based on eligibility criteria; (5) general health questionnaire

to identify potential health concerns that prevent participation; and (6) contact information for scheduling purposes.

The landing page of the questionnaire will contain a forced response question asking if the respondent is above 18 years old, then (if yes) branching logic will display the privacy notice, consent letter that contains the elements necessary for eligibility consent. Participants will provide consent to the online questionnaire when they answer "yes" to both the eligibility consent and study interest questions. These questions will be set to force response. Respondents who are not between the ages of 18 and 70 years old, who do not give consent to provide responses to the online eligibility questionnaire, or who are not interested in the study will be directed to a message thanking them for their time. Everyone else will be directed to the questionnaires. These questions will ask potential participants about their ability to adhere to study requirements, driving qualifications, general health history, and information about their vehicle(s), as well as VCI systems used.

If criteria are not met, participants will be directed to a message thanking them for their time and telling them they are not eligible. If criteria are met, respondents will be asked to provide their contact information and general availability for a session. They will be informed this would link their questionnaire responses to their name. If a respondent meets the study criteria, a researcher will schedule the session using NHTSA Form 2072: Scheduling Form. Participants will also be provided a link to NHTSA Form 2073: Pre-Study Materials to be completed before their session. The Pre-Study Materials packet includes a series of documents for participants to review and complete certain forms prior to their study session, including (1) a privacy notice for describing types and purposes of data collection per California state law (read), (2) a confidentiality agreement to protect proprietary DRI information and technology (read and sign), (3) a copy of the informed consent for participant records (signatures will be obtained at the scheduled session), (4) an indemnification form to hold DRI harmless and allow participation in the study (read and sign), (5) a general information questionnaire to collect participant information (i.e., mailing address, demographic information, health condition). All of these items will be completed in Voxco. Participants will receive a copy of the informed consent along with this survey link for their records.

Participants will be assigned to a study group based on responses to the vehicle information and VCI system block of questions. A copy of the approved informed consent document will be available to participants for review prior to the study visit as part of the pre-study materials. The information collected in the online eligibility questionnaire largely will not be used as data. An exception is the demographic and vehicle information blocks of questions. For participants who sign NHTSA Form 2075: Informed Consent Document at the study visit, responses will be aggregated so we have information on the vehicles and driving history with those vehicles for participants who completed the study. Responses will not be tied to an individual and will not be kept for individuals who do not complete the data collection session.

Approximately 48 hours before the study visit, participants will be sent a reminder email with information and reminders for their visit (NHTSA Form 2074: Appointment Confirmation Form). Participants must refrain from alcohol and illicit or recreational drugs (e.g., cannabis) for the 12 hours preceding their study visit. The email also requests that participants verify they have

no current illness symptoms or feel unwell and that they have experienced no changes to their health or mobility since completion of the Eligibility Questionnaire. Participants will also be reminded to complete NHTSA Form 2073: Pre-Study Materials if they have not already, with a link to the survey.

A dedicated preparation room at DRI serves as the starting point for data collection during scheduled sessions, providing the necessary equipment and a private setting for administering consent. Following the informed consent component, participants transition to the driving simulator. Throughout the in-person data collection event, all questionnaires and forms will be hosted on Voxco (an online survey administration platform) and administered on a tablet equipped with a keyboard cover that permits touch or traditional response entry, except for NHTSA Form 2075: Informed Consent Document, which will be printed for participants to read and sign the day of their session. Study sessions will last approximately 2.5 hours.

The study visit will begin with participants completing NHTSA Form 2075: Informed Consent Document. A researcher will provide participants time to read the informed consent, will verbally review it, and answer any questions before obtaining written consent. The researcher will then verify the form for accuracy (i.e., name is spelled correctly, form is dated appropriately) and then also sign and date the consent. Participants will be provided a printed copy of the informed consent for their records.

Following consent, participants will be asked a series of yes/no questions to verify their answers from the online eligibility questionnaire and verify that their health criteria (e.g., no new, unexpected back or neck pain) has not changed and that they have not used any alcohol or illicit or illegal substances in the last 12 hours (NHTSA Form 2076: Daily Health Survey). A researcher will then verify the participant’s driver’s license. This includes confirming date of expiration (to ensure it is currently valid), date of birth (to ensure age eligibility), sex (to assist with balancing the sample), and restrictions (to confirm ability to drive research vehicles in the simulator). Participants with a driver's licenses that has been expired for more than sixty days will not be permitted to participate and will be dismissed. They may be rescheduled if they renew their license while researchers are still enrolling participants or else will be deemed ineligible. If age criteria are not met or the license has an exclusionary restriction, participants will be sent home and not be eligible to continue.

Participants will be escorted to the research vehicle and instructed on how to adjust the seat for optimal comfort. They will be instrumented with an electrocardiogram (ECG) to measure heart rate variability (HRV), eye-tracking glasses to record gaze and pupil data, and the tactile detection response task (TDRT) sensors to measure cognitive workload. Next, participants will begin the training and driving component of the protocol. Training begins with information about the study, the vehicle and system operation, as well as the TDRT training (e.g., how to respond to the TDRT), and details specific to the research vehicle the participant will drive (e.g., how to initialize the infotainment and VCI systems). After the training, a researcher will address any concerns and answer questions.

Participants will be given the opportunity to walk through the steps to activate the VCI and manual interface while in the DRI simulator. After this training, a researcher will address

concerns and answer questions. Next, participants will complete a 4-minute familiarization drive. This period allows them to:

- Become familiar with the research vehicle.
- Acclimate to wearing the ECG sensors and eye-tracking glasses.
- Practice responding to the TDRT system.
- Experience scenario elements similar to the study drive, such as driving within a simulated traffic environment.

After the familiarization drive, a researcher will address any concerns and answer questions.

Participants will complete a series of eight study drives. Seven study drives will consist of participants executing a secondary task while driving, called task drives. Three secondary tasks will be repeated twice (called common tasks), once with the VCI and once with the manual interface (summing to six of seven task drives). The seventh task drive will be a VCI task that is unique to the current system the participants are testing. Participants will undergo task training before each task drive, consisting of a brief explanation, followed by task practice. Participants must successfully complete three trials before beginning the study drive. All task drives will be counterbalanced to control for order effects. The eighth and final drive is a safety-critical event (SCE) drive that will always occur at the end of the study drives. During this drive, the participants will engage in a secondary task (navigation task). Half of the participants will complete this task using visual-manual controls, while the other half will utilize the VCI. While engaged in the secondary task, participants will encounter an unexpected safety-critical event: a hidden reveal of a stopped vehicle. They must then respond appropriately to this critical event.

After each drive, participants will complete NHTSA Form 2077: Simulator Sickness Questionnaire to ensure they are well enough to continue driving. After participants have completed all the drives, they will undergo a debrief, receive their honorarium, and complete NHTSA Form 2079: Debrief to confirm payment for their participation.

Like the vehicles and VCI systems, we anticipate task availability and functionality to change throughout the PRA approval process. Therefore, tasks will be confirmed after the PRA approval process in conjunction with the annual technology review.

B.3 Describe methods to maximize response rates.

Participation in the study is voluntary. Response rate will be maximized by initially contacting only individuals who have previously expressed interest in driving research. Respondents will receive no payment or gift for completion of the online eligibility questionnaire. Once scheduled, participants will be offered $60 per hour as compensation for completing all study procedures. This rate of pay is comparable to the local area average hourly rate and was chosen based on our experience. Anything less than $50-55 per hour would likely result in failure to recruit enough participants to provide adequate statistical power. In addition to compensation, several methods will be used to maximize response rates, including:

- Completing recruiting and screening electronically for respondent convenience.

- Sending a visit confirmation email including the scheduled date and time, directions, pertinent study information, and a contact email address and phone number in case of cancellation or questions.
- Sending reminder emails within 48 hours of the scheduled session to boost show rate and minimize scheduling misunderstandings or forgetfulness.

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

The online format for the eligibility screening has been used since 2017 in industry- and government-funded trials and was based on phone-screening procedures used for well over a decade. The driving simulator, physiological sensors and tactile detection response task (TDRT), have all been extensively used in prior data collections. Workflows have been established to improve data collection and data handling processes. Additionally, a series of small pilot studies (totaling nine or fewer participants) will be conducted to assist in refining study scenarios, tasks, validating workflow, data collection procedures, and data quality.

Vehicle data will be collected using DRI's driving simulator, which collects and calculates a wide variety of vehicle performance metrics such as speed, lane position, pedal and steering wheel dynamics. Eye-tracking data will be gathered using the Pupil Labs Neon, a portable eye-tracker worn like glasses that records pupil data, as well as gaze metrics. We will also use the Polar H10 for collection of heart rate variability data.

Researchers anticipate cleaning and analyzing the data using the R statistical software program. Researchers plan to use a combination of linear mixed effect models (LMMs) and analysis of variance (ANOVAs) to compare tasks and systems across driver performance (e.g., standard deviation of lane position), driver distraction (e.g., total glance time), and cognitive workload (e.g., pupil diameter). They will also compare how VCI system input compares to visual-manual input during task drives and during the safety-critical event (SCE). Advanced VCI tasks that have not previously been assessed will undergo evaluation using test method one from NHTSA's Visual-Manual Driver Distraction guidelines.

B.5 Provide the name and telephone number of individuals consulted on statistical aspects of the design.

- Jeffrey Dressel, Ph.D., Research Psychologist, National Highway Traffic Safety Administration, Office of Vehicle Safety Research, Human Factors/Engineering Integration Division NSR-310, 202-493-0492

- Kathryn Lucaites, Ph.D., Research Psychologist, National Highway Traffic Safety Administration, Office of Vehicle Safety Research, Human Factors/Engineering Integration Division NSR-310, 202-366-6146

- Amy Benedick, PMP, Principal Human Factors Research Associate, Westat, 240-314-5816
- Lauren Mims, Ph.D., Senior Research Associate, Westat, 301-610-8830
- Kyle Hickerson, Ph.D., Lead Research Associate, Westat, 301-738-3687