TITLE OF INFORMATION COLLECTION: Drivers' Use of Camera-Based Rear Visibility Systems Versus Traditional Mirrors

OMB CONTROL NUMBER: 2127-NEW

ABSTRACT[1]

The National Highway Traffic Safety Administration (NHTSA) has proposed to perform research involving the collection of information from the public as part of a multi-year effort to learn about drivers' use of camera-based rear visibility systems as compared to their use of traditional vehicle outside mirrors. This research will support NHTSA in evaluating whether to pursue a regulation modification which would permit technologies other than mirrors, such as camera monitor systems (CMS), for compliance with FMVSS No. 111. The data collections will be performed once to obtain the target number of valid test participants.

Study participants will be members of the general public and participation will be voluntary. Participants will include licensed car and/or commercial truck drivers aged 25 to 65 who are healthy and able to drive without assistive devices. Participants will be recruited using print and online newspaper advertisements. Study participation will be voluntary and monetary compensation will be provided.

The research will be conducted in two parts. Data collection will begin upon receipt of PRA clearance and will first involve light vehicles, and a second, subsequent part will involve heavy trucks. Participants will experience a production vehicle equipped with a commercially available or prototype camera-based system in place of outside mirrors and a vehicle equipped with an original equipment mirror system. The research will involve laboratory (i.e., stationary), track-based, and on-road, semi-naturalistic driving experimentation. Vehicles used in testing will be equipped with instrumentation for recording driver eye glance behavior, as well as vehicle speed, position, steering angle, and turn signal status. Sensors will also be used to determine and record the distances between the test vehicle and surrounding vehicles during testing.

Information will be collected over the course of the research through participant recruitment screening questions, observation of driving behaviors, and post-drive questionnaires. Questions addressed to individuals will serve to assess individuals' suitability for study participation, to obtain feedback

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[1] The Abstract must include the following information: (1) whether responding to the collection is mandatory, voluntary, or required to obtain or retain a benefit; (2) a description of the entities who must respond; (3) whether the collection is reporting (indicate if a survey), recordkeeping, and/or disclosure; (4) the frequency of the collection (e.g., bi-annual, annual, monthly, weekly, as needed); (5) a description of the information that would be reported, maintained in records, or disclosed; (6) a description of who would receive the information; (7) the purpose of the collection; and (8) if a revision, a description of the revision and the change in burden.

regarding participants' use of the CMS, and to gauge individuals' level of comfort with and confidence in the CMS performance and safety.

Part B. Statistical Methods

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

The respondent universe includes individuals solicited through print and online newspaper advertisements in the West Central Ohio area.

No statistical methods will be used in selecting study participants. 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
b. For drivers of passenger light vehicles: Hold a valid U.S. driver's license and drive at least 11,000 miles annually
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 recent criminal convictions 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 3 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
j. Not have anyone in their household who works for or is retired from any automotive manufacturer, which may constitute a conflict of interest with the research.

Criteria satisfaction is 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 retained only for the duration of the study and used to schedule facility visits and provide appointment reminders. Contact information will be stored separately from study data and destroyed after study completion.

For both light vehicle driver and commercial truck driver samples, we will attempt to balance age and sex to the extent possible based on availability of candidate participants.

2. Describe procedures for collecting information including statistical methodology for stratification and sample selection, estimation procedures, degree of accuracy needed, and less than annual periodic data cycles.

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

Candidate participants who view and choose to respond to an advertisement will complete the Interest Response Form (hosted online on a secure website). Individuals, whose responses to the Interest Response Form meet study participation criteria (described in Question 1 above), will be contacted 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.

Scheduled participants will be randomly assigned to groups corresponding to different vehicle conditions/configurations. Vehicle conditions will consist of a vehicle model for which a mirror-equipped version and a version equipped with a camera-based rear visibility system are available. Camera-based rear visibility systems will differ for the light vehicle and heavy truck parts of data collection. For the light vehicle part of data collection, participants will be grouped into one of two camera-based rear visibility system conditions. For the heavy truck part of data collection, participants will also be grouped into one of two camera-based rear visibility system conditions.

For the light vehicle part of data collection, it is estimated that the means for time to initiate lane changes will differ by 1.0 second based on previous research (Beck, Lee, & Park, 2017; Beck & Park, 2019; Large et al., 2016). Power analysis results indicated that a group sample size of 16 is required to detect a difference between means of 1.0 s with power equal to 0.8. Therefore, participant recruitment and testing will continue until 16 participants are completed for each of the two camera-based rear visibility system groups. This means there will be 16 participants for CMS group A and 16 participants for CMS group B.

Since the heavy truck part of data collection includes an additional variable (Time of Day), a larger sample size is needed to account for variances due to that variable. Power analysis results indicated that a group sample size of 24 is required to detect a difference in lane change behavior. As such, participant recruitment and testing of heavy truck drivers will continue until 24 participants are completed for each of the four experimental groups. This means that for CMS C, there will be a total of 48 participants: 24 participants in the CMS C Daylight condition and 24 participants in the CMS D Darkness condition.

We have determined that 128 total participants across both parts of data collection are necessary to obtain sufficient power to detect a mean difference in lane change behavior. Anticipating a typical rate of data loss, the total number of participants that will likely need to be run to obtain 128 valid data sets is 110 individuals in the light vehicle data collection and 40 individuals in the heavy truck data collection, for a total of 150 individuals across both parts of data collection. To provide for unforeseen issues that may arise, we have estimated burdens for a total of 200 participants.

Participants will experience a production vehicle equipped in two different configurations: 1) equipped with original equipment, FMVSS-compliant outside mirrors, and 2) equipped with a production or prototype camera-based rear visibility system in place of traditional outside mirrors. Participants will be asked to complete two drives along a specified route on a controlled test track and/or on public roads while their eye glance behavior and driving behavior are recorded. Upon completion of each test drive, participants will complete the Post-Drive Questionnaire, once after driving the test route in a mirror-equipped vehicle and once after driving a vehicle equipped with a camera-based rear visibility system. The questionnaire will address their subjective impressions of general use, comfort, and visibility while using the two visibility technologies. After both test drives, participants will complete the Post-Drive Final Opinions Questionnaire to address participants' final opinions and ultimate preference for either visibility technology.

Vehicle instrumentation will include cabling for connecting to the vehicle's Controller Area Network (CAN) bus and sensors for capturing vehicle position, acceleration, velocity, longitudinal and lateral distances between vehicles during steady state driving and lane changes. One or more video cameras will capture image data documenting the driving environment and in-vehicle audio data. An eye tracker will record driver eye glance behavior. All these data streams will be passed to an in-vehicle data acquisition computer for recording and synchronization during the test drive. Upon completion of both test drives, data will be transferred from the computer to an encrypted portable hard drive. Data files will then be copied to a limited-access local area network (LAN). Raw data files, including video and audio data, will be stored on the LAN server. Processing and analysis of data containing PII will only be performed while accessing the LAN. Data not containing PII and that relate to driving performance measures will be copied to a different limited-access network drive where research staff can access and analyze the data. All data will be protected as confidential according to IRB requirements and best practices for protecting participant information.

3. <u>Describe methods to maximize response rates</u>.

Recruitment of light vehicle drivers will be accomplished using online and print advertisements. Recruitment of professional commercial truck drivers will be conducted both using online and print advertisements as well as through partnership will local trucking companies. Working with trucking companies to identify drivers for study participation will help ensure that the sample includes a sufficient number of productive, employable, commercial truck drivers.

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 hourly rate of approximately $50.00.

4. Describe tests of procedures or methods.

Both the light vehicle and heavy truck data collections will utilize the same approach. For the light vehicle data collection, two camera-based rear visibility systems, System A and System B, will be installed in two separate vehicles. Participants will be randomly assigned to either System A or System B. Participants will complete two drives: one with the camera-based rear visibility system and one with traditional outside mirrors. This will create four conditions: Participants assigned to the System A condition will complete two drives: one for mirrors and one for System A. Participants assigned to the System B condition will complete two drives: one for mirrors and one for System B.

For the heavy truck data collection, two camera-based rear visibility systems will be installed in two separate heavy trucks. Participants will be randomly assigned to either System C or System D. Participants will complete two drives: one with the camera-based rear visibility system and one with traditional outside mirrors. Additionally, drives will take place in two different time of day conditions: daylight and darkness. Participants will be randomly assigned to either the daylight or darkness condition. Half of the participants assigned to System C will complete two drives: one for mirrors and one for System C in daylight; and the remaining half will complete two drives: one for mirrors and one for System C in darkness. Half of the participants assigned to System D will complete two drives: one for mirrors and one for System D in daylight; and the remaining half will complete two drives: one for mirrors and one for System D in darkness. This will create the following 8 conditions: System C in daylight, System C in darkness, System C mirror comparison in daylight, System C mirror comparison in darkness, System D in daylight, System D in darkness, System D mirror comparison in daylight, and System D mirror comparison in darkness.

Table 1. Experimental Design

Data Collection	Vehicle	CMS System	Condition	
Data Collection Part 1	Light Vehicle	CMS A	Mirrors	
			CMS A	
		CMS B	Mirrors	
			CMS B	
Data Collection Part 2	Heavy Truck	CMS C	Mirrors	Daylight
				Darkness
			CMS C	Daylight
				Darkness
		CMS D	Mirrors	Daylight
				Darkness
			CMS D	Daylight
				Darkness

Research questions being investigated in both parts of data collection include:

1. **Lane Change Performance**
   - **Does lane change performance differ when driving with a camera-based rear visibility system compared to traditional outside rearview mirrors?**
   - **Does driving with a camera-based rear visibility system result in differences in distance judgments when passing a slower moving vehicle compared to traditional outside rearview mirrors?**
   - **For the heavy truck part of data collection: Is driving at night with a camera-based rear visibility system affected by issues of blooming or glare from other vehicles' headlights?**

Several driving performance metrics will be used to evaluate whether differences in driving performance while changing lanes exist across the conditions. A lane change will be defined by a lateral velocity greater than 0.3 m/s without a subsequent lateral reversal. The lane change will end once the lateral velocity returns below this threshold. Dependent measures related to lane change performance will include the total time to complete a lane change, longitudinal distance to a slow forward vehicle at lane change start, resultant distance to an adjacent rearward vehicle at lane change start, longitudinal distance to an adjacent rearward vehicle when passing in front of a slower moving vehicle, and the total time to pass a slower moving vehicle.

Data will be aggregated for all participants and the mean, median, and standard deviation for each dependent variable will be calculated. Separate analyses will be performed for each system.

For the light vehicle part of data collection, separate paired samples t-tests will be performed within each camera-based rear visibility system to assess whether each of the lane change performance dependent measures differ between the mirror and camera-based rear visibility system conditions. For the heavy truck data part of collection, within each camera-based rear visibility system, separate 2 (Rear Visibility Technology) x 2 (Time of Day) mixed analysis of variance (ANOVA) will be performed to assess whether each of the lane change performance dependent measures differ across conditions.

2. **Eye Glance Behavior**
   - **Does driving with a camera-based rear visibility system lead to differences in eye glance behavior compared to traditional outside rearview mirrors?**

Eye glance metrics will be gathered to evaluate whether differences in eye-scanning patterns exist across conditions. Specifically, proportion of total glances to rear visibility technology, average glance duration to rear visibility technology, and proportion of long glances to rear visibility technology will be calculated and compared for each condition.

Data will be aggregated for all participants and the mean, median, and standard deviation for each dependent variable will be calculated. Since the Rear Visibility Technology and Time of Day (for the heavy truck part of data collection) are nested within camera-based rear visibility systems, separate analyses will be performed for each camera-based rear visibility system.

For the light vehicle part of data collection, separate paired samples t-tests will be performed within each camera-based rear visibility system to assess whether each of the eye glance behavior dependent measures differ between the mirror and camera-based rear visibility system conditions. For the heavy truck part of data collection, within each camera-based rear visibility system, separate 2 (Rear Visibility Technology) x 2 (Time of Day) mixed analysis of variance (ANOVA) will be performed to assess whether each of the eye glance behavior dependent measures differ across conditions.

3. **Post-Drive Questionnaire**
   - **Do drivers' subjective impression of general use, comfort, and visibility differ for camera-based rear visibility systems compared to traditional outside rearview mirrors?**
   - **For heavy trucks: Is driving at night with a camera-based rear visibility system affected by issues of blooming or glare from other vehicles' headlights?**

Subjective ratings about each rear visibility technology will be assessed via a post-drive questionnaire. Questions will be asked concerning the general ease of using each rear visibility technology, the image quality provided by each rear visibility technology, and how well each rear visibility technology aided in driving performance. Data will be aggregated for all participants and the mean, median, and standard deviation of ratings will be calculated for use, trust, and safety.

5. Provide the name and telephone number of individuals who were consulted on statistical aspects of the IC and who will actually collect and/or analyze the information.

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

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

Kelly Satterfield, PhD, Transportation Research Center, Inc., 937-666-3247

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