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An Evaluation of the Visual Demands of Portable Telematics Technologies among Young Adult Drivers

Bruce Mehler, Bryan Reimer, Jonathan Dobres

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Proposed visual-manual distraction guidelines for in-vehicle electronic devices (NHTSA, 2012) specify 3 criteria by which unacceptable levels of visual distraction are to be quantified using driving simulation testing. This paper reports on data obtained on a sample of 24 younger adults (20-29 years) dialing a flip-style phone with tactile buttons and a smart phone with a touch screen, entering a destination address into a portable navigation device, and, for comparison purposes, manually interacting with the vehicle radio at 3 distinct levels of complexity. It is our intent to limit this document to a presentation of the results and allow readers to consider the data in relation to the proposed distraction guidelines for in-vehicle devices and possible implications for the eventual development of guidelines for nomadic devices. No overt support or critique of the guidelines is offered by the authors in this context. It is our expectation that making these data available may be a useful contribution to the overall discussion of the proposed and future guidelines.

1. Introduction

In early 2012, NHTSA issued a notice of proposed visual-manual distraction guidelines (2012) for public comment. Useful but somewhat limited background data (Ranney et al., 2011; Ranney, Baldwin, Parmer, Martin, & Mazzae, 2011) was made available for evaluation and comment on aspects of the criteria presented. Availability of data is particularly important for the ongoing discussion over the criteria selected for the various proposed thresholds to be conducted on the basis of scientific analysis. One area that appears particularly limited is the availability of eye glance testing data analyzed following the proposed criteria for Eye Glance Testing Using a Driving Simulator (EGDS). Significant attention in the NHTSA document was directed to the "classic" Alliance of Automobile Manufacturers (the Alliance) and the Collision Avoidance Metrics Partnership (CAMP) Driver Workload Metrics project radio task (Angell et al., 2006; Driver Focus-Telematics Working Group, 2006) as well as to interactions with various nomadic devices such as portable GPS units and cell phones. As NHTSA moves forward with plans to finalize the visual-manual driver distraction guidelines for in-vehicle electronic devices and to offer guidance on the visual-manipulative demands of portable technologies, the availability of more data to support decisions will be critical.

NHTSA's draft guidelines pertaining to visual-manual distraction for in-vehicle electronics provide a set of clear criteria for eye glance evaluation in driving simulation. The EGDS guidance is based largely on the Alliance (2006) principles, but with lower thresholds and clearer testing criteria. For a secondary task to be considered acceptably safe (NHTSA, 2012), 85% or more of a test sample must meet these criteria. Using the NHTSA specified minimum sample size, and following the rounding up requirement, this translates into a requirement that 21 out of 24 of a sample of subjects across a specific demographic group must meet these criteria:

1. “the mean duration of all individual eye glances away from the forward road scene should be less than 2.0 seconds while performing the secondary task” (p. 105), and
2. “no more than 15 percent (rounded up) of the total number of eye glances away from the forward road scene should have durations of greater than 2.0 seconds while performing the secondary task” (p. 106), and
3. “the sum of the durations of each individual participant’s eye glances away from the forward road scene should be less than, or equal to, 12.0 seconds while performing the secondary task one time” (p. 108).

NHTSA recommends that a broad age range of participants be considered in testing to ensure that a secondary task can be performed across “virtually the entire range of drivers without being unreasonably distracting” (p. 108). Based on each group of 24 participants, the current recommendation is that there should be 6 participants inclusive in each of the following age groupings: 18-24, 25-39, 40-54, and 55-up.

This paper reports on selected results from an experiment designed to assess the extent to which the visual demands of a number of portable telematics devices, two types of phones and a portable navigation system, compare to three levels of the “classic radio task” and relate to various levels of two surrogate visual tasks. The data was collected in 2011 as part of the first of two studies. (It is anticipated that results from the second study, which examined the impacts of selected tasks across three age groups, will be released once final data analysis is complete.) The present report has been developed to provide a synopsis of key variables as they related to the pending guidelines. Results are computed using basic statistical models and the proposed metrics for Eye Glance Testing Using a Driving Simulator (EGDS).

2. Methods

2.1 Participants

Recruitment methods and experimental content were approved by MIT’s institutional review board. The sample was intentionally drawn from a younger age group (20-29 years) likely to have a high proportion of individuals with extensive experience using in-vehicle technologies. It is relevant to note that the recruitment sample for this study straddled the first two NHTSA recommended age groups, but did not include older drivers.

Participants were required to be active, experienced drivers, defined as driving 3 or more times a week and having held a valid driver’s license for 3+ years. Additionally, they needed to demonstrate a safe operating history by reporting a driving record free of accidents for the past year. Eye glasses were set as an exclusion criterion due to the use of eye tracking metrics as a primary dependent variable. Participants were drawn from community volunteers in the greater Boston area who responded to online, print advertisements, or referrals. Compensation of $60 was provided.

2.2 Apparatus

The study was conducted in a driving simulator consisting of a fixed base, full cab Volkswagen 2001 New Beetle situated in front of an 8’ by 6’ (2.44m by 1.83m) projection screen positioned 76” (1.93m) in front of the mid-point of the windshield. This provided approximately a 40 degree view of the virtual world at a resolution of 1024 x 768 pixels. Graphical updates were generated at a minimum frame rate of 20 Hz by STISIM Drive version 2.08.02 (Systems Technology, Inc., Hawthorne, CA) based upon a driver’s interaction with the steering wheel, brake and accelerator. Force feedback was provided through the steering wheel and auditory feedback consisting of engine noise, cornering sounds, and brake noise was played through the vehicle’s sound system. Audio tasks and instructions were also provided through the vehicle sound system. Driving performance data were captured at 10 Hz. A FaceLAB® 5.0 eye tracking system (Seeing Machines, Canberra, Australia) recorded data at up to 60 Hz. Two video cameras, one mounted in front and one behind and to the side of the driver, captured images of the participant’s face and hands to monitor general behavior and interaction with the cell phones. Validation work has established high correspondence between this simulator configuration and on-road behavior in the allocation of visual attention in interactions with visual manipulative human machine interfaces (HMIs) (Wang et al., 2010) and cognitive demands (Reimer & Mehler, 2011).

The simulation scenario consisted of a divided highway with two lanes in each direction plus a 2 foot (0.61 m) shoulder on each side of the roadway. Lane width was 15 feet (3.62 m) and posted speed limit was 65 mph (104.6 km/h). Typical traffic events on the virtual highway included passing vehicles, lane changes, and slow downs. The average traffic density in the virtual scenario was set at 23 vehicles/mile (14.3/km). Average traffic speed for vehicles in the left lane was set equal to the posted speed limit of 65 mph (104.6 km/h) and 5 mph slower (96.5 km/h) for the right lane.

A radio (Mitsubishi MR587248) meeting the guidelines established by the Alliance of Automobile Manufacturers (2006) for the radio reference task was obtained and mounted in place of the original vehicle radio. (The unit was flush mounted and there was no reason for a participant to assume that is was anything other than the original unit supplied with the vehicle.) Functional controls included a rotational control knob for power and volume control, rotational control for station tuning, seek up and down buttons, AM/FM toggle, CD selection, 6 preset push-buttons, and scan, RDM, and eject buttons for the CD interface. Character size for the band display (AM/FM1/FM2) averaged 5mm tall by 3 mm wide and numbers for station display (92.9) averaged 8 mm tall by 5 mm wide. A Garmin nüvi 1490LMT 5-inch (12.7 cm) backlit TFT color touchscreen display with 480x272 WQVGA pixel resolution was employed as a portable navigation device. The physical dimensions of the unit were 5.4 x 3.4 x 0.6 inches (13.97 x 8.89 cm). The GPS unit was mounted on top a touch screen display used for presenting surrogate tasks (see Figure 1). This placed the GPS unit at approximately the height that might be typical of a window mounting option. Two types of phone interfaces were tested: a flip-style phone with tactile buttons that the participant had to physically depress to engage (Samsung Model SCH-A670) and a smart phone with a touch screen representation of the same keyboard layout (original Apple iPhone).

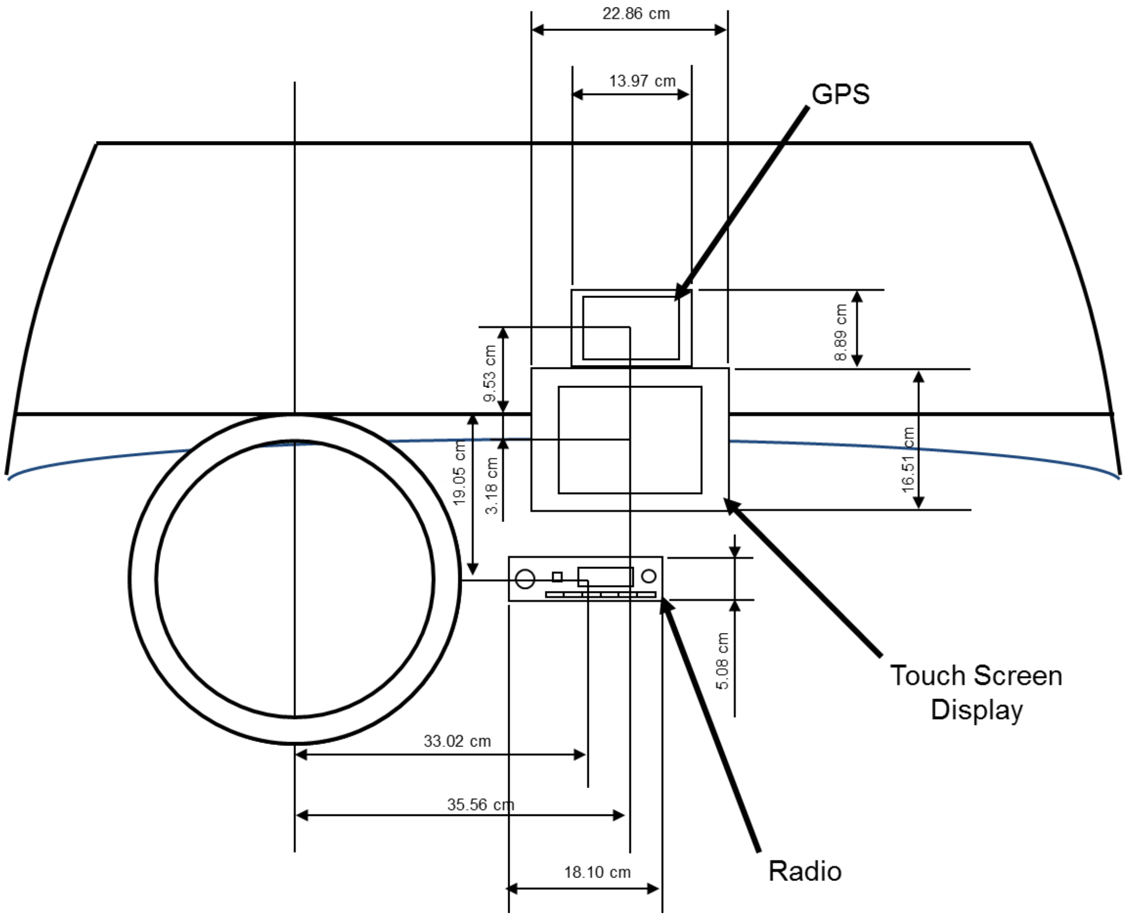

Figure 1. Layout of radio, touch screen display, and GPS navigation device in the simulator.

2.3 Design

The assessment of address entry in a portable navigation system, phone dialing, and vehicle radio interactions took place in a broader study where two surrogate tasks, each of which presented multiple levels of visual demand, were also examined. To control for order effects, tasks were presented in a design in which the three face valid tasks were presented in positions 1, 3 and 5 and the two surrogate tasks in positions 2 and 4. The ordering of the face valid tasks across the three positions was counterbalanced so that participants experienced each of the six possible task orders. Similarly, approximately half of the participants experienced one surrogate task first and half the other. Within the phone task period, half of the participants were presented the flip-phone first and the other half the iPhone. As detailed below, interaction with the navigation device consisted of two separate manual address entries, interaction with the phones consisted of dialing the same phone number in two separate trials with each phone type (4 total calls), and interaction with the radio consisted of 3 presumed difficulty levels of assessed task types (selecting a specified pre-set button, manually selecting a station using the tuning knob, and a compound task of turning the radio, switching from AM to FM, and manually changing the station using the running knob). Just as navigation entry and phone dialing for each phone type was assessed twice, each of the 3 levels of radio task were presented in the order described and then presented a second time in the same order (but with different target values).

2.4 Procedure

Participants read and signed an informed consent, eligibility was verified by interview, and a questionnaire that included items related to cell phone experience and type usage was completed. Participants were asked to provide a 10 digit phone number that they knew well that would be used for dialing during the phone task. This was done to avoid demand due to the participant needing to hold an unfamiliar number in memory.

When participants were seated in the simulator, the driver’s seat and steering wheel were adjusted so that the individual was comfortable and their eyes and mouth nominally visible for the recording and eye tracking cameras. An eye tracking head model was then created. Recorded audio instructions described the simulator and provided the following guidance and incentive: “During the study, you will receive a monetary award for performing the tasks while you continue driving the simulator. While performance on the tasks is important, you should balance driving safety while you attempt to complete the tasks, just as you would when driving a real car. Since in the real world you cannot disregard the traffic code, you may be penalized $2 for every ticket you receive and $5 for any collision.” These instructions were intended to encourage a realistic balance between secondary task engagement and driving safety and reinforced guidance that was provided in the informed consent form where it was specified that the monetary award for performing the secondary tasks could be up to $10. In actuality, all participants received equivalent compensation.

A short drive of 2.65 miles (approximately 5 minutes) followed to provide initial familiarization with the simulator. Participants then received instructions to pull over to the side of the highway and stop the car. Recorded instructions concerning the first task set were presented along with supplemental training by a research associate to ensure that participants were able to complete the tasks. Participants then resumed driving.

The driving simulation scenario consisted of a divided highway with two lanes in each direction plus a 2’ (0.61 m) shoulder on each side of the roadway. Lane width was 15’ (3.62 m) and posted speed limit was 65 mph (104.6 km/h). Typical traffic events on the virtual highway included passing vehicles, lane changes, and slow downs. The mean traffic density in the virtual scenario was set at 23 vehicles/mile (14.3/km). Mean speed for traffic in the left lane was set equal to the posted speed limit of 65 mph (104.6 km/h) and 60 mph (96.5 km/h) for the right lane.

Two minutes after highway speed was obtained, the subsequent 2 minutes were designated as a single task reference period. Thirty seconds after the reference period, recorded instructions for the first task were presented. Once all tasks for a task set were complete, 2 minutes of single task driving followed, and then the participants were again instructed to pull to the side of the highway and stop. A self-report workload rating was obtained (see below) and training for the next task set then began. This same procedure was followed until all task sets were presented. At a stop point approximately mid-way through the simulation session, participants were offered the opportunity to briefly exit the simulator.

2.4.1 Radio Tasks

Basic radio interaction was modeled on guidelines established by the Alliance of Automobile Manufacturers (2006) and on protocols developed as part of the CAMP Driver Workload Metrics project (Angell, et al., 2006), which presented participants with "easy" and "hard" levels of most task types. The "low" demand radio task in the present study consisted of changing a station when the radio was already on; this required the single step of pressing a specified station preset button. The "medium" task consisted of manually rotating the tuning knob to select a specified station. The "high" demand radio-manual task required 3 steps (pressing the volume control to turn the radio on, pressing the band selection button, and rotating the tuning knob to the specified frequency number). During the training period, participants were given the opportunity to explore the radio controls and practiced each of the tasks at least once. During the secondary task portion of the driving assessment, participants were prompted to turn the radio on and a 2 minute adaption period followed. Subsequently, recovery intervals of 1 minute were provided between the completion of a task and the initiation of a new task prompt (detailed below). Following the procedure established by CAMP, training instructions emphasized that participants were not to begin a task until they heard the word "begin". They were also instructed to say the word "done" as soon as they completed a task. Task completion time was based on this interval.

Recorded Audio Command	Task Level	Action
Your task is to turn the radio on by pressing the main control knob. Begin.	-	
Your task is to change the radio to preset-1. Begin.	Low	goes to 92.9
Your task is to tune the radio to 100.7 FM. Begin.	Medium	tune to 100.7
Your task is to turn off the radio. Begin.	-	
Your task is to turn on the radio, switch to FM1, and tune to 96.9. Begin.	High	tune to 96.9
Your task is to change the radio to preset-3. Begin.	Low	goes to 100.7
Your task is to tune the radio to 92.9 FM. Begin.	Medium	tune to 92.9
Your task is to turn off the radio. Begin.	-	
Your task is to turn on the radio, switch to FM2, and tune to 107.9. Begin.	High	tune to 107.9
The task is complete. Please turn off the radio and continue driving.	-	

2.4.2 Phone Task

During the training portion of the phone task set, participants practiced placing phone calls on both the flip and touch screen phone by dialing their self-selected familiar 10-digit number. When not in use, the phones were located in cup holders in the center console between the driver and front passenger seats. The flip-phone was always stored in the open position. During training, participants were instructed to pick-up a phone from the cup-holder, enter the 10-digit number, press SEND (CALL for the iPhone), then press the END button (CANCEL for the iPhone) to cancel the call, and then to return the phone to the cup-holder. As with the other tasks, participants were trained to say the word 'done' after pressing the SEND/CALL button to indicate that they had completed the task. 'Done' was used as a marker for determining the end point for timing task duration. The prompt to initiate a task consisted of the recorded instructions, "Your task is to make the phone call using the xxxx phone" where xxxx was either "touch screen" or "flip". A 2 second pause followed and then the prompt, "Begin". Participants placed 2 phone calls with one type of phone followed by 2 phone calls with the other. There were 1 minute spacing intervals between the completion of one phone call and the prompt to initiate the next.

Recorded Prompt Structure

Your task is to make the phone call using the flip phone. Begin.

Your task is to make the phone call using the touch screen phone. Begin.

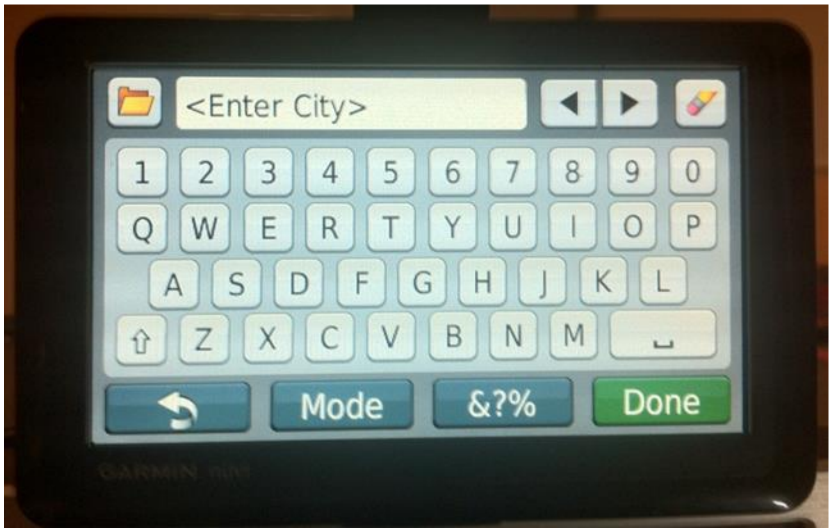

Figure 2. Portable navigation system interface for city and street information entry.

2.4.3 Navigation Task (Destination Address Entry)

During the training period, participants were taken step by step through the procedure for manually entering a street address into the navigation device and practiced entering two addresses. Addresses were presented on index cards that were placed directly below the GPS device screen. One card with two addresses was used during training and replaced by a second card for the driving portion (see below). A one minute spacing interval was present between the completion of the first address entry and the presentation of the second address entry task. Manual entry of an address into the GPS unit is a multi-step process. In the case of the Garmin unit and conditions studied, the following minimum set of steps was required: selecting "Where to?" and then "Address" on the main screen, visually confirming that the currently selected state is "Massachusetts" and then selecting "Spell City", entering the first three or so letters of the city name (see Figure 2) to produce a listing of possible match names, selecting the city name from the list, entering the street number for the address, pressing "Done", entering the first three or so letters of the street name to produce a listing of possible match names, selecting the street name from the list, pressing "Done". At this point, the participant was to say the word "Done" to indicate completion of the task. If errors were made at any point during the address entry, participants were instructed to use the back arrow as needed to make corrections.

Practice Addresses:

1 Amherst Street, Cambridge, Massachusetts

20 Fruit Street, Boston, Massachusetts

Task Addresses:

77 Massachusetts Avenue, Cambridge, Massachusetts

55 Park Street, Boston, Massachusetts

Recorded Prompt Structure

Your task is to enter the top address from the address card. Begin.

Your task is to enter the bottom address from the address card. Begin.

2.4.4 Workload Rating

Participants stopped the vehicle by the side of the virtual highway at the end of each period and were asked to complete two global workload rating scales – one for what they considered the easiest task during the previous period and one for what they considered the hardest task. All of the scales for the study were presented on a single sheet of 11x17 inch (legal size) paper so that participants were able to rate each task relative to tasks that they had already rated. Each scale consisted of 21 equally spaced dots oriented horizontally along a 10cm line with the numbers 0 through 10 equally spaced below the dots and end points labeled “Low” and “High” on the left and right respectively. Participants were told that workload is best defined by the person doing the task and may involve mental effort, the amount of attention required, physical effort, time pressure, distraction or frustration associated with trying to do the task while continuing to drive safely. They were instructed to circle a point along each scale that best corresponds to how much workload they felt was involved in trying to do each task.

2.5 Data Reduction & Analysis

Eye data were processed following ISO standards (ISO 15007-1, 2002; ISO 15007-2, 2001). In terms of the EDGS criteria, the percentage of eye glances greater than 2 seconds away from the forward road scene while performing the secondary task was computed as the ratio of the number of glances in excess of 2 seconds to the secondary device over the overall number of glances to the secondary device. The mean duration of all eye glances away from the forward road scene was computed as the ratio of the total glance duration to the secondary device to the overall number of glances to the secondary device. Finally, the sum of the durations of each individual participant’s eye glances away from the forward road scene was reported as the total glance duration to the secondary task. Following NHTSA guidelines, only participants who successfully completed each task, and for whom full a complete data was available, were included in this analysis.

3. Results

3.1 Sample Characteristics

Data from 24 subjects, equally balanced by gender, are considered here. Among this group, male and female subjects averaged 24.1 (SD=1.9) and 24.8 (SD=2.6) years old, respectively. Age did not differ significantly between the genders ($p = .417$, t-test).

3.2 Traditional Analysis of Task Response Behavior

As noted earlier, subjects were asked to perform six face-valid secondary tasks while driving in a simulator: radio control (low, medium, and high difficulty levels), phone dialing (flip-phone and touch screen), and destination entry with a portable navigation system. Results are summarized in Table 1 on the next page.

Table 1: Means (and standard deviations) of the behavioral metrics for each secondary task.

Task	Mean Velocity (m/s)	Total Task Duration (s)	Total Glance Duration (s)	Number of Glances	Number > 2.0s	Self-Report Workload
Navigation Entry	28.2 (0.9)	60.29 (16.6)	32.94 (11.36)	29.12 (11.25)	3.06 (3.48)	5.36 (1.83)
Flip Phone Dial	28.1 (1.6)	17.20 (4.2)	6.57 (2.44)	7.17 (2.34)	0.33 (0.58)	2.71 (1.37)
Touch Phone Dial	28.2 (1.5)	18.99 (3.9)	8.48 (2.22)	8.21 (2.48)	0.56 (0.68)	4.81 (1.76)
Radio - Low	28.2 (0.9)	7.98 (1.7)	1.76 (0.58)	2.00 (0.81)	0.06 (0.17)	0.94 (0.85)
Radio - Medium	25.9 (1.2)	14.50 (4.3)	4.94 (2.02)	5.94 (2.28)	0.17 (0.32)	NA
Radio - High	25.2 (2.1)	18.11 (4.3)	6.49 (1.65)	7.58 (2.12)	0.21 (0.46)	3.73 (1.74)

For each measure, (average velocity, total task duration, total glance duration, number of glances, number of glances over 2s, and self-reported workload), significant differences were found between tasks ($p < .001$ for all measures, Friedman's test). For all but average velocity, the navigation entry task was the most demanding, requiring the longest and most frequent glances to complete. The low demand radio task (pressing a station preset selection button) was consistently the least demanding.

3.3 Eye Glance Testing Using a Driving Simulator (EDGS) Analysis

The core eye glance metrics for this study were derived prior to NHTSA's release of the draft guidelines document and were based on an analysis of glances to a device. NHTSA suggests that these values can be expected to be equal to or somewhat less than values for glances away from the forward road scene. Keeping this in mind as a limitation in applying these data to the NHTSA criteria, mean glance duration (criteria 1) and the percentage of glances greater than 2 seconds (criteria 2) were calculated for each of the six tasks from the source data in Table 1, to go along with total glance duration (criteria 3). The values for these 3 criteria are summarized for each secondary task in Figure 1. There was a significant effect of task type for all three metrics ($p < .001$, $p = .035$, $p < .001$ respectively, Friedman's test).

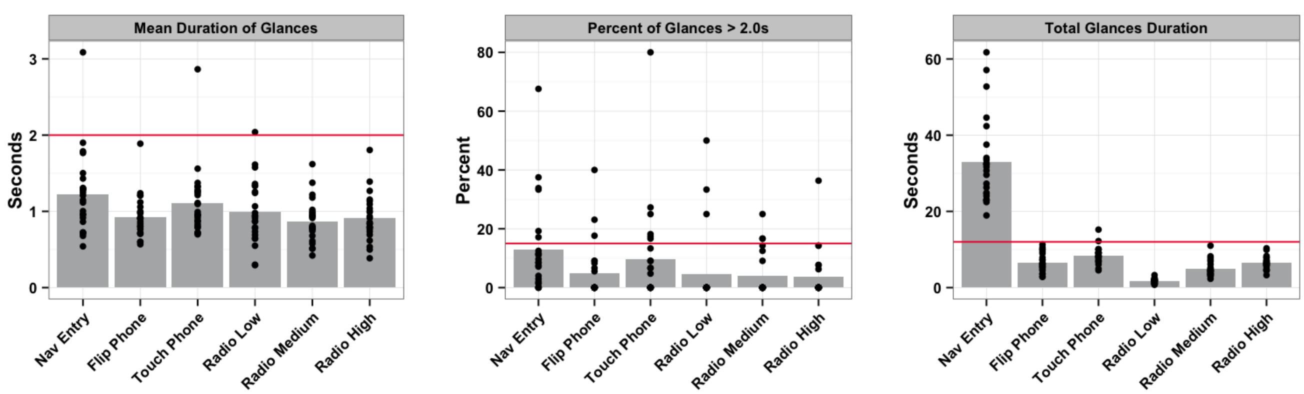

Figure 1: Plots visualizing individual subject performance for each secondary task (black dots) against NHTSA's proposed guidelines (red lines). Gray bars indicate group mean performance.

Table 2: Percent of sample meeting each of the 3 proposed NHTSA safety guidelines.

Task	Criterion 1 Mean Glance Duration	Criterion 2 Glances > 2s	Criterion 3 Total Glance Duration
Navigation Entry	95.8%	**75%**	**0**%
Flip Phone	100%	87.5%	100%
Touch Phone	95.8%	**75%**	91.7%
Radio - Low	95.8%	87.5%	100%
Radio - Medium	100%	87.5%	100%
Radio - High	100%	95.8%	100%

Table 2 presents the percentage of the sample that meets each of NHTSA's proposed thresholds. NHTSA adopted the Alliance's criteria that 85% of a sample must meet each specification. Rounding-up in a sample of 24 participants, this translates into 21 participants, or 87.5% of the sample or higher. Ignoring for the moment the sample characteristics for age distribution proposed by NHTSA, all three difficulty levels of the radio task and the flip-phone dialing task meet the 87.5% threshold (rounded up for a sample size of 24) for all three criteria when evaluated in terms of glances to the device. For the touch screen dialing and navigation entry tasks, the results were mixed. During the touch phone dialing task, only 75% of the participants were able to complete the activity with a brief glance rate (glances lasting less than 2 seconds) of 85% or more. A similar result appears for criteria 2 for the navigation entry task. Moreover, in addition to not meeting criterion 2, navigation entry did not meet criteria 3, as none of the participants were able to complete the destination entry within the 12 seconds of total glance duration allotted. Further detail on the differences between these six tasks on each of the critical metrics can be found in the pairwise differences that appear in Table 3.

Table 3: Post-hoc tests of significance (Wilcoxon signed rank) for all 3 metrics across task pairings.

	Mean Glance Duration					Glances > 2.0s					Total Glance Duration				
	Nav Entry	Flip Phone	Touch Phone	Radio L	Radio M	Nav Entry	Flip Phone	Touch Phone	Radio L	Radio M	Nav Entry	Flip Phone	Touch Phone	Radio L	Radio M
Flip Phone	*	--				*	--				***	--			
Touch Phone	NS	***	--			NS	NS	--			***	**	--		
Radio L	NS	NS	NS	--		**	NS	NS	--		***	***	***	--	
Radio M	**	NS	*	NS	--	**	NS	NS	NS	--	***	*	***	***	--
Radio H	**	NS	NS	NS	NS	**	NS	NS	NS	NS	***	NS	***	***	**

*** p < .001, ** p < .01, * p < .05

4. Discussion

As might have been expected, and in line with other research, application of the proposed visual-manual NHTSA distraction guidelines for in-vehicle electronic devices would classify manual destination entry into a portable navigation device as problematic on the basis of total glance duration (criterion 3). At a mean value of 33 seconds for this sample of younger adults, total glance duration for the task exceeded the criterion of 12 seconds by over 2X. Looking at individuals, none of the younger adult participants were able to complete the task under the threshold. Manual destination entry with the portable navigation device similarly would not meet application of the proposed guidelines on the basis of the criteria for percentage of glances greater than 2.0 seconds (criteria 2). To the extent that there is a consensus that manual address destination entry into a portable device should be considered as an unsafe activity, criterion 1, that the mean duration of all eye glances away from the forward road scene should be less than 2.0 seconds, appears to be a less sensitive metric than the other criteria for so classifying this task.

The touch screen phone does not meet criterion 2 on the allowable percentage of eye glances greater than 2.0 seconds by exceeding the 87.5% threshold by 12.5%. In contrast, the flip phone, using more traditional tactile push buttons, just meets the threshold for this criterion in this relatively young sample. Inclusion of a broader age range (older drivers) in the sample might well have impacted the results such that the flip phone no longer met criterion 1. An expansion of this work to consider a broader age range of participants to address this question is underway. Keeping in mind again the age characteristics of the sample, each of the radio tasks met the visual distraction criteria. It can be observed that criterion 2, the percentage of glances greater than 2.0 seconds, is the most stringent threshold for the radio tasks as was also the case for the consideration of the interaction with the 2 phone types.

It can be observed in this dataset that a common compensatory behavior for dealing with overt task demand, reducing vehicle speed, aligns well with the 3 levels of the radio task. Mean velocity for the objectively defined low, medium, and high demand tasks were 63.0, 58.0 and 56.3 mph respectively. Interestingly, mean velocity during the navigation task and during phone dialing was in the same range as that seen during the low demand radio task, i.e. approximately 63 mph. This begs the question as to why the seemingly appropriate compensatory behavior that appears during different levels of overt task demand when working with the radio interface does not appear when operating these other devices.

It should be emphasized that some aspects of our methodology and our sample do not conform to NHTSA's proposed guidelines since this study was initiated prior to their release. For instance, we study a younger sample of drivers. The simulation scenario (highway driving) differs from the lead vehicle scenario specified by NHTSA, and the eye data was coded as glance to the device as opposed to glances away from the road. It is our intent to limit this document to a presentation of the results and allow readers to interpret the data in relation to the proposed visual-manual guidelines for in-vehicle devices and possible implications for the eventual development of guidelines for nomadic devices. No overt support or critique of the proposed NHTSA guidelines is offered by the authors in this context. It is our expectation that making these data available may be a useful contribution to the overall discussion of utility of the proposed guidelines.

5. Limitations

This study was exploratory and, given the small sample size, these data should be interpreted cautiously, although it is appropriate to note that the proposed guidelines do suggest that samples as small as 24 cases may be employed for assessment. It should be kept in mind that vehicle performance, possibly other eye behavior metrics, and physiological measures of workload might also be profitably utilized in developing a more complete understanding of overall impact of the tasks. As noted above, the present sample was limited to younger adults and a broader age range should be considered to more fully represent the active driving population. Finally, the extent to which the visual demands associated with the portable navigation system and the two portable phone types reflect the demands associated with various built-in automotive systems cannot be assumed from the current dataset.

6. Acknowledgments

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ABOUT THE AUTHORS

Bruce Mehler, M.A.

Bruce Mehler is a Research Scientist in the Massachusetts Institute of Technology AgeLab and the New England University Transportation Center, and is the former Director of Applications & Development at NeuroDyne Medical Corporation. He has an extensive background in the development and application of non-invasive physiological monitoring technologies and research interests in workload assessment, individual differences in response to cognitive demand and stress in applied environments, and in how individuals adapt to new technologies. Mr. Mehler is an author of numerous peer reviewed journal and conference papers in the biobehavioral and transportation literature. He continues to maintain an interest in health status and behavior from his early work in behavioral medicine. He received an MA in Psychology from Boston University and a BS degree from the University of Washington.

bmehler@mit.edu
(617) 253-3534
http://agelab.mit.edu/bruce-mehler

Bryan Reimer, Ph.D.

Bryan Reimer is a Research Engineer in the Massachusetts Institute of Technology AgeLab and the Associate Director of the New England University Transportation Center. His research seeks to develop new models and methodologies to measure and understand human behavior in dynamic environments utilizing physiological signals, visual behavior monitoring, and overall performance measures. Dr. Reimer leads a multidisciplinary team of researchers and students focused on understanding how drivers respond to the increasing complexity of the operating environment and on finding solutions to the next generation of human factors challenges associated with distracted driving, automation and other in-vehicle technologies. He directs work focused on how drivers across the lifespan are affected by in-vehicle interfaces, safety systems, portable technologies, different types and levels of cognitive load. Dr. Reimer is an author on over 70 peer reviewed journal and conference papers in transportation. Dr. Reimer is a graduate of the University of Rhode Island with a Ph.D. in Industrial and Manufacturing Engineering.

reimer@mit.edu
(617) 452-2177
http://web.mit.edu/reimer/www/

Jonathan Dobres, Ph.D.

Jonathan Dobres is a postdoctoral research associate in the Massachusetts Institute of Technology AgeLab. Dr. Dobres's research interests are varied and include human-computer interaction, user experience design, visual attention, and visual learning. He received a BA, MA, and PhD in Psychology (Brain, Behavior, and Cognition) from Boston University. His research concerned the effects of feedback, or knowledge of results, on how people learn visual tasks, as well as computational approaches to visualizing changes in human perception. He has also worked for the Traumatic Brain Injury Model System at Spaulding Rehabilitation Hospital, part of a long-term national study on the effects of traumatic brain injuries. His current research focuses on driver behavior, and how interacting with in-vehicle technologies impacts driver behavior, cognition, and physiology.

jdobres@mit.edu
(617) 253-7728

About the New England University Transportation Center & MIT Center for Transportation & Logistics

The New England University Transportation Center is a research, education and technology transfer program sponsored by the US Department of Transportation. Together the faculty, researchers and students sponsored by the New England Center conduct work in partnership with industry, state & local governments, foundations and other stakeholders to address the future transportation challenges of aging, new technologies and environmental change on the nation's transportation system. For more information about the New England University Transportation Center, visit utc.mit.edu. For more information about the US Department of Transportation's University Transportation Centers Program, please visit utc.dot.gov. The New England Center is based within MIT's Center for Transportation & Logistics, a world leader in supply chain management education and research. CTL has made significant contributions to transportation and supply chain logistics and helped numerous companies gain competitive advantage from its cutting edge research. For more information on CTL, visit ctl.mit.edu.

About the AgeLab

The Massachusetts Institute of Technology AgeLab conducts research in human behavior and technology to develop new ideas to improve the quality of life of older people. Based within MIT's Engineering Systems Division and Center for Transportation & Logistics, the AgeLab has assembled a multidisciplinary team of researchers, as well as government and industry partners, to develop innovations that will invent how we will live, work and play tomorrow. For more information about AgeLab, visit agelab.mit.edu.