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16. Abstract

Experiment: An experiment was conducted to assess the distraction potential of secondary tasks performed using in-vehicle systems (radio tuning, destination entry) and portable phones (10-digit dialing, selecting contacts, text messaging) while driving. One hundred participants, ages 25-64, completed a single session in which they drove a low-fidelity (PC-based) simulator while performing the secondary tasks. The phone tasks were performed with two smart phones, one with a touch screen interface (iPhone) and one with a hard button interface (Blackberry). The Dynamic Following and Detection (DFD) driving protocol, which combines car-following with target detection, in which drivers responded to simple visual targets presented in the simulated roadway display, was used. Each combination of primary (driving) and secondary task was performed during a single 3-minute drive. Driving performance metrics included: lane position variability, car-following delay, target-detection accuracy and target-detection response time.

Results: Text messaging was associated with the highest level of distraction potential. Ten-digit dialing was the second most distracting task; radio tuning had the lowest level. Although destination entry was no more demanding than radio tuning when task duration effects were eliminated with DFD metrics, it exposes drivers to more risk than radio tuning and phone tasks due to its considerably longer duration. Modest differences between phones were observed, including higher levels of driving performance degradation associated with the touch screen relative to the hard button phone for several measures. Additional analyses demonstrated that the way in which task duration is considered in the definition of metrics influenced the outcomes of statistical tests using the metrics. The results are discussed in the context of the development of guidelines for assessment of the distraction potential of tasks performed with in-vehicle information systems and portable devices.

Additional analyses were conducted to compare the DFD and Alliance and decision criteria in a simulated compliance scenario. With the large sample size (N = 100), both protocols supported the conclusion that neither text messaging nor 10-digit dialing is suitable for combining with driving; however, when a smaller (N = 40) sample was used, the protocols led to different conclusions. Additional analyses found that for, using just the vehicle performance metrics (not the eye glance metrics), samples of 20 participants did not provide sufficient statistical power to differentiate among secondary tasks.

Driver age had significant effects on both primary and secondary task performance; younger drivers completed more secondary task trials on a given drive, with relatively less primary task interference than older drivers. Tests conducted using samples with wide age ranges (25-64) required larger samples to compensate for reduced homogeneity relative to samples with narrow age ranges.

Half of the participants were given specific monetary incentives, while half received an equivalent amount in an unspecified completion bonus. Incentives had some effects, primarily among older participants, but no consistent overall effects on primary or secondary task performance, or on the emphasis given by drivers to the primary task.

17. Key Words
Driver performance, distraction, cognitive distraction, navigation system, in-vehicle information systems (IVIS), visual-manual distraction, distraction assessment

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EXECUTIVE SUMMARY

Background

The National Highway Traffic Safety Administration's (NHTSA) Vehicle Research and Test Center (VRTC) has developed a protocol to assess the distraction potential of secondary tasks performed using in-vehicle information systems (IVIS) in production vehicles or portable devices. The protocol can be used with different vehicles and requires minimal set up. Test participants perform secondary tasks while driving a fixed-base driving simulator. The primary task in this protocol combines a dynamic car following task with a visual target detection task. Thus, the protocol will be referred to as the Dynamic Following and Detection (DFD) protocol. Performance degradation on measures of lateral position, car following, visual target detection, and measures of glance behavior, recorded on trials with secondary tasks, is compared to baseline driving performance and trials with a benchmark task (destination entry). The DFD protocol has demonstrated sensitivity for detecting the effects of both visual-manual and cognitive distraction; it has been used with simulated and real-world tasks performed using integrated and portable systems.

In recent years, the automobile industry has also been developing methods for use in measuring distraction. In recent years, the Alliance of Automobile Manufacturers (Alliance) has developed a set of guidelines for managing driver workload and distraction associated with IVIS. According to Alliance Principle 2.1, "Systems with visual displays should be designed such that the driver can complete the desired task with sequential glances that are brief enough not to adversely affect driving." The Alliance proposed two alternatives for assessing compliance. Alternative A includes two criteria: (1) durations of single glances to the task should generally not exceed 2 seconds; and (2) total glance time (TGT) should not exceed 20 seconds. Their Alternative B, justified by the reasonable concern that glance behavior measures "may not be fully indicative of overall driving performance," requires a driving task and identifies two driving performance measures (lateral position control and car-following headway). Unlike Alternative A, it does not define absolute criteria for acceptability; rather it outlines a generic test protocol in which task-related degradation on performance metrics is related to degradation on a (radio tuning) benchmark task performed under identical test conditions.

Numerous studies have examined the effects of number and text entry on driving performance, primarily within the context of phone dialing and destination entry. Studies of phone dialing have focused primarily on two questions: whether dialing is more disruptive to driving than cell phone conversation and whether hand-held (manual) dialing is more disruptive than hands-free (voice) dialing. Studies of phone dialing have been relatively consistent in demonstrating that: (1) manual dialing is more disruptive to driving than talking, and (2) voice-dialing is less disruptive than manual dialing. Some recent research has addressed the more contemporary problem of text messaging while driving. The results reveal increased driving performance degradation (e.g., delayed response to brake light onset and impaired lateral control) and proportionately less time spent focusing on the road while texting, relative to baseline driving.

Destination entry using integrated and portable route navigation systems has also been the focus of numerous research studies. Results from our own work have shown that destination entry by address, which requires entering street and city names using a virtual QWERTY keyboard, is more demanding and thus potentially more distracting than selecting a previously destination, which requires scrolling through a list of previously entered addresses, but no text entry.

Experiment

An experiment was conducted to assess the distraction potential of secondary tasks performed using in-vehicle systems (radio tuning, destination entry) and portable phones (phone dialing, text messaging) while driving. This experiment had three objectives: (1) to assess the distraction potential of secondary tasks involving manual number and text entry performed using integrated and portable systems, (2) to compare DFD metrics with Alliance Principle 2.1 measurement alternatives, including their respective benchmark tasks, and (3) to evaluate different test participant selection criteria, sample sizes and the effects of performance incentives on driving performance.

In this experiment, 100 participants performed number and text entry tasks together with a driving task that combined car following and visual target detection (the DFD protocol). Sensors connected to the steering, brake, and throttle of a single stationary vehicle (with engine off) provided control inputs to the fixed-base driving simulator. The significant overlap in data collection requirements between Alliance and the DFD protocols allowed the data necessary for a side-by-side comparison to be obtained from a single experiment. The experiment had four independent variables: (1) portable device; (2) benchmark; (3) driver age; and (4) monetary incentives. The portable devices included two smart phones: a Blackberry Curve (hard button interface) and an iPhone (touch screen interface). Secondary tasks performed with these devices included two methods of manual phone dialing (10-digit dialing and dialing via contact list) and manual text messaging. Participants completed three-minute drives while performing each secondary task on each portable device. They also drove while performing the two benchmark tasks (radio tuning and destination entry), and completed a baseline trial with no secondary task. To facilitate evaluation of different subject selection criteria, a relatively wide range of participant ages (25 – 64) was tested. Half of the participants (incentive group) was given detailed information to define task priorities and specific performance feedback, while the other half (no-incentive group) was given general instructions concerning task priorities but no monetary incentives.

Analyses addressing the differences among secondary tasks and phones used the following four DFD metrics: standard deviation of lateral position (SDLP), car following response delay, target-detection proportion correct, and target-detection mean response time. Analyses of eye position data were also conducted to determine the incidence of long glances and the total glance time required to perform the secondary tasks.

Differences among secondary task conditions were also examined using Alliance (2.1B) metrics, including lane exceedance frequency and headway variability. Metrics were computed in two different ways; first, using data from individual trials, as specified in the Alliance Guidelines, and second, using data from the entire drive, as specified in the DFD protocol. The Alliance computation method compares performance among tasks with different durations, which combines effects due to differences in task demands with effects due to differences in task duration. The DFD computation method uses data from equivalent time intervals, which eliminates effects due to differences in task duration and emphasizes differences in task demands. The computation method had no effect on the pattern of differences among secondary task conditions for lane exceedance frequency. However, the computation method did affect the pattern of results for headway variability. These different patterns reflect differences between the Alliance and DFD computational approaches with respect to the influence of task duration.

Results

Initial analysis found that text messaging, as implemented in this study, was associated with the highest level of distraction potential. Ten-digit phone dialing was the second most distracting task; radio tuning had the lowest level. Although destination entry was not consistently more demanding than radio tuning when compared using DFD metrics that eliminate duration effects, it exposes drivers to more risk than radio tuning and the phone tasks due to its considerably longer duration. Modest differences between phones were observed, including higher levels of driving performance degradation associated with the touch screen relative to the hard button phone for several measures. Three of twelve comparisons revealed statistically significant differences; however, the differences were consistent in revealing higher levels of driving performance degradation associated with the touch screen relative to the hard button phone interface.

Based on the foregoing analysis results, two specific questions were posed as a way to evaluate the DFD and Alliance test protocols. These questions were: (1) is text messaging suitable for performance while driving, and (2) is 10-digit dialing suitable for performance while driving? The DFD and Alliance test protocols, along with their respective benchmarks and decision rules, were used to answer these questions using data from all test subjects (N = 100) and a reduced sample size (N = 40). Both samples used data from the overall age range (25-64).

With respect to the question of text messaging suitability, the four DFD metrics all provided outcomes consistent with test failure, indicating that text messaging is not suitable for combination with driving. The results were the same for both sample sizes. For the Alliance metrics, three of four primary metrics provided outcomes consistent with test failure. The fourth metric, based on the average glance duration criterion, provided a pass outcome. However, because the Alliance decision criteria require both of the respective metrics in an alternative (2.1A or 2.1B) to provide consistent results, the overall outcome was failure, which was consistent with the DFD protocol results and with our expectations. This pattern of outcomes was identical for both sample sizes.

With respect to the question of 10-digit dialing suitability, the DFD protocol results were identical to those for text messaging. All four metrics provided outcomes consistent with test failure, indicating that 10-digit dialing is not suitable for performance while driving. The results were the same for both sample sizes. For the Alliance metrics, the test results for the larger sample were identical to those reported for the first question, namely three of four metrics provided outcomes consistent with test failure. The fourth metric again was average glance duration and the decision criterion requirement for consistency led to an overall test fail outcome, consistent with the DFD protocol results. However, for the reduced sample size, both components of Alliance Alternative 2.1A led to pass outcomes, while both components of Alliance Alternative 2.1B led to test fail outcomes.

Additional analyses were conducted to compare the DFD and Alliance vehicle performance metrics (not the Alliance eye glance metrics) and decision criteria in a simulated compliance scenario. Samples of 20 participants did not provide sufficient statistical power using just the vehicle performance metrics to differentiate among secondary tasks. Different effects of sample size might be seen using the eye glance metrics; however, those analyses have not yet been performed.

The effects of sample size (N = 20, 40, 100) and sample construction (i.e., age range) were also examined using a single DFD metric (detection task response time) and data from the entire drive, which was thus normalized for task duration. Both sample size and sample construction had significant effects on test outcome. Generally, more differences among task conditions were statistically significant when larger sample sizes were used, reflecting the influence of sample size on statistical power. Specifically, of 10 planned comparisons, the use of N = 100 participants (ages 25-64) revealed 6 statistically significant differences, while the use of N = 40 participants revealed 0, 2, 3, and 4 differences, depending on the age ranges included in the sample. Age ranges compared included: narrow (ages 35-44), representative (ages 25-64), medium (ages 35-54) and the Alliance model (ages 45-64), respectively.

The effect of test replication was also examined in two analyses. First, three representative (ages 25-64), partially overlapping samples (N = 40) were constructed. The respective numbers of statistically significant planned comparisons were 0, 1, and 2 (out of 10). Finally, four smaller representative samples (N = 20) were constructed. Results of comparisons made using these samples were consistent in revealing that none (0) of the ten planned comparisons was statistically significant for any of the samples. Additional comparisons were made using the remaining DFD metrics and the Alliance vehicle performance metrics (not the Alliance eye glance metrics).

Driver age had significant effects on both primary and secondary task performance; younger drivers completed more secondary task trials on a given drive, with relatively less primary task interference than older drivers. Tests conducted using samples with wide age ranges (25-64) required larger samples to compensate for reduced homogeneity relative to samples with narrow age ranges.

Half of the participants were given specific monetary incentives, while half received an equivalent amount in an unspecified completion bonus. Incentives had some effects, primarily among older participants, but no consistent overall effects on primary or secondary task performance, or on the emphasis given by drivers to the primary task.

Based on these results, issues were identified that have implications for developing guidelines to assess the distraction potential of tasks performed with IVIS and portable devices. The first issue pertains to the question of how to incorporate task duration into the construction and interpretation of metrics. Secondary tasks differ in duration and these differences influence the overall exposure to risk. Metrics that summarize performance over varying durations are influenced by differences in task duration. In contrast, metrics that normalize for task duration summarize task performance over equivalent time intervals and thus represent the expected magnitude of performance degradation at any point in time during which a task is performed. These approaches provide complementary information, which could be used together to characterize the total exposure to risk associated with different tasks. One approach toward integration involves using duration-controlled metrics to estimate the average level of performance degradation associated with a particular secondary task and multiplying this estimate by the average or some specified percentile (e.g., 85^{th}) task duration to estimate the total exposure to risk associated with performing the task once.

The second issue pertains to the selection of a benchmark task. The Alliance Guidelines use radio tuning as a benchmark task in Principle 2.1B. Tasks that are more disruptive to driving than radio tuning are considered not acceptable to perform while driving. This approach is suitable for use in a development context, in which the goal is to identify tasks in need of redesign; however, the use of this test structure is less appropriate for compliance testing, if the focus is on demonstrating that tasks are acceptable for performance while driving. Specifically, demonstrating acceptability by the absence of a difference is not consistent with the logic of hypothesis testing in the scientific method, which is designed to identify differences, not equivalences. It is therefore inappropriate to conclude that a task imposes equivalent demand on driving if the task shows no detectable difference from radio tuning.

The emerging consensus that destination entry is unacceptable for performance while driving offers an opportunity for consensus-based compliance test pass/fail criteria. Accordingly, a task would be considered acceptable to perform while driving if that task were demonstrably less distracting than destination entry. Requiring a positive difference for compliance is consistent with the logic of scientific hypothesis testing. This approach also provides an implicit incentive for the use of strong experimental methods for demonstrating the acceptability of new tasks. A test structure that required no difference as a pass criterion would be more likely to erroneously reveal no differences due to insufficient statistical power associated with smaller samples. In contrast, a test structure that requires a positive difference would motivate the use of larger sample sizes to maximize statistical power. A positive-difference benchmark thus increases the probability that the test outcome will correctly reflect the real-world situation. Two potential problems remain. First, there is no standardized destination entry task. Second, while consensus supports the conclusion that destination entry is not acceptable for performing while driving, there is no consensus supporting the corollary conclusion that any tasks that are statistically less distracting than destination entry would be considered acceptable for performing while driving.

The third issue pertains to a potential problem with the implementation of the long-glance criterion in Alliance Principle 2.1A. While the principle refers to the long glances (i.e., glances $\geq$ 2 s), which reside in the tail of the distribution of glance durations, the metric is defined with reference to the mean of the glance duration distribution and thus appears inconsistent with the focus on the commonly-accepted problem of excessively long glances. It is desirable that the operational definition be reformulated so that it refers not to the distribution mean but to the tail of the distribution, which represents the excessively long glances.

In the context of guideline development, two knowledge gaps were identified. The first gap concerns the need to establish car-following task demand level. The Alliance 2.1B protocol uses a much less demanding car-following task than the DFD protocol. The less demanding car-following task affords drivers more spare attentional capacity than the more difficult car-following task. Different levels of attentional capacity devoted to secondary task performance are likely to create uncontrolled disparities in the level of driving performance degradation associated with various secondary tasks. The different car-following task demands could easily affect test outcomes. The second knowledge gap concerns the need to establish a reliable conversion estimate between estimates of TGT and eyes-off-road-time (EORT) estimates obtained directly via eye tracker in a driving situation. TGT estimates are not directly comparable with EORT estimates obtained in driving because not all of the time looking away from the forward roadway view is devoted to the secondary task. A direct comparison using a range of tasks is necessary to determine the relation between TGT and EORT.

Conclusions

The following conclusions are supported by this study's results:

1. Text messaging was associated with the highest level of distraction potential. Ten-digit phone dialing was the second most distracting task; radio tuning had the lowest level.

2. The use of a portable touch screen interface was slightly more distracting than use of a hard button interface on some measures; however, the differences were relatively small and were based only on drivers who had no prior experience with the devices used in the study.

3. The Alliance and DFD metrics and decision criteria both supported the conclusion that text messaging is not suitable for performing with driving. The same conclusion was reached using samples of 100 and 40 participants. However, the protocols led to different outcomes in response to the question of whether phone dialing is suitable for performance while driving. The different outcome was apparent only with the smaller sample size.

4. The results for the Alliance 2.1A long-glance metric were inconsistent with the results based on the other metrics. The operational definition of the long-glance metric appears inconsistent with its intent and was considerably weaker than the other metrics.

5. Differences in sample size and sample construction (age) had significant differences on test outcome. Samples of 20 participants did not provide sufficient statistical power using just vehicle performance metrics for detecting any of the differences that were apparent using larger sample sizes. Samples of 40 participants provided increased power, but the results differed considerably according to the construction of the sample. Samples of size 40 that were constructed in the same way also revealed different test outcomes. The results suggest the need for replication of test results, particularly if sample sizes of 40 or fewer participants are used. Different effects of sample size and construction might be seen using the eye glance metrics; however, those analyses have not yet been performed.

6. The Alliance's use of radio tuning as presenting a maximum level of acceptable distraction is appropriate for identifying tasks with excessive distraction potential indicating the need for redesign. This approach is not appropriate for compliance testing of finished products, if the goal is to demonstrate that tasks are acceptable to perform while driving. Requiring a positive difference from an established level of unacceptable distraction is consistent with the scientific method and could motivate the use of strong methods, thus reducing errors in which the failure to find differences may be due to the use of small samples rather than the absence of real differences.

1.0 INTRODUCTION

1.1 Background

The National Highway Traffic Safety Administration's (NHTSA) Vehicle Research and Test Center (VRTC) has developed a protocol that can be used to assess the distraction potential of secondary tasks performed using in-vehicle information systems (IVIS) in production vehicles or portable devices (e.g., hand-held GPS devices). The protocol can be used with different vehicles and requires minimal set up. Test participants perform secondary tasks while driving a fixed-base driving simulator. The primary task in this protocol combines a dynamic car following task with a target detection task. Thus, the protocol will be referred to as the Dynamic Following and Detection (DFD) protocol. Performance degradation on measures of lateral position, car following, visual target detection, and visual glance behavior, recorded on trials with secondary tasks, is compared to baseline driving performance with no secondary task. The simulator-based test protocol has demonstrated sensitivity for assessing effects of both visual-manual and cognitive distraction. It has been used with reference/calibration tasks, which allow systematic variation of processing loads, and real-world tasks, including destination entry using integrated and portable route navigation systems.

In recent years, the automobile industry has also been developing methods for use in measuring distraction. The Alliance of Automobile Manufacturers (Alliance) developed a set of guidelines for managing driver workload and distraction associated with IVIS (Alliance of Automobile Manufacturers, 2006). According to Alliance Principle 2.1, "Systems with visual displays should be designed such that the driver can complete the desired task with sequential glances that are brief enough not to adversely affect driving." The Alliance proposed two alternatives for assessing compliance, one focused on glance behavior and one focused on driving performance. For Alternative A, they proposed two criteria: (1) the durations of single glances to the task should generally not exceed 2 seconds; and (2) total glance time (TGT) should not exceed 20 seconds. Their Alternative B, justified by the reasonable concern that glance behavior measures "may not be fully indicative of overall driving performance," requires a driving task and identifies two driving performance measures (lateral position control and car-following headway). Unlike Alternative A, it does not define absolute criteria for acceptability; rather it outlines a generic test protocol in which task-related degradation on performance metrics is related to degradation on a (radio tuning) benchmark task performed under identical test conditions.

1.2 Number and Text Entry While Driving

Numerous studies have examined the effects of number and text entry on driving performance, primarily within the context of phone dialing and destination entry. Studies of phone dialing have focused primarily on two questions: whether dialing is more disruptive to driving than cell phone conversation and whether hand-held (manual) dialing is more disruptive than hands-free (voice) dialing. These studies have been relatively consistent in demonstrating that: (1) manual dialing is more disruptive to driving than talking, and (2) voice-dialing is less disruptive than manual dialing (Briem and Hedman, 1995; Reed and Green, 1999; Jenness, et al., 2002). Destination entry using integrated and portable route navigation systems has also been the focus of numerous research studies. Results of our own work have consistently shown that destination entry by address, which requires entering street and city names using a virtual QWERTY keyboard, is more demanding and thus potentially more distracting than selecting a previously destination, which requires scrolling through a list of previously entered addresses, but no text entry (Ranney, Baldwin, Parmer, Domeyer, and Mazzae, 2011).

Some recent research has addressed the more contemporary problem of text messaging while driving. The results revealed increased driving performance degradation and proportionately less time spent focusing on the road while texting, relative to baseline driving (Drews et al., 2009; Hosking et al., 2006, 2007; Crisler et al., 2008; Reed and Robbins, 2008). In a driving simulator study, Drews and colleagues (2009) found that participants responded more slowly to the onset of brake lights and showed impaired forward and lateral vehicle control while texting relative to driving alone. Similarly, Hosking and colleagues (2007) found that when text messaging, drivers' ability to maintain their lateral position on the road and to detect and respond appropriately to traffic signs was significantly reduced. Drivers spent up to 400 percent more time with their eyes off the road when text messaging, relative to driving alone. Drivers generally did not reduce their speed while distracted although there was some evidence that they attempted to compensate for being distracted by increasing their following distance. Decrements to lane-keeping performance and speed variability were found in a study by Crisler and colleagues (2008) that examined the effects of wireless communication and entertainment devices on driving performance. Increased brake response times and slower driving were reported in a Swedish simulator study, when participants were retrieving text messages (Kircher et al., 2004). In that study, drivers engaged in hands-free or hand-held phone conversations, dialed, received text messages, and watched a DVD film while driving in urban and rural traffic environments. Driving performance was similar for both hands-free and hand-held phone modes, except that when drivers were retrieving text messages their braking reaction times increased in response to a motorcycle hazard. Some results, including increased following distances and reduced speeds, suggested compensatory attempts by the drivers to manage their workload.

1.3 Test Participant Selection Criteria

The outcome of any behavioral experiment is determined in part by the capabilities and limitations of the participants included in the sample. Testing requires use of selection criteria to ensure that the test is fair and the results are repeatable. Most generally, participant selection involves a balance between representativeness and homogeneity. Representativeness is desirable to ensure that the test results apply to the appropriate population segment. Homogeneity is desirable to minimize the influence of individual differences on test outcome and thereby increase statistical power for a given sample size. When test results are applicable to relatively narrow population segments, there is unlikely to be a significant conflict between these two values. However, when test results are intended to apply to a wide range of users, a representative sample will likely be more diverse and thus less homogeneous.

Age is an important participant selection criterion. Alliance Principle 2.1 specifies that test participants shall be between ages 45 and 65. The rationale for this range is not provided; however, it poses several potential problems for the present work. First, it includes components of what have traditionally been considered both middle-aged and older drivers. It is therefore likely to be less homogeneous than a sample defined to include a more narrow range of middle-aged drivers. Many experimental studies use the well-established distribution of mileage-based fatality rates by driver age (e.g., NHTSA, 2000) to support their use of middle-aged drivers (e.g., 30 – 60 years old) because crash rates for these driver ages are relatively consistent across the entire range, whereas crash rates for older and younger drivers are both higher and more volatile. The second problem with the Alliance-specified age range for the present work derives from the fact that portable technologies are more likely to be used by younger drivers (Shinar, 2007). This suggests a need both for inclusion of younger drivers and exclusion of older drivers to better represent that population of likely users, when the testing includes portable devices.

Alliance Principle 2.1 also asserts that participants should not have familiarity with the systems under investigation. Test participants will therefore not be selected based on their experience with specific devices. This requirement implies that test results may not generalize to real-world use of devices among experienced users if the devices become easier to operate as users become familiar with advanced features. Rather, using unfamiliar test participants represents the worst-case scenario, something akin, for example, to the distraction effects of route navigation systems used by drivers of rental cars. While this criterion may be perceived as a potential weakness of the test protocol, it represents an attempt to facilitate a fair comparison among multiple devices by ensuring that all test participants start from the same relative position of device-specific experience. Moreover, the extent to which familiarity with a particular device determines the potential for distraction among drivers using the device while driving is not well established (however, see Chisholm, Caird, and Lockhart, 2008; Shinar, Tractinsky, and Compton, 2005).

1.4 Research Objectives

The main objectives of this research are to: (1) compare DFD metrics with Alliance Principle 2.1 measurement alternatives; (2) evaluate test participant selection criteria; and (3) use the DFD distraction protocol to assess distraction potential of secondary tasks (using integrated and/or portable systems) involving manual number and text entry. The results will provide information to help NHTSA develop or modify existing guidelines for the assessment of distraction potential associated with IVIS in production vehicles or portable devices. The present work will also focus on determining criteria of acceptable performance for the metrics provided by the DFD protocol and compare the outcomes of testing using these criteria with the outcomes of tests using the metrics and threshold criteria specified in the two alternatives of Alliance Principle 2.1.

2.0 METHOD

2.1 Approach

The study objectives were addressed in a single experiment, in which participants performed different categories of secondary tasks while performing a driving task that combined car following and target detection. The experiment was conducted in a single stationary vehicle, which was connected to a fixed-base driving simulator. Sensors connected to the vehicle steering, brake, and throttle provided control inputs to the driving simulator. The vehicle was not running. The experiment used the VRTC simulator-based test protocol to compare the DFD metrics with those specified in Alliance Principle 2.1. The significant overlap in data collection requirements between the test protocol specified in Alliance Principle 2.1 and the DFD protocol allowed the data necessary for a side-by-side comparison to be obtained from a single experimental protocol. The applicability of data provided by the simulator to the Alliance Alternatives and to the DFD protocol is shown in Table 1.

Table 1. Relation of DFD Protocol Metrics to Alliance 2.1 Assessment Alternatives

Metric	**Alliance 2.1 Alternative A**	**Alliance 2.1 Alternative B**	**DFD Protocol**
Total glance time (TGT)	X		
Glance duration (< 2 sec)	X		X
Lane departure event		X	
Lateral position (SDLP)			X
Car-following headway		X	X
Car-following delay / coherence			X
Detection task RT / proportion correct			X

Alliance Principle 2.1 is intended for use in assessing visual-manual tasks that require the acquisition of information from a visual display. The focus of this experiment was on the distraction potential effects of contemporary visual-manual tasks performed with portable devices. Integrated systems were included as benchmark tasks, as discussed below. The experiment was also designed to test the effects of different age-based participant selection criteria as well as two methods of providing performance-based compensation.

2.2 Experimental Design

The experiment used a four-factor design in which the independent variables and their respective levels were:

Within subject variables:

1) Portable device (hard button, touch screen)
    a. Number/text entry task (phone dialing, text messaging)
2) Benchmark (radio tuning, destination entry)

Between subject variables:

3) Age (25-34; 35-44; 45-54; 55-64)
4) Monetary incentives (incentives, no incentives)

The portable devices included two smart phones, one with a hard button interface (Blackberry Curve) and one with a touch screen interface (iPhone). Secondary tasks performed with these devices included two methods of phone dialing (10-digit dialing and contact selection) and text messaging. Radio tuning is the benchmark specified in Alliance Principle 2.1; destination entry is a benchmark that has been used in the DFD protocol. To facilitate a comparison of different subject selection criteria, a relatively wide range of participant ages (e.g., 25 – 64) was tested.

A secondary objective of the study was to determine the effect of the monetary incentives on performance. Accordingly, half of the participants (Incentive group) were given detailed information to define task priorities and specific feedback on their performance following each trial (see Table 8 and Table 9). Participants in the No-incentive group were given general instructions concerning task priorities but no monetary incentives.

2.2.1 Sample Size Determination

The expected number of participants needed to differentiate between task conditions was determined through power analysis. We used data from one of our core metrics (detection task response time) for the two visual-manual task conditions that have consistently been found to differ with respect to distraction potential, namely destination entry by address and selecting a previous destination. Results of the power analysis are presented in Table 2.

Table 2. Power Analysis

Detection Task Mean Response Time	**Power**	**Mean Difference**	**Standard Deviation**	**Total N***
Destination Entry: Address vs. Previous Destination	0.8 (desired)	1.09 - .99	0.155	78
	0.7 (marginal)	1.09 - .99	0.155	62
	0.6 (insufficient)	1.09 - .99	0.155	50

*Half of participants in each group

According to Cohen (1988), the desired power for behavior research is 0.8, which means that there is a probability of 0.8 of detecting a real difference between conditions, if one exists in the real world. As shown in Table 2, 78 subjects are required to provide this level of power. This total is based on upon a comparison between two groups with half of the subjects in each group. The required group size to obtain power = 0.8 would therefore be 39. For power = 0.7, half of 62, or 31 subjects would be required for each group.

0 shows the planned allocation of participant ages and Table 4 shows how samples were constructed to assess the effects of different participant selection models on test outcome.

Table 3. Participant Age Distribution

Group	Age Range	N
1	25 – 34	20
2	35 – 44	40
3	45 – 54	20
4	55 – 64	20
Total		100

Table 4. Construction of Participant Selection Criteria Models

Subject Selection Model	**1 (25-34)**	**2 (35-44)**	**3 (45-54)**	**4 (55-64)**	**Total N**	**Group Age Range**
Narrow	0	40	0	0	40	35 – 44
Medium	0	20	20	0	40	35 – 54
Representative	10	10	10	10	40	25 – 64
Expanded Representative	20	20	20	20	80	25 – 64
Alliance 2.1	0	0	20	20	40	45 – 64

The total number of recruited participants shown in 0 (N=100) was not sufficient to create independent samples required for all participant selection criteria models shown in Table 4 (N = 240) using different participants. The constructed samples were therefore not independent of each other; subjects were assigned to more than one sample. This eliminated the possibility of using selection criterion as an independent variable in each analysis. Rather, a qualitative comparison was made at the level of the test outcome. Outcomes of tests performed using different samples were represented in terms of the number of planned comparisons that revealed statistical significance.

The data presented in Table 2 and Table 4 allowed us to estimate the level of statistical power associated with the design. Because the assessments of metric sensitivity were conducted within subjects, the group sizes required to achieve a specific level of statistical power were half of the Total N values shown in Table 2. In essence, a single group served as both halves of the larger group, the sizes for which are shown in Table 2. Therefore, comparing the Total N values shown in Table 4 with half the Total N values shown in Table 2 provides an estimate of the statistical power associated with the planned comparisons. Note from Table 2 that with one exception, the number of participants in a constructed sample was 40. This corresponds most closely with half of the Total N in Table 2 associated with statistical power of 0.8 (Total N = 78, half = 39). Therefore, assuming that the metrics in this study provide comparable differences between means and comparable levels of variance relative to those shown in Table 2, groups of 40 participants should provide statistical power of approximately 0.8.

2.3 Participants

One hundred drivers participated in the experiment. Ages ranged between 25 and 64 years. Approximately half of the participants in each age category were female, half male. Participants were active drivers with a valid driver's license and a minimum of 7,000 miles driven per year. All participants reported having experience using a wireless phone while driving. Wireless phone use was considered to be a surrogate for multi-tasking experience; we expected drivers who were experienced phone users to be more representative of drivers who would chose to perform various secondary tasks while driving. Most of the participants were active users of text messaging and most were comfortable constructing text messages while driving (See Appendix G and Table 79, for a complete breakdown of participants' self-reported text messaging activity.)

Fifty-seven percent of the participants reported some previous experience with a navigation system. Data for this experiment were collected between October and December of 2010.

2.3.1 Recruiting

Participants were recruited through advertisements placed in local newspapers, including the Columbus Dispatch and smaller local papers, including those in Marysville and Bellefontaine, Ohio. We also used web-based networks (e.g., Craigslist). Respondents were asked a series of questions to ensure that they were licensed drivers with no vision problems, active users of text messaging, and regular users of a cell phone while driving. Cell phone use has been successfully used as a surrogate for time-sharing aptitude in our previous studies. Our intention was to select participants with time-sharing aptitude, who were active users of text messaging.

Gender was balanced within each age group. To facilitate recruitment, an online application procedure was implemented; the procedure allowed participants to complete the screening questionnaire online. This eliminated a considerable amount of phone interaction and allowed suitable candidates to be selected without an initial conversation. Participants received mileage-based pay to supplement the hourly and incentive compensation.

2.4 Apparatus

2.4.1 Laboratory

For this experiment, a temporary enclosure was assembled inside a larger laboratory to provide a controlled environment in which to set up the fixed-base driving simulator. Figure 1 shows a drawing of the simulator enclosure with the relative dimensions and layout of the vehicle and equipment inside.

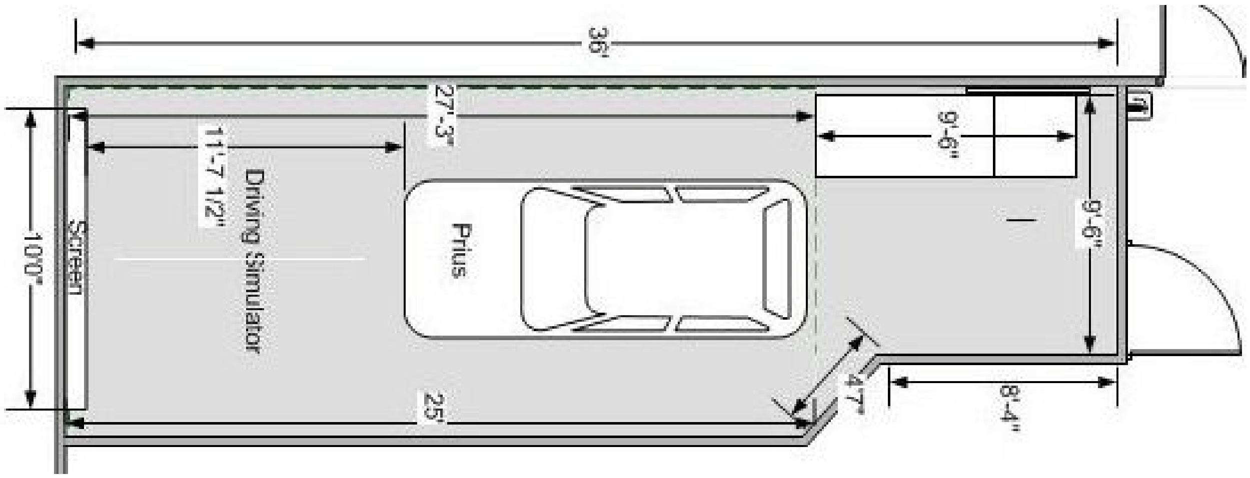


Figure 1. Dimensions and Basic Layout of Simulator Environment

The enclosure's structure consisted of materials from two portable canopies made of interlocking aluminum poles with white tarps for covering the roof and sides. While the canopy tarps provided basic simulator cover, additional materials were added to the roof and walls to permit better experimental control of both light and sound. The wall panels can be seen in Figure 2.

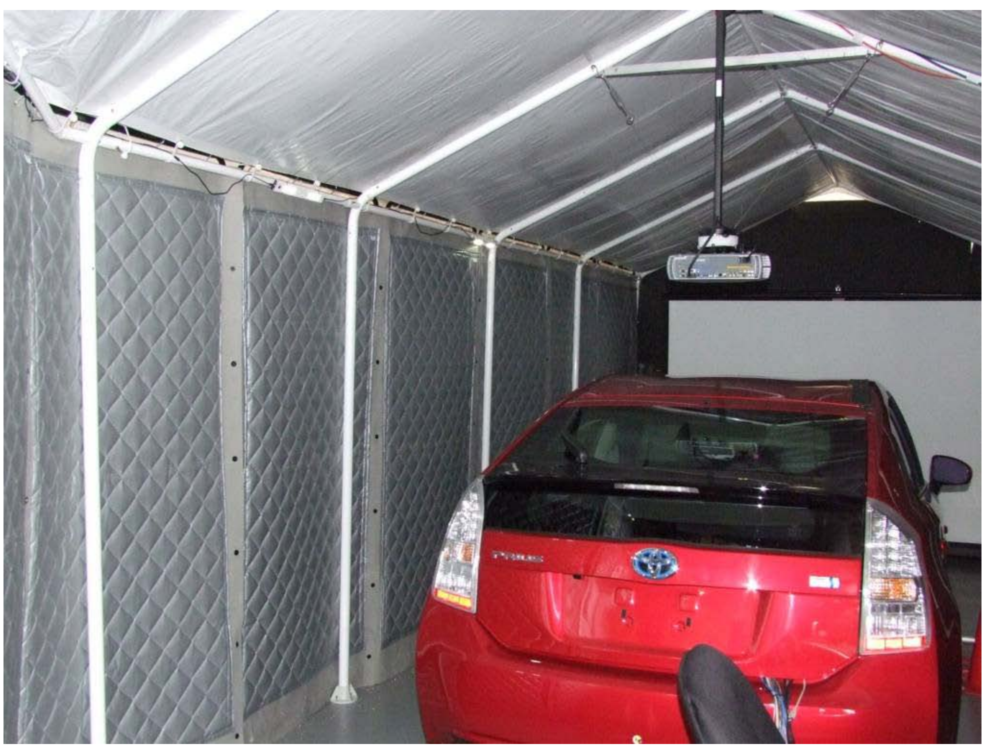


Figure 2. Simulator Enclosure, Roof and Wall Construction Materials

The wall panels were free-standing modular acoustical screens with a noise reduction coefficient of 0.75. These acoustical screens were each 4 feet wide by 8 feet tall. Each screen had a black tubular steel frame that was attached to the canopy frame and the frames of other screens to form the desired light and sound barrier for the simulator walls. Acoustic foam was then placed on top of the roof of the canopy, supported by the canopy frame and white tarps. Thus, the canopy's frame supported both the acoustic foam panels above the roof tarp and the acoustic screens used for the walls.

Once the structure was complete, accent lighting was added to the junction of the wall and ceiling to provide a lighted path to the driver's side of the vehicle. As seen in Figure 1, a door was placed at the end of the structure behind the vehicle. This door was made of one of the acoustical screens and frame, in which a hinge was fabricated to attach the door to the canopy frame. A wheel was mounted under the door frame to allow it to open and close easily.

2.4.2 Driving Simulator

Inside the simulator enclosure, components of the fixed-base simulator included a production test vehicle (2010 Toyota Prius), an Intel Pentium 4 computer, a ceiling-mounted digital projector (1024 x 768) positioned above the vehicle, and a forward projection screen (10 ft x 10 ft). The STISIM drive simulator software was used.

The roadway scene consisted of a 4-lane rural highway with two (12 foot wide) lanes in each direction, separated by double yellow lines. After an initial curve, all secondary tasks were performed on straight-road sections. There were no cross roads and lighting was selected to simulate daytime driving conditions. Single oncoming vehicles were programmed to appear approximately every 1300-1600 feet (i.e., once every 15-20 seconds), with varying speeds and lateral positions in the nearest oncoming lane. Scenario, roadway, and vehicle parameters are described in Appendix I.

A touch screen was installed inside the vehicle and was connected to a separate computer, which was used to generate visual stimuli for secondary tasks (see Figure 3). The simulator computer, secondary task computer and other experimenter materials were located at a control station located behind the vehicle on the passenger side. From there, two experimenters could operate all the equipment and communicate with a participant using a speaker and microphone system.

Figure 3. Prius Interior and Touch Screen

Sensors that recorded steering, accelerator and brake inputs were attached temporarily to the test vehicle. Specifically, a bracket (see Figure 4) was developed to couple either front tire of the test vehicle to a turn plate on the ground while the vehicle tires were off the ground (vehicle supported by 5 jack stands). The bracket and turn plate assembly mounted to the front tire provided steering inputs to the driving simulator when the participant moved the steering wheel, allowing the simulator to run without the vehicle being turned on.

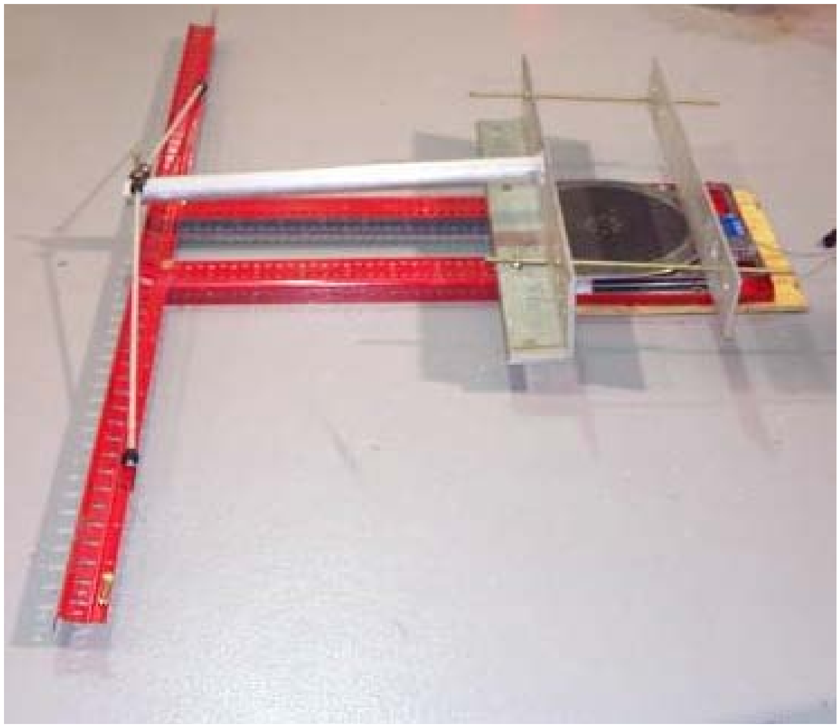


Figure 4. Apparatus for Recording Steering Wheel Movement

A Seeing Machines FaceLAB eye tracking system was used to record the driver's head pose and gaze. Head pose used three parameters to define position and three parameters to define orientation. FaceLAB output gaze rays for each eye. Each ray had an origin at the center of the respective eye and vectors pointing toward the object being looked at. Gaze was represented as pitch and yaw angles. The pitch and yaw angles were transformed into a direction vector. Dual gaze was converted into a single gaze vector. The system used two stereo cameras mounted on the dashboard and was relatively unobtrusive. To assist the system in tracking facial features, participants applied five latex target stickers to their faces during system calibration.
The vehicle data acquisition system was configured to collect steering wheel position, brake and throttle inputs, and participant responses to the target detection task. That system also collected video data from multiple camera locations, in addition to collecting timing data from the various systems (STISIM, FaceLAB, and the secondary task computer) to provide time syncing of all the data in post processing routines. In addition, the STISIM simulation computer collected data for its respective performance measures. The primary data channels are displayed in Table 5.

Table 5. Data Collection Channels

Data Channel	Description	Units	Resolution
Vehicle Speed	STISIM	km/h	1 km/h
Range	Distance to the lead vehicle, STISIM	m	.5 m
Range-Rate	Relative velocity between the vehicles, STISIM	m/s	.1 m/s
Lateral Position	Lateral position in reference to the simulated lanes, STISIM	cm	2 cm
Hand Wheel Position	Angular position of the steering wheel (0 degrees = straight)	deg	.1 deg
UTC Time	Time of day	HH:MM:SS	1 s
Event Task	DT button press response	0 or 1	$1/30^{th}$ s

2.4.3 Portable Devices

Two smart phones were used in the experiment, including: an iPhone 3GS (32GB) and a Blackberry Curve 8310.

2.5 Driving Task

A dynamic car-following paradigm modeled after that used by Brookhuis and colleagues (Brookhuis, Waard, and Mulder, 1994), was programmed into the scenario run on the STI simulator. This task required participants to maintain a constant following distance behind a lead vehicle, which changed speed according to a predefined complex waveform (see Figure 5). Participants were required to follow a simulated lead vehicle's speed changes on straight road segments. Prior to testing, drivers were given training and feedback about the range of following distances considered acceptable. During the experiment, participants received feedback and, if they were part of the Incentive Group, monetary incentives based on their ability to maintain an acceptable following distance. Feedback included the average and standard deviation of the distance between the vehicles, and the percentage of time the participant stayed within an acceptable range (120 feet ± 60 feet). An auditory warning system was used to encourage drivers to maintain a fairly close following distance. When drivers exceeded a pre-defined criterion (200 feet), an audible tone sounded once every five seconds until the driver returned to an acceptable following distance.

Figure 5 presents the lead vehicle speed signal that was created for this experiment. The signal is a modification of a signal that had been used previously. The modification involved increasing the y-axis scaling of the previous signal around its mean, which had the effect of retaining the same relative frequency components while increasing the amplitude. The original construction of the complex signal is described in an earlier study (Ranney, Mazzae, Baldwin, and Salaani, 2007).

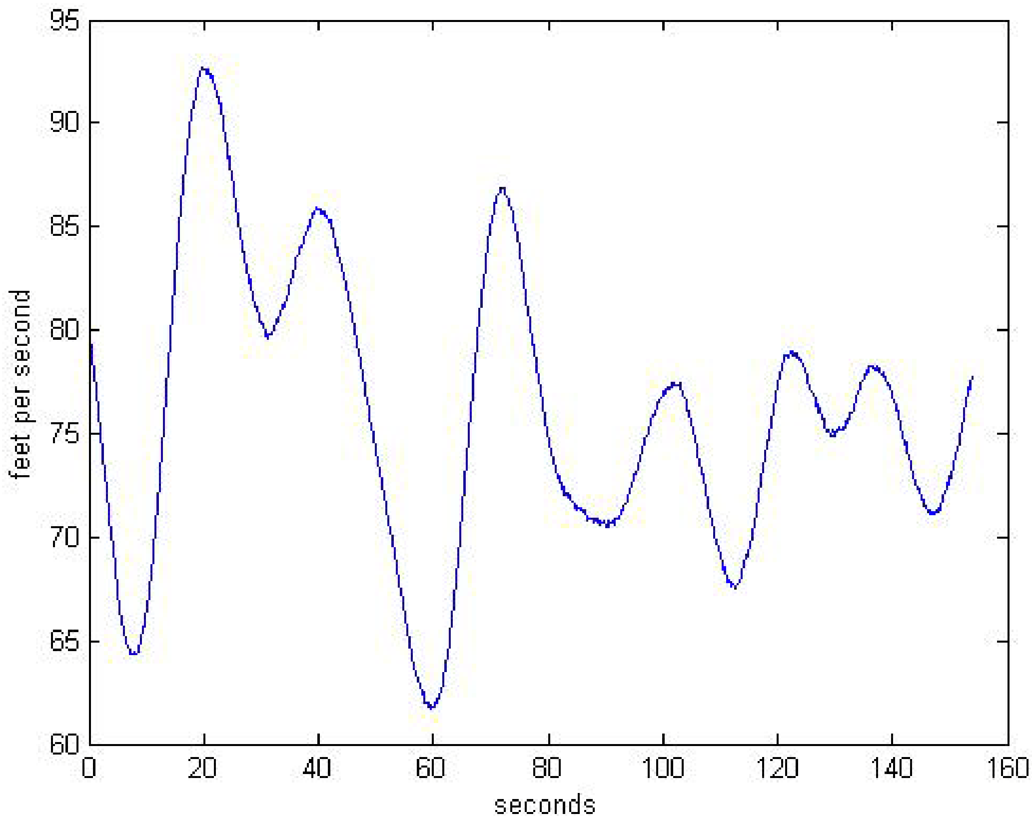


Figure 5. Lead Vehicle Car-Following Speed Signal

2.6 Visual Target Detection Task

The visual target detection task was a modification of the original Peripheral Detection Task (PDT) (Harms and Patten, 2003). Instead of LEDs reflected off the windshield, the targets were computer-generated, red-colored circles intended to approximate the size of the reflected LEDs in the traditional PDT. Targets appeared one at a time at one of six locations on a single horizontal line near the horizon in the driving scene as shown in Figure 6. The targets subtended a visual angle of approximately 1 degree, based on an approximated average driver's eye location. Figure 7 shows the locations of the targets with respect to an average driver's seated position. Participants responded to targets by pressing a button attached to their left index finger. The button was connected by wire to a transmitter box that was worn on the wrist. Hardware components used to implement the visual target detection task are described in Appendix A.

One target appeared every 3-5 seconds; the inter-stimulus interval (ISI) durations were sampled from a uniform distribution of times within this range. The target appeared on the roadway display for 1.5 seconds or until the participant pressed the response button. The subsequent ISI was initiated either by the participant's response (for correct trials) or 0.5 seconds following target disappearance (for miss trials). Targets not responded to within 1.5 seconds were considered misses. Details of target location information are presented in Appendix I.

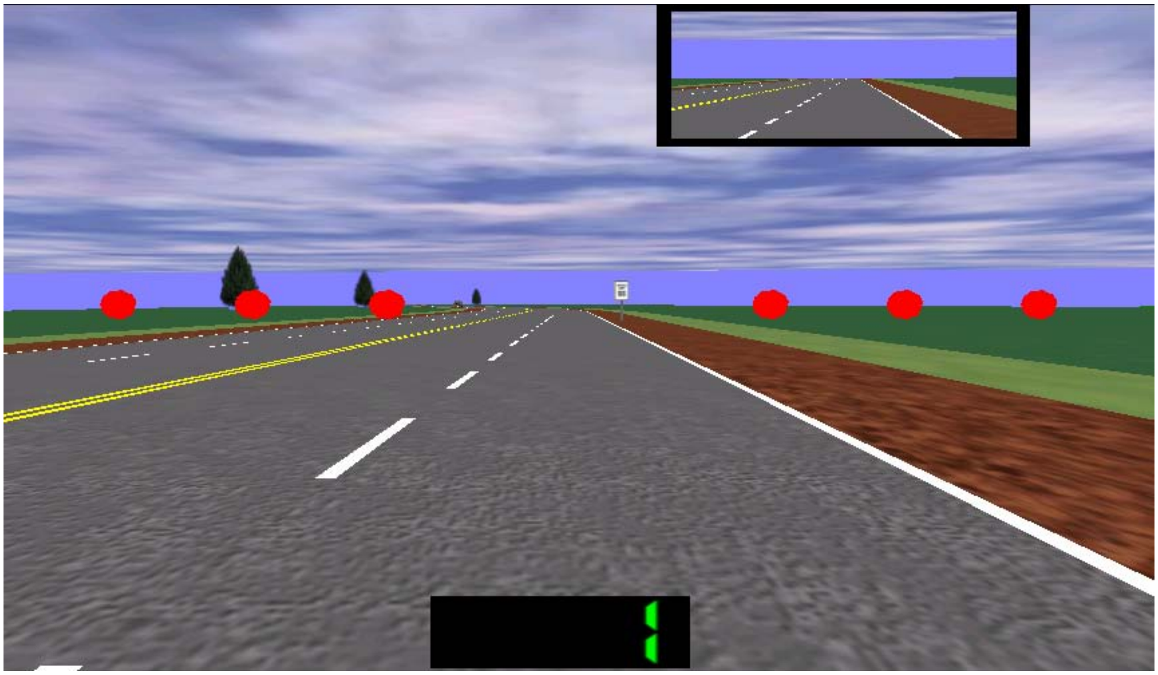


Figure 6. Visual Detection Task

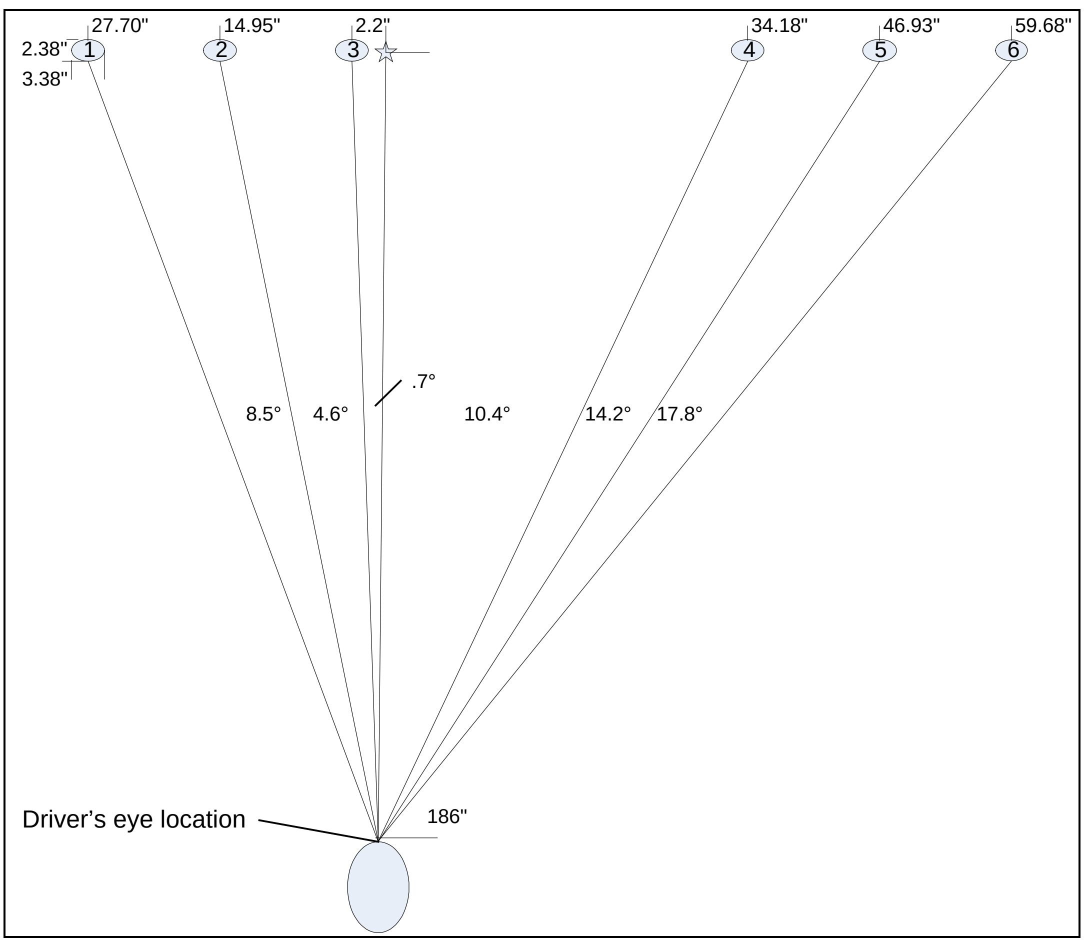


Figure 7. Detection Task Target Size and Location

2.7 Secondary Tasks

The following specific manual number and text entry tasks were used in the experiment:

- Radio tuning (Alliance 2.1 benchmark)
- Destination entry by address (DFD protocol benchmark)
- Phone dialing (10-digit, contact)
- Text-messaging

Appendix J contains the specific list of stimuli presented to participants on a task screen during the main trials for each of these number and text entry tasks. Destination entry by address is a complex and relatively difficult task that requires selecting entry modes [(state or region, if applicable), city, street and house number] and entering text and/or numbers in each mode. Ten-digit phone dialing is the traditional dialing task. Phone dialing via contact selection is a more contemporary version of dialing, which requires searching a list of stored numbers rather than entering an entire number.

Destination entry and phone dialing are realistic and well defined tasks, however text messaging represents a range of possible activities, typically constrained only by the number of characters allowed in a message. Its difficulty depends on how it is implemented. Previous experimental studies have used a variety of texting tasks. A summary is presented in Appendix B. Only one previous texting study (Drews et al., 2009) used a realistic texting task; participants in that study were given a topic, with no additional constraints on the messages. This approach was considered too open-ended for the present experiment. Specifically, it provided no apparent basis for controlling task difficulty or scoring.

The text messaging task used in this experiment was a phrase-completion task, derived from the television game show "Wheel of Fortune" paradigm. In each text message, participants were given a meaningful, well known phrase (e.g., movie title, famous saying, song lyrics), with one or more words missing. Their task was to open and read each message then to create and send a text message reply that contained the missing word(s). This task embodies the essential characteristics of real-world text messaging, including interpreting brief real-world phrases and creating replies to emphasize brevity. It is repeatable, allows task difficulty to be systematically varied, and allows performance to be scored. The task is inherently engaging, thus simulating one of the more salient features of real-world text messaging. Examples of stimulus phrases and correct responses are presented in Table 6.

Table 6. Examples of Text Message Phrases with Missing Word(s)

Category	Stimulus	Response
Song Lyric	WE ALL LIVE IN A______ SUBMARINE	YELLOW
Movie Title	WILLY WONKA'S _________ FACTORY	CHOCOLATE
Famous Saying	WE HOLD THESE ______ TO BE SELF-EVIDENT	TRUTHS
Phrase	TIME FLIES WHEN YOU'RE _________	HAVING FUN

Because the task was used with participants from different age groups, it was expected that some stimuli would be more familiar to some participants than others. If participants could not readily complete a phrase, they were instructed to send a brief message to indicate that they don't know the answer (e.g., “don’t know”, “not sure”). Training emphasized the need to move through the messages. Prior to each driving trial, the phones were preloaded with a set of messages. This approach avoided having to rely on the performance of a real-world telecommunications system for timely delivery of messages.

2.8 Procedure

Each participant completed one session, which lasted approximately four hours. Appendix J contains a complete set of instruction materials and test procedure steps used in this study. All testing was done in a single vehicle. Upon arrival, the participant was asked to read and sign the Participant Information Summary (Appendix C), thereby giving informed consent to participate in the study. Participants were then asked to generate a list of familiar phone numbers that they could dial from memory. Examples included their home phone, their cell phone, their partner’s cell phone, phone numbers of friends and family members, and other numbers frequently called. Verbal tags (e.g., “Call Home”) were created for these numbers and used as stimuli in the experiment. The use of visual tags was intended to ensure that participants needed only one glance to the stimulus screen to identify and recall the number to be dialed.

The participant was then escorted to the experimental vehicle and given an overview of the vehicle controls and displays, including adjusting the seat position (see Appendix J for the actual simulator orientation script that was read to each participant). This was followed by an explanation of the monetary performance incentive system (if appropriate) and the Rating Scale Mental Effort (RSME, Appendix D), which was used after each trial to record participants’ subjective assessment of mental workload. The participant was then asked to affix latex stickers to his or her face for eye tracker calibration. During this procedure, the experimenter instructed the participant concerning head position and point of gaze and made adjustments to a head/eye model. A test of the model was conducted to determine whether calibration was successful. If necessary, several calibration steps were repeated and a second model test performed.

Next, the participant was given instructions and practice for the driving task components, including car following and target detection (as shown in Appendix J). The desired following distance was demonstrated and participants were advised that a warning signal would sound if their following distance increased beyond an acceptable range. Participants were given practice with the combination of car following and target detection, followed by performance feedback (see Table 8 and Table 9). The participant was then given an opportunity to ask questions about any aspect of the protocol.

Data collection consisted of four separate blocks, as shown in Table 7. To minimize carryover effects due to the requirement that participants perform tasks using multiple devices, the presentation order of the secondary tasks was balanced within age groups. The procedural steps and secondary task training materials, as well as an example of a participant’s test presentation order can be found in Appendix J.

Table 7. Structure of Experimental Session

Task Block	Secondary Task Conditions (within Ss)
1	Benchmarks - Address entry (DFD protocol) - Radio tuning (Alliance 2.1)
2	Hard button portable phone - 10-digit dialing - Dialing via contact list - Text message
3	Touch screen portable phone - 10-digit dialing - Dialing via contact list - Text message
4	Baseline driving

Training on the secondary tasks began following a break. Training, practice, and testing were completed for each block in the order assigned to a particular participant.

The experiment had 9 main driving trials, 8 of which involved concurrent performance of the secondary tasks shown in Table 7, plus approximately 10 practice drives. As can be seen in Appendix J, participants would perform a practice trial before each main trial. Participants could ask to repeat the practice trial as much as was necessary to achieve a certain level of confidence with performing the combination of primary and secondary tasks.

Each main driving trial lasted approximately three minutes. After each trial, the participants were asked to complete the RSME and were provided performance feedback, if appropriate. The experimenter then provided the participant with training and stationary practice for the next trial and secondary task. The participant was offered a break after each secondary task block. The experimenters were positioned at a control station behind the vehicle during data collection. Communication with the participant was accomplished by a speaker and microphone system.

At the completion of data collection, the participant was asked to complete a simulator sickness questionnaire (Appendix E) to determine if rest was required before being allowed to drive home. The participant was also asked to complete a post-test questionnaire (Appendix F) containing questions about the secondary tasks that were performed during testing. The results of the post-test questionnaire can be found in Appendix G.

The participant was then given compensation, which consisted of the total of three amounts: (1) Base pay ($31 per hour) for participation, (2) Performance incentive pay or completion bonus, and (3) mileage reimbursement for travel to and from the test facility. The performance incentive or completion bonus was computed for each trial based on the amounts shown in Table 8. The completion bonus pay was determined in exactly the same manner as the performance incentive pay; participants just did not know any details about the completion bonus until their participation was complete.

Table 8. Monetary Incentive/Performance Bonus Amounts per Trial

	Performance			
Task	**Priority**	**Good**	**Acceptable**	**Poor**
Car Following / Target Detection	1	$2.60	$1.30	$0.0
Secondary Task	2	$1.40	$0.70	$0.0
Total		$4.00	$2.00	$0.0

On each trial, the participant had the opportunity to earn $4.00 in addition to the base pay. Thus, for consistently good performance on each of the 9 main trials, the participant could earn an additional $36.00. The performance for each trial was determined subjectively by the experimenter based on the general criteria presented in Table 9.

Table 9. Task Performance Incentive Criteria

Task	Good Performance	Acceptable Performance	Poor Performance
Car Following	Maintains close following distance consistently with minor deviations	Maintains close following distance mostly with some noticeable deviations	Generally fails to maintain close following distance
Target Detection	Consistently attentive to target detection, detecting most targets	Moderate number of targets not detected	Fails to detect significant number of targets
In-Vehicle Secondary	Performs secondary task continuously with minimal errors	Performs secondary task either intermittently or with moderate number of errors	Performs secondary task with considerable difficulty, slowly, and with moderate number of errors

Specific criteria were established during pilot testing to differentiate among the three performance categories.

The experimenter answered questions and then accompanied the participant to his or her personal vehicle.

A separate small-scale pilot test was conducted to estimate how many of each task type could be completed in a static setting. Following training and practice, six participants performed each of the secondary tasks five times (with no driving).

2.9 DFD Protocol Metrics

DFD metrics are summary metrics, which characterize performance over the entire 2.5-minute drive. They are typically mean values such that each metric represents the average performance at any instant in time during the drive. Core DFD metrics include the following 4 metrics:

<u>Car-Following Delay.</u> This measure represents the response lag in seconds during car following. Cross correlation is used to compute the delay. Details of the analyses based on cross correlation are presented in Ranney, et al, (2011).

<u>Standard Deviation of Lane Position (SDLP).</u> This measure reflects the variability of lateral position over the entire data collection interval. It has been widely used as a measure of driving

performance and has been shown to be sensitive to impairment due to fatigue, alcohol, drugs and distraction.

Detection Task Mean Response Time (DT MRT). Drivers responded to approximately 30 targets during each driving trial. Responses recorded between 0.2 and 2.0 seconds following the target activation were considered correct responses. Mean response time is computed for the correctly detected targets on each trial.

Detection Task Proportion Correct (DT P Corr). This measure represents the proportion of DT targets detected correctly on a given trial.

Secondary DFD metrics include the following:

Percentage of Time Viewing Road Center (PRC). Software was developed to identify primary and secondary regions of maximum density, using FaceLAB two-dimensional yaw/pitch eye-position data obtained for each drive. Using a circular window with radius of 8 degrees of visual angle together with a predefined scan step, an automated search algorithm identified the two regions with the greatest number of points, subject to constraints defined to ensure that the two regions represented looking forward and looking at the secondary task display. The search algorithm is described in greater detail in Ranney, Baldwin, Parmer, Domeyer and Mazzae (2011). This metric represents the proportion of the samples obtained during a complete drive for which the eye gaze position was contained within the area defined as road center.

Proportion of Long Glances (P Long Glance). The duration of each glance away from the road center was computed for each trial. Metrics were created to represent the proportion of glances away from center that exceeded 1.5 and 2.0 seconds. Additional metrics were created to represent the portion of each glance that was directed at the secondary task display. The duration of glances away from the roadway center was considered of more direct relevance to safety than the portion of the duration that was directed to the secondary task display. The implications of this difference in approach are addressed in more detail in the Discussion section.

Rating Scale Mental Effort (RSME). Workload rating scale (see Appendix D) measures the participants' ratings of the subjective difficulty associated with each combination of primary and secondary task.

2.10 Alliance Principle 2.1 Metrics

Alliance Principle 2.1 metrics were computed for each complete instance of a secondary task. The number of complete instances varied by secondary task and among individuals.

Lateral Position Control. Alliance Principle 2.1B refers to three metrics that characterize lane keeping, including the number of lane departure events and the distributions of extent and integral of lane exceedances. Extent refers to the maximum lateral distance outside of the travel lane associated with each lane departure event. The integral of lane exceedance refers to the area under the curve, where the curve represents the distance by time displacement for each lane exceedance.

Headway Maintenance. According to the Alliance Principle 2.1B, car-following headway is calculated as the inter-vehicle range divided by the subject vehicle velocity, which produces a measurement in units of seconds. The metric is the variability of headway.

Glances > 2.0 seconds. Within each task instance, all glances away from the forward roadway view are characterized. This definition is not completely consistent with the Alliance Guideline definition, which is based on the average duration of all glances to the secondary task.

Total Glance Time. For each secondary task instance, the total glance time represents the total amount of time that the driver is looking away from the forward roadway view in the direction of the secondary task.

3.0 RESULTS

3.1 Overview

Analyses addressed the following categories of questions: (1) methodological issues, (2) distraction effects of different secondary tasks, and (3) comparison of DFD metrics versus Alliance 2.1 metrics. Proc Mixed of SAS (Version 9.1.3) was used to compute analyses of variance (ANOVA) for each dependent measure. Planned comparisons were specified and the results were adjusted for family wise error.

3.2 General Methodological Questions

3.2.1 Effects of Incentives on Test Performance

A summary metric of overall performance was created to assess the global effects of incentives and driver age. Overall performance was defined to include the combination of primary and secondary task performance. Primary task performance was defined as the combination of car-following accuracy and the proportion of visual targets correctly detected. Car-following accuracy was the proportion of time during which the participant maintained a following distance in the acceptable range (60 – 180 feet). Secondary task performance was defined as the percentage of tasks completed, based on the overall maximum completed during a 2.5 minute drive for each respective task. To create overall performance, primary and secondary task scores were weighted according to the proportions defined in the monetary incentive structure: car following performance was multiplied by .35, target detection task performance was multiplied by .30, and secondary task performance was multiplied by .35.

Half of the participants had performance incentives, which were specified in detail before the experiment. The other half received a completion bonus that was computed in the same way, but for which no details were presented. Analyses were conducted to examine the effects of providing explicitly defined incentives on overall, primary task, and secondary task performance. Results for total performance are shown in Figure 8 and Table 10.

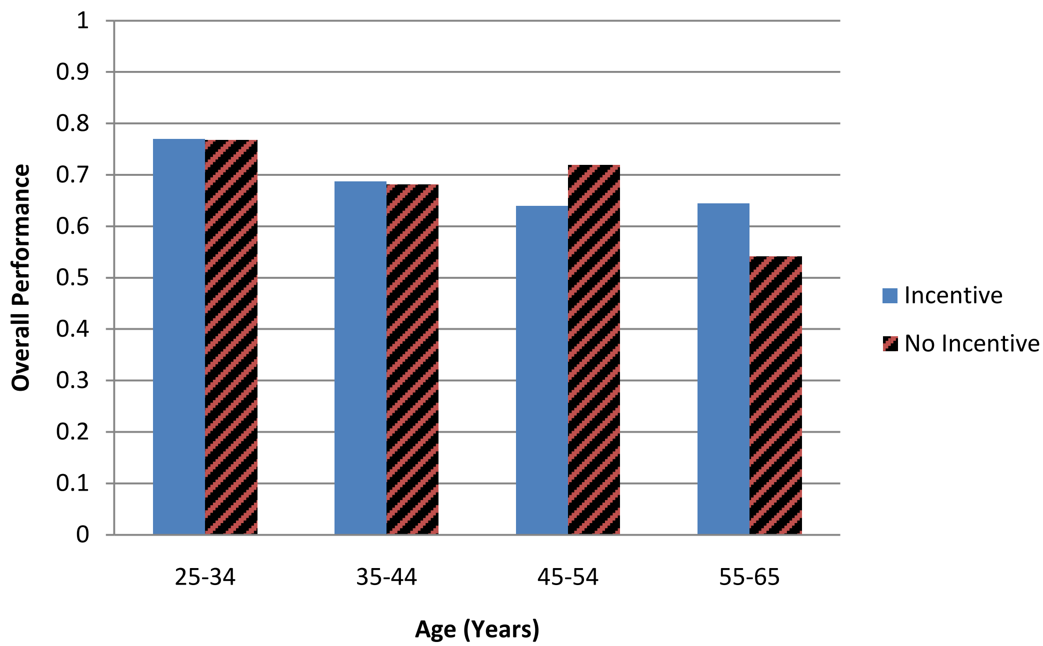


Figure 8. Effects of Performance Incentives on Overall Performance

Table 10. Statistical Test Results: Incentive Effects on Overall Performance

Age	F Value	Pr > F
25-34	0.04	0.8512
35-44	0.28	0.5954
45-54	8.77	0.0032*
55-64	10.95	0.001*

* Statistically significant difference ($p < .05$)
+ Marginally significant ($.05 < p < .10$)

Results of statistical tests reveal that the differences between incentive conditions were statistically significant for the two older age categories, albeit in different directions.

Analysis results for incentive effects on primary task performance are shown in Figure 9 and Table 11.

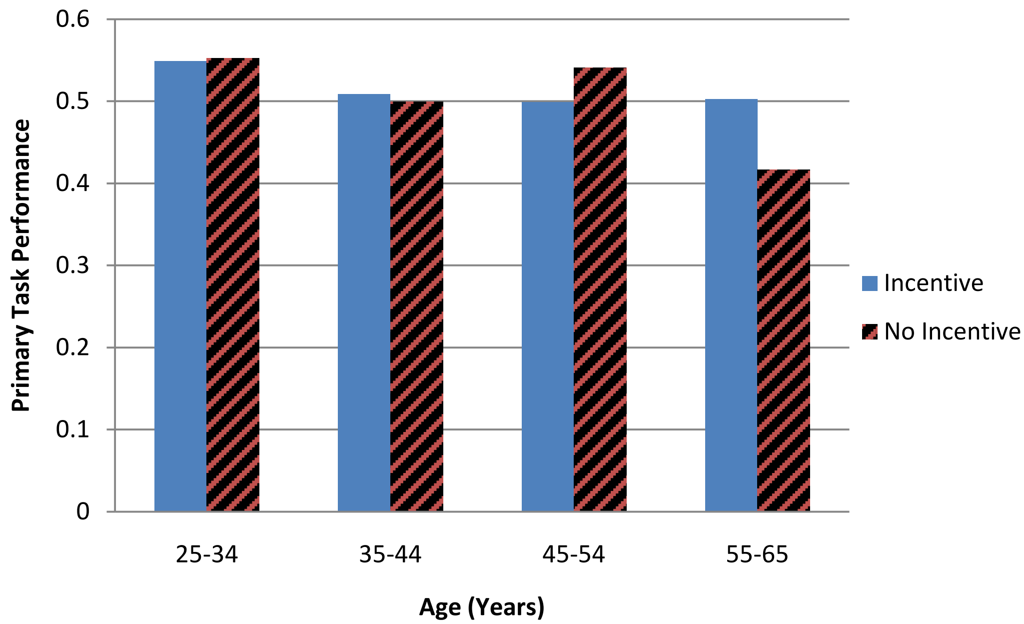


Figure 9. Effects of Performance Incentives on Primary Task Performance

Table 11. Statistical Test Results: Incentive Effects on Primary Performance

Age	F Value	Pr > F
25-34	0.06	0.8115
35-44	1.02	0.3128
45-54	4.31	0.0385*
55-64	14.48	0.0002*

* Statistically significant difference (p < .05)
+ Marginally significant (.05 < p < .10)

Incentive effects on primary task performance were essentially identical to those for overall task performance. Differences between conditions were statistically significant for the two older age groups; however, the directions of the differences were not consistent.

Analysis results for incentive effects on secondary task performance are shown in Figure 10 and Table 12.

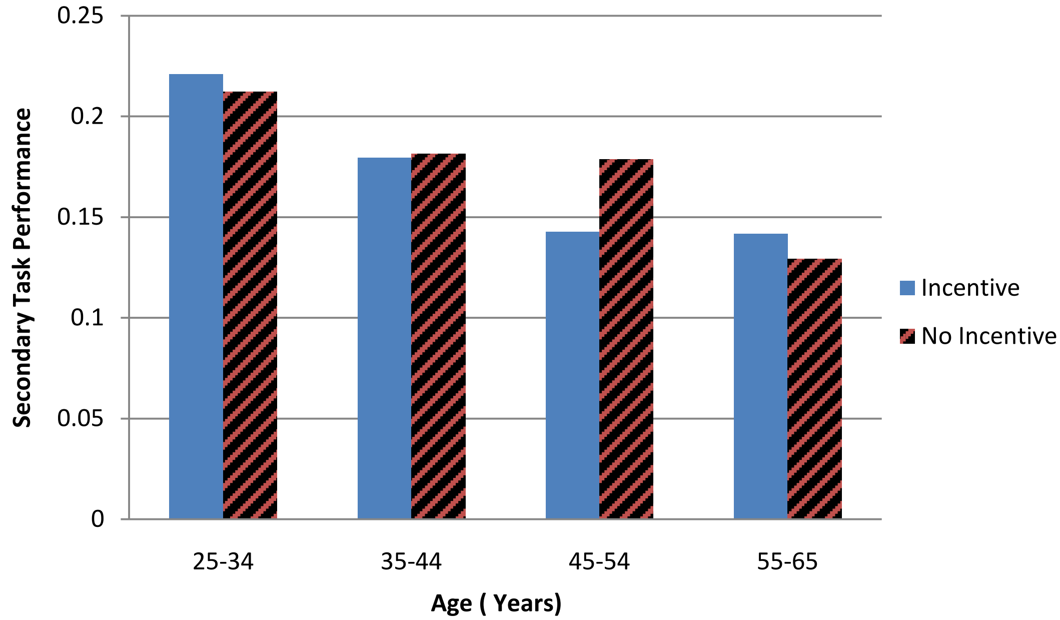


Figure 10.Effects of Performance Incentives on Secondary Task Performance

Table 12. Statistical Test Results: Incentive Effects on Secondary Performance

Age	F Value	Pr > F
25-34	0.8	0.3725
35-44	0.07	0.7978
45-54	5.32	0.0215*
55-64	0.48	0.4866

* Statistically significant difference (p < .05)
+ Marginally significant (.05 < p < .10)

Differences between incentive conditions on secondary task performance were only statistically significant for the 45 – 54 year age group.

To assess the effects of incentives on the relative emphasis given by drivers to primary versus secondary task performance, primary task emphasis was defined as the primary task performance divided by total task performance. Incentive and age effects on this measure are presented in Figure 11 and Table 13.

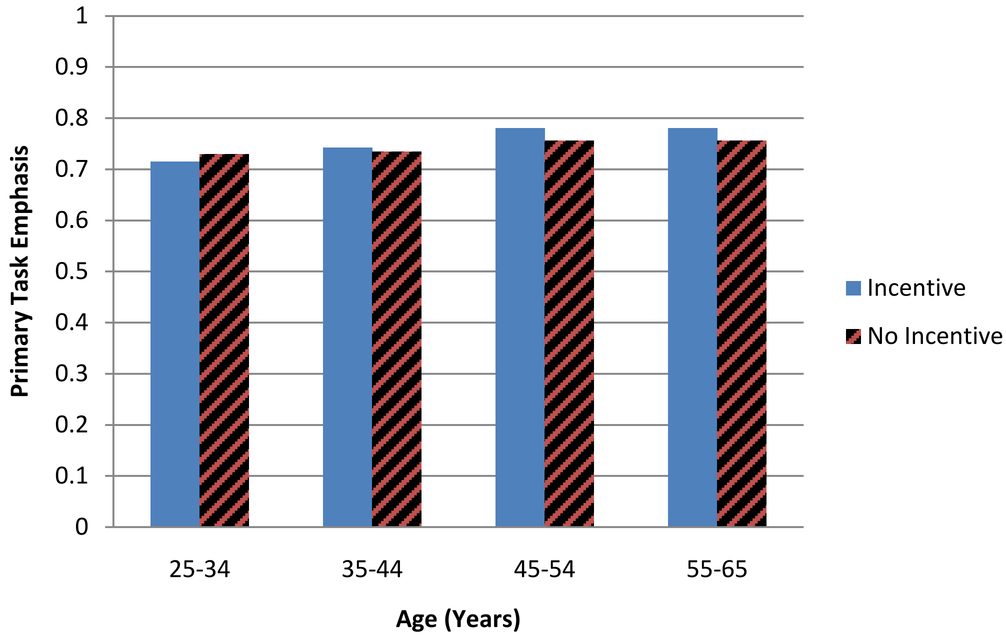


Figure 11.Primary Task Emphasis by Incentive and Age Group

Table 13. Statistical Test Results: Incentive Effects on Primary Emphasis

Age	F Value	Pr > F
25-34	1.57	0.2105
35-44	0.91	0.3412
45-54	1.75	0.1861
55-64	1.33	0.2503

* Statistically significant difference (p < .05)
+ Marginally significant (.05 < p < .10)

None of the differences related to primary task emphasis was statistically significant.

3.2.2 Effects of Participant Age on Test Performance

Age effects on primary and secondary task performance are presented in Figure 12.

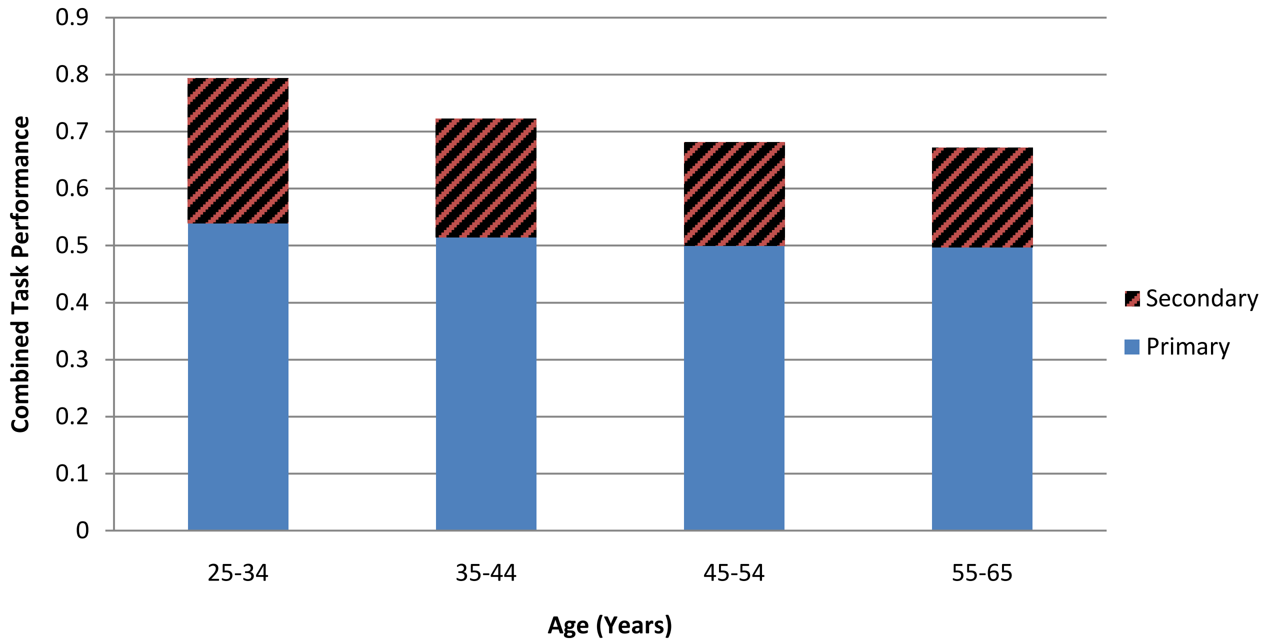


Figure 12.Effects of Participant Age on Primary and Secondary Task Performance

Both the primary and secondary task performance decreased with increasing age. The secondary task performance declined more than the primary task performance.

3.3 Effects of Phone Type: Touch Screen vs. Hard Button

Comparisons between phones reflected performance differences between the touch screen interface (iPhone) and the Blackberry (hard button).

Figure 13 shows means (and standard errors) for detection task response times for the three phone tasks by phone type during the 2.5-minute drive. The observed differences between phones were very small; none of the differences was statistically significant.

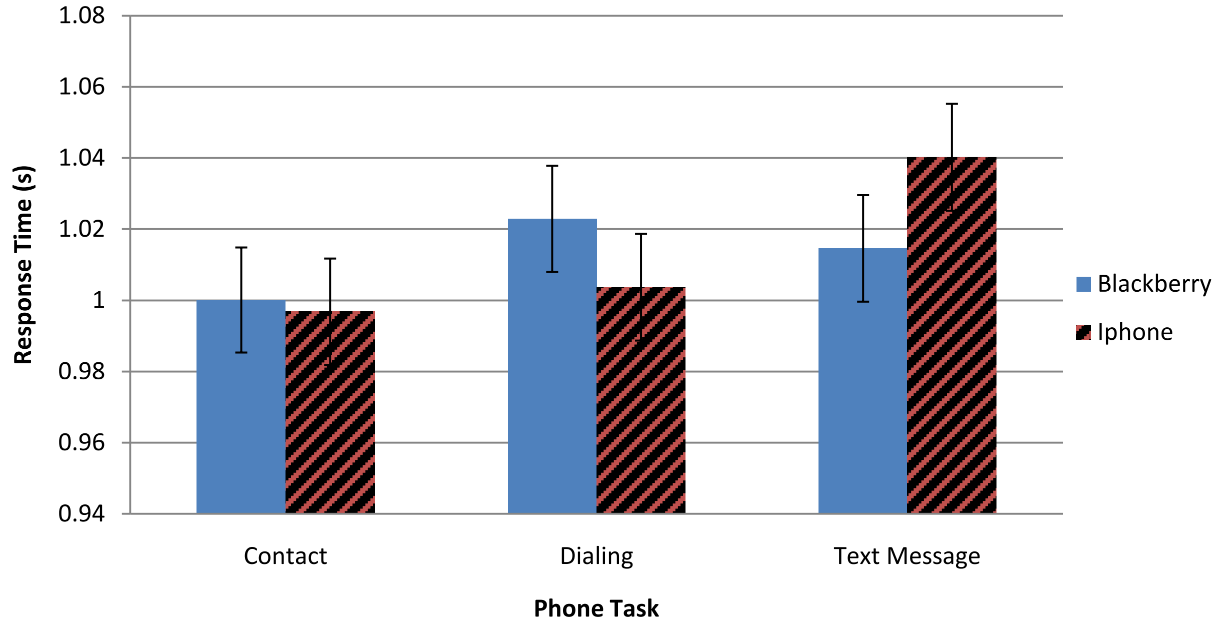


Figure 13.Effects of Phone Interface Type on Mean Detection Task Response Time (± Standard Error)

Figure 14 presents the same comparison for mean detection task proportion correct during the 2.5-minute drive.

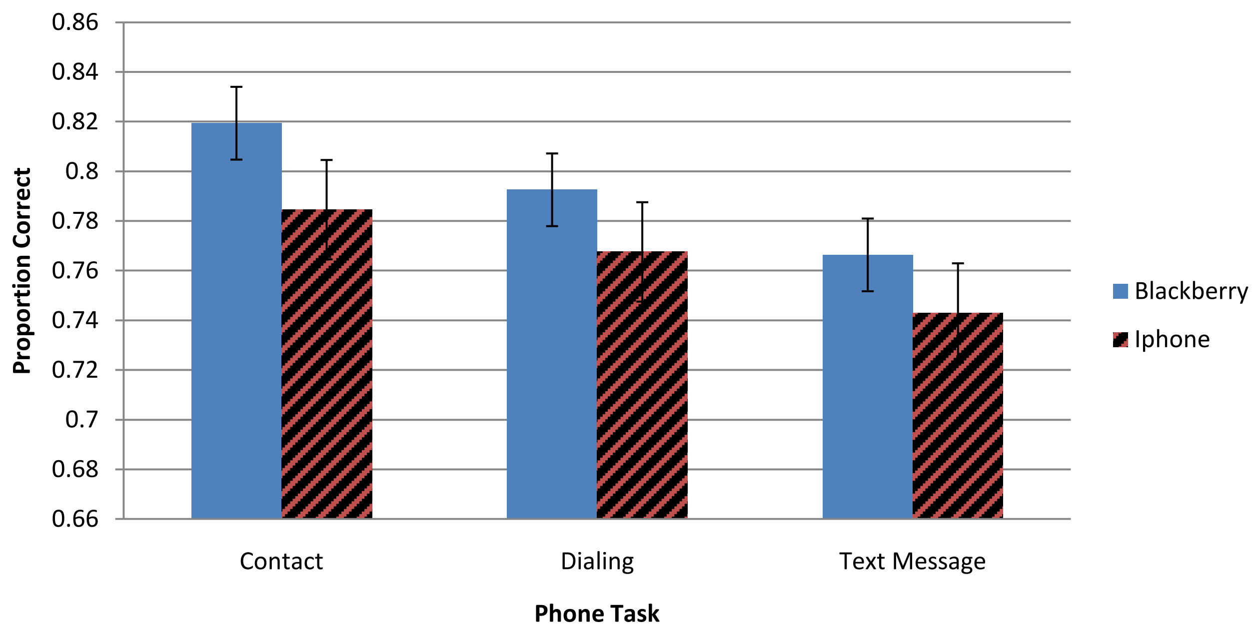


Figure 14.Effects of Phone Interface Type on Mean Detection Task Proportion Correct (± Standard Error)

The difference between phone types was statistically significant for the contact calling task, F(1,477) = 5.13, p = .024. The iPhone contact calling task was associated with a significantly lower proportion of targets detected than the Blackberry contact calling task.

Figure 15 presents means (and standard errors) of car-following delay by phone and phone task.

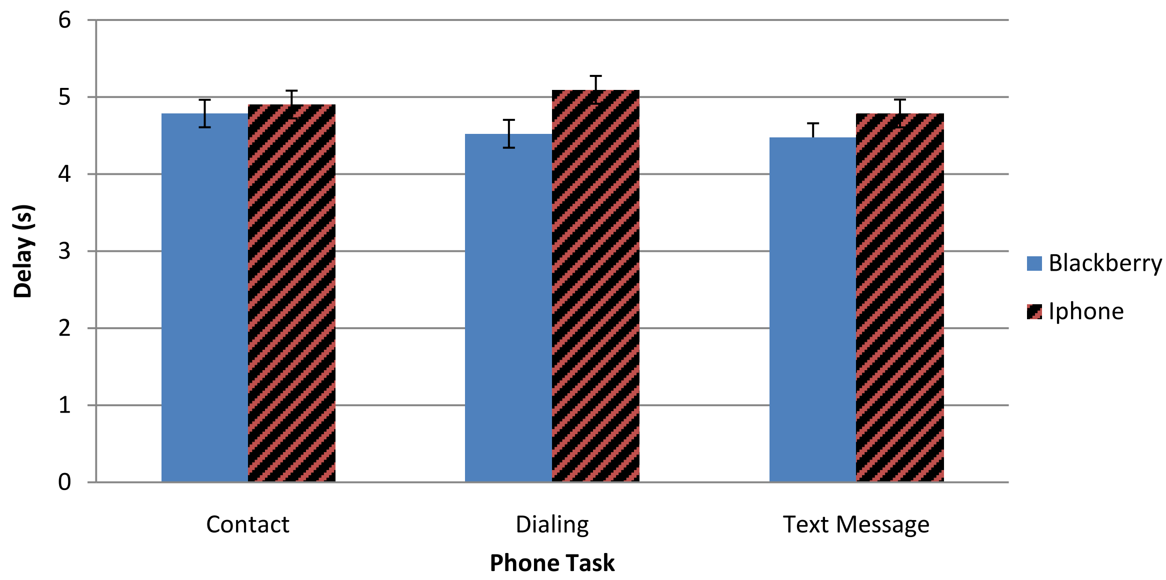


Figure 15.Effects of Phone Interface Type on Mean Car-Following Delay (± Standard Error)

The 10-digit dialing task performed using the iPhone was associated with significantly greater car-following delay than dialing with the Blackberry, F(1,455) = 7.93, p = .005. The other differences were not statistically significant for this measure.

Figure 16 presents means (and standard errors) of SD lane position by phone and phone task.

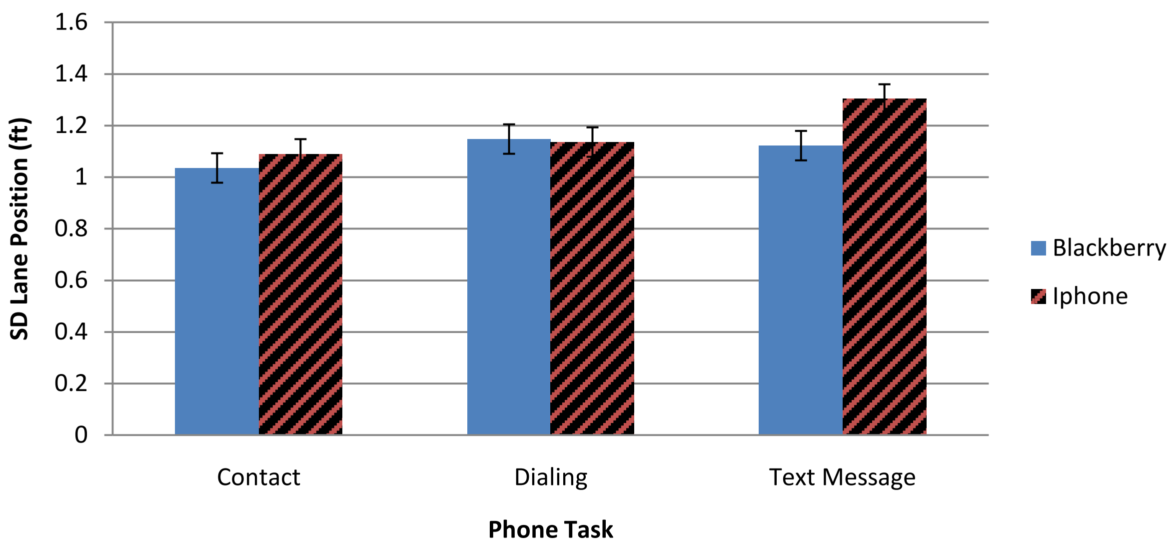


Figure 16.Effects of Phone Interface Type on Mean SD Lane Position (± Standard Error)

Text messaging with the iPhone was associated with significantly greater lane position variability than with the Blackberry, $F(1,478) = 10.03$, $p = .0016$. Among the other tasks, there were no significant differences between the phones for this measure.

3.4 Effects of Number/Text Entry Tasks on Distraction Potential

The DFD metrics summarize performance over the entire 2.5-minute car-following interval, while the Alliance 2.1 metrics are based on the duration of single trials of each secondary task. The secondary task conditions included the following:

1. Baseline – No secondary task
2. Alliance benchmark – Radio tuning
3. DFD protocol benchmark – Destination entry by address
4. Hard button phone – 10-digit dialing
5. Hard button phone – Contact dialing
6. Hard button phone – Text messaging
7. Touch screen phone – 10-digit dialing
8. Touch screen phone – Contact dialing
9. Touch screen phone – Text messaging

Because the observed differences between phones were relatively small in magnitude and not consistent across metrics and tasks, and because the intent of the analysis was to look at the effects of phone tasks more generally, the data from the two phones were combined for the analyses. We therefore identified the following planned comparisons:

1. Contact dialing vs. Destination entry
2. Contact dialing vs. 10-digit dialing
3. Contact dialing vs. Radio tuning
4. Contact dialing vs. Text messaging
5. Destination entry vs. 10-digit dialing
6. Destination entry vs. Radio tuning
7. Destination entry vs. Text messaging
8. 10-digit dialing vs. Radio tuning
9. 10-digit dialing vs. Text messaging
10. Radio tuning vs. Text messaging

Separate F tests were computed for each planned comparison for each performance measure. Probability values were adjusted for family-wise error by using Hochberg's step-up method (Westfall, Tobias, Rom, Wolfinger, and Hochberg, 2003). Adjusted p values of less than .05 were considered to be statistically significant. Adjusted p values between .05 and .10 were considered marginal and discussed where applicable. Results are presented in the following figures (Figure 17 through Figure 20) and tables (Table 14 through Table 17) for the four primary DFD protocol metrics, analyzed using data from all 100 participants (ages 25-64). These metrics summarize performance over the entire 2.5-minute drive.

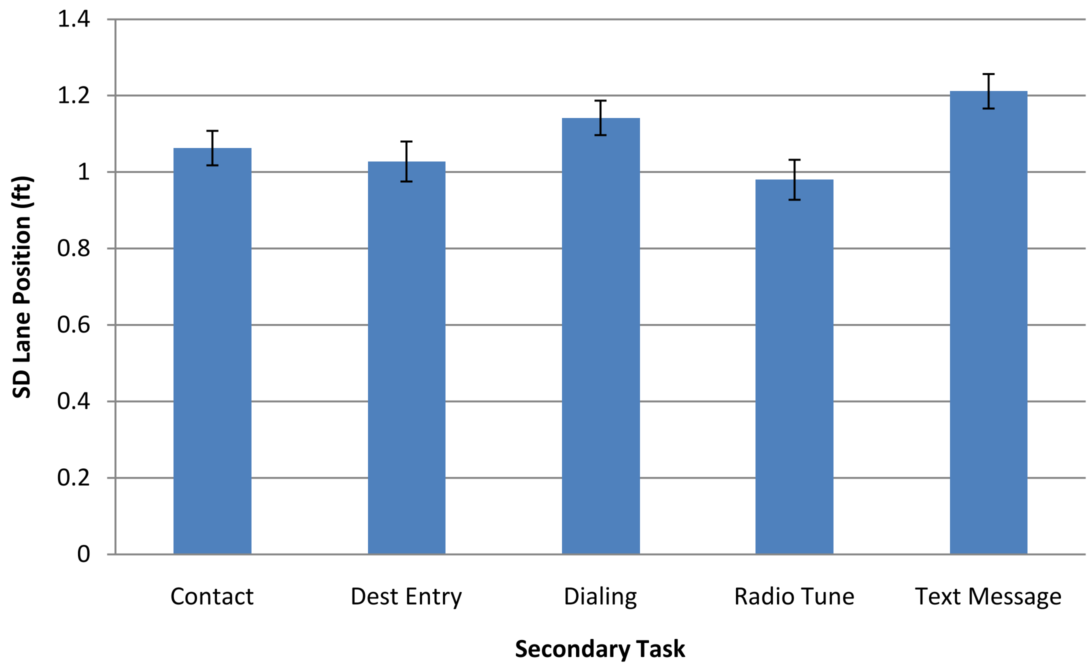


Figure 17.Mean (± Standard Error) SD Lane Position by Secondary Task (2.5-minute drive)

Table 14. Results of Planned Pairwise Comparisons: SD Lane Position (N = 100, 2.5-minute drive)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.44	.18	.21	.0007*
Destination Entry		.08+	.44	.0006*
Dialing			.0032*	.21
Radio Tuning				<.0001*

* Statistically significant difference (p < .05)
\+ Marginally significant (.05 < p < .10)

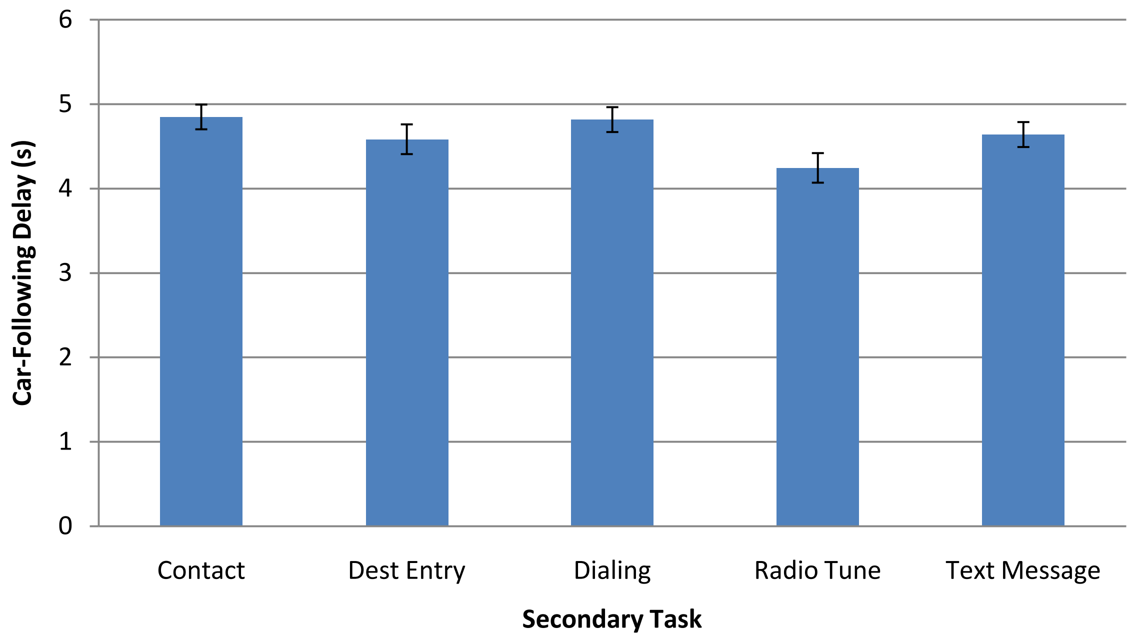


Figure 18.Mean (± Standard Error) Car-Following Delay by Secondary Task (2.5-minute drive)

Table 15. Results of Planned Pairwise Comparisons: Car-Following Delay (N = 100, 2.5-minute drive)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.64	.82	.004*	.64
Destination Entry		.64	.58	.82
Dialing			.007*	.64
Radio Tuning				.17

* Statistically significant difference (p < .05)
\+ Marginally significant (.05 < p < .10)

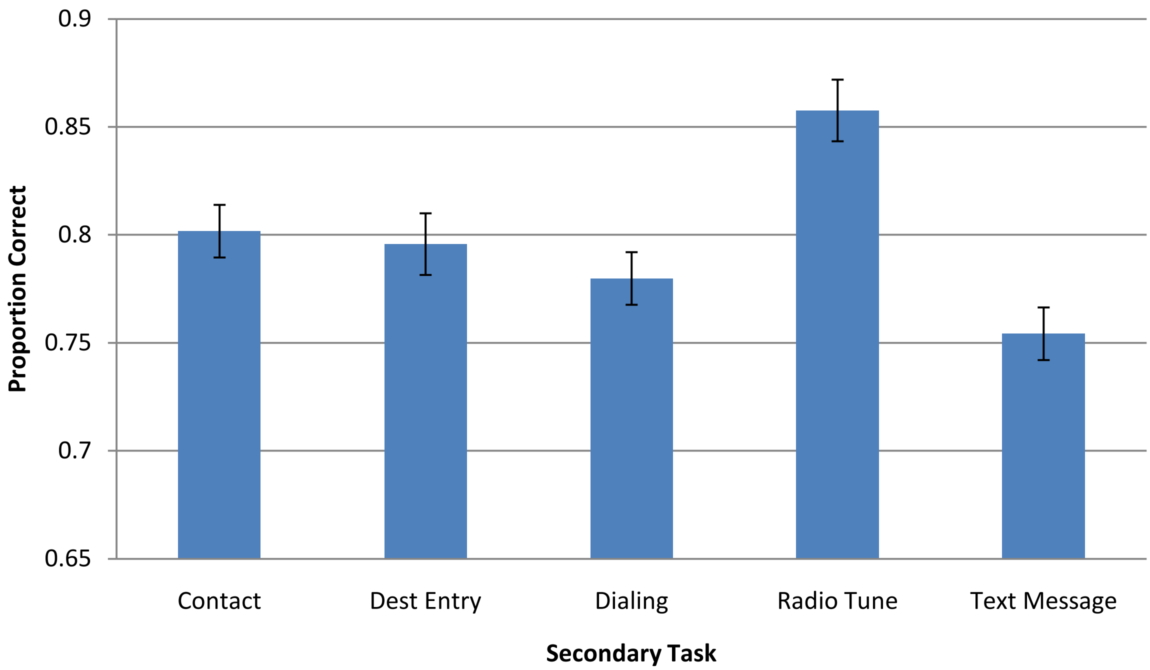


Figure 19.Mean (± Standard Error) Detection Task Proportion Correct by Secondary Task (2.5-minute drive)

Table 16. Results of Planned Pairwise Comparisons: Detection Task Proportion Correct (N = 100, 2.5-minute drive)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.65	.11	.0001*	< .0001*
Destination Entry		.43	.0002*	.007*
Dialing			< .0001*	.06+
Radio Tuning				< .0001*

* Statistically significant difference ($p < .05$)
+ Marginally significant ($.05 < p < .10$)

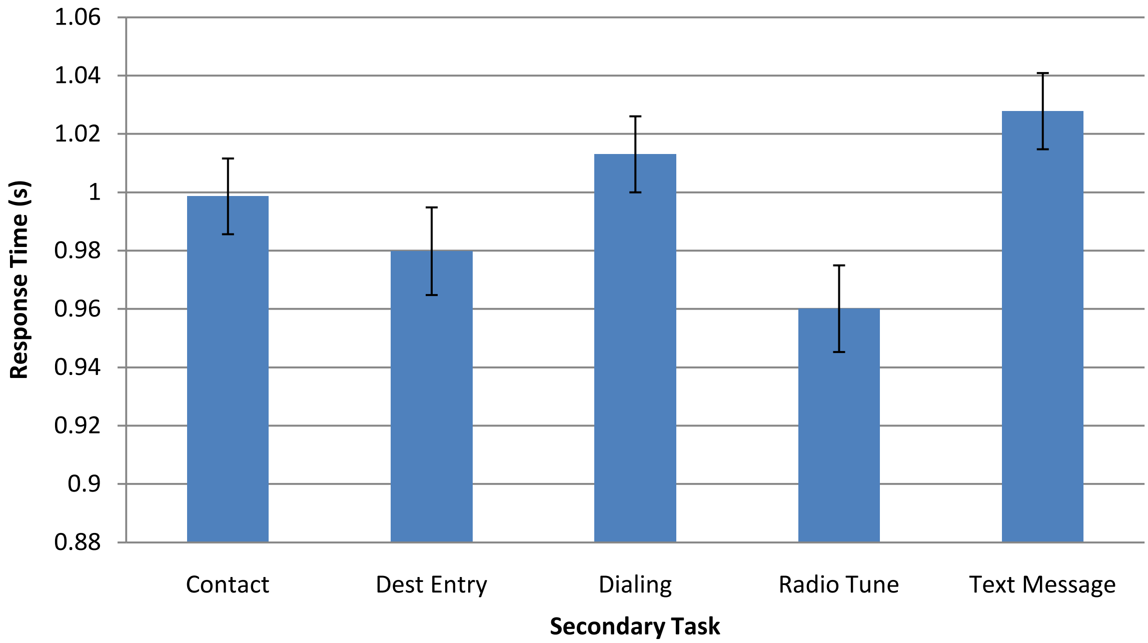


Figure 20.Mean (± Standard Error) Detection Task Response Time by Secondary Task (2.5-minute drive)

Table 17. Results of Planned Pairwise Comparisons: Detection Task Response Time (N = 100, 2.5-minute drive)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.19	.19	.02*	.04*
Destination Entry		.05*	.18	.002*
Dialing			.0004*	.19
Radio Tuning				< .0001*

* Statistically significant difference (p < .05)
+ Marginally significant (.05 < p < .10)

3.5 Comparison of DFD and Alliance Principle 2.1 Analysis Protocols

Analyses were conducted to assess the Alliance 2.1B driving performance metrics computed according to both the Alliance analysis protocol and the DFD analysis protocol. Specifically, Alliance metrics were computed using data from individual trials of each task type, while the DFD protocol computation used the entire car-following segment of each respective drive. The data available from this experiment were not fully consistent with the Alliance Guidelines, which specify that participants should be tested multiple times on each task. (Personal communication with one manufacturer that uses the 2.1B protocol subsequently revealed that multiple typically implies three replications of each task.) The 2.5-minute drive used in the present experiment afforded sufficient time for drivers to perform three replications of the shorter duration tasks (e.g., radio tuning and dialing via contact), but not consistently for the longer-duration tasks (e.g., destination entry and text messaging). Because using data from the subset of participants who completed three replications of each task could bias the data by systematically excluding the slower performers, the primary analyses were conducted using data from the first replication of each task only. As background, Figure 21 presents the average durations for the various secondary task types by driver age group.

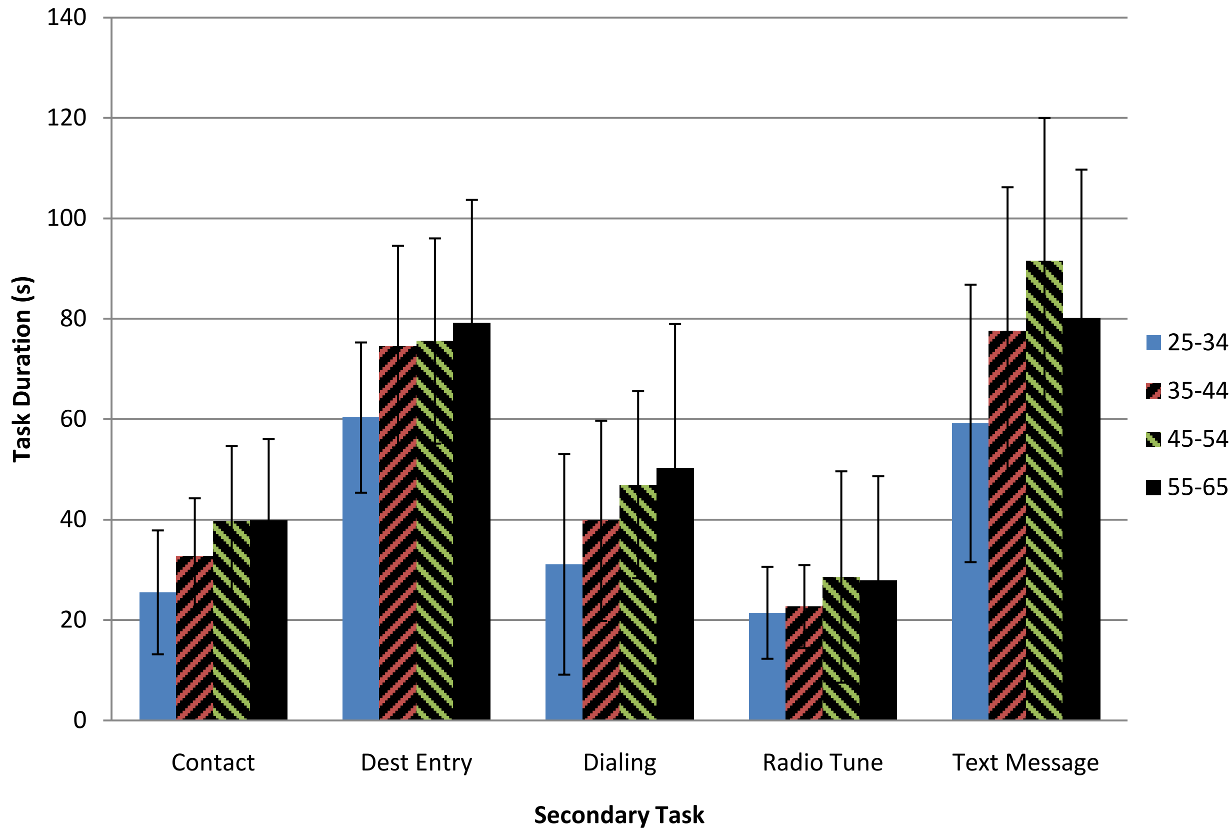


Figure 21.Mean (± Standard Error) Task Duration of First Trial by Task and Age Group

Generally, the text message task had the longest durations, followed closely by destination entry. Radio tuning had the shortest durations. Task durations had relatively large variability, both within and between age groups. Effects of driver age are most evident for text messaging.

Lane exceedance frequency was zero for 75 percent of the total number of trials. Means for lane exceedance frequency by secondary task condition are presented in Figure 22. Results of statistical tests are presented in Table 18. These tests used the Alliance approach of taking data from a single trial, independent of task duration. The results presented in Figure 23 and Table 19 are based on the analysis of data taken from the entire 2.5-minute car-following interval during the respective drives.

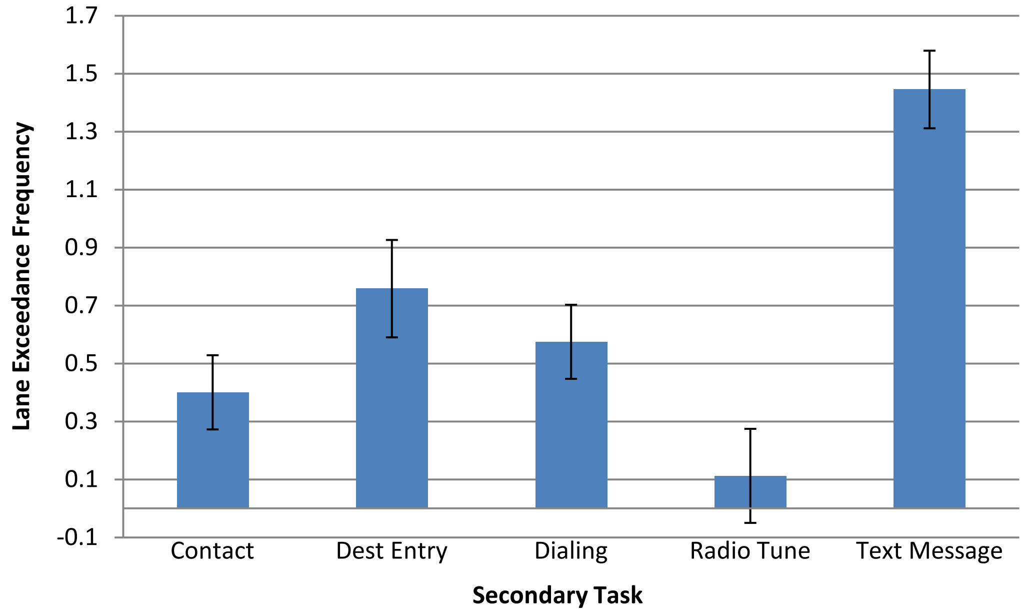


Figure 22.Mean (± Standard Error) Lane Exceedance Frequency by Secondary Task (N =100, Single trial)

Table 18. Results of Planned Pairwise Comparisons: Lane Exceedance Frequency Secondary Task (N = 100, Single trial)

	Destination Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.19	.31	.31	< .0001*
Destination Entry		.31	.01*	.001*
Dialing			.04*	< .0001*
Radio Tuning				< .0001*

* Statistically significant difference (p < .05)
+ Marginally significant (.05 < p < .10)

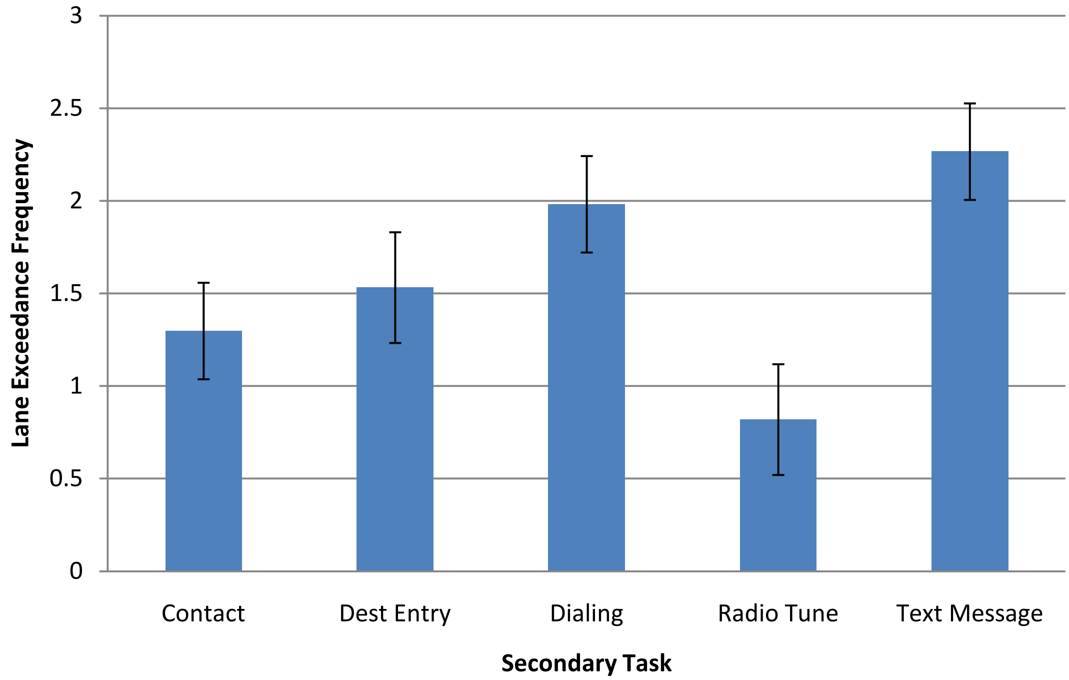


Figure 23.Mean (± Standard Error) Lane Exceedance Frequency by Secondary Task (N = 100, 2.5-minute drive)

Table 19. Results of Planned Pairwise Comparisons: Lane Exceedance Frequency by Secondary Task (N = 100, 2.5-minute drive)

	Destination Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.36	.007*	.23	< .0001*
Destination Entry		.23	.07+	.02*
Dialing			.0001*	.34
Radio Tuning				< .0001*

* Statistically significant difference ($p < .05$)
\+ Marginally significant ($.05 < p < .10$)

The Alliance approach resulted in more differences being statistically significant. This was due primarily to the differences between the computation approaches; Alliance computation procedure was based on trials with considerably different durations. Lane exceedance count is significantly correlated with task duration because longer-duration tasks provide more opportunity for lane departure events than do shorter-duration tasks.

A similar comparison was made for the second Alliance 2.1B metric, standard deviation of headway, as shown in Figure 24, Table 20, Figure 25, and Table 21.

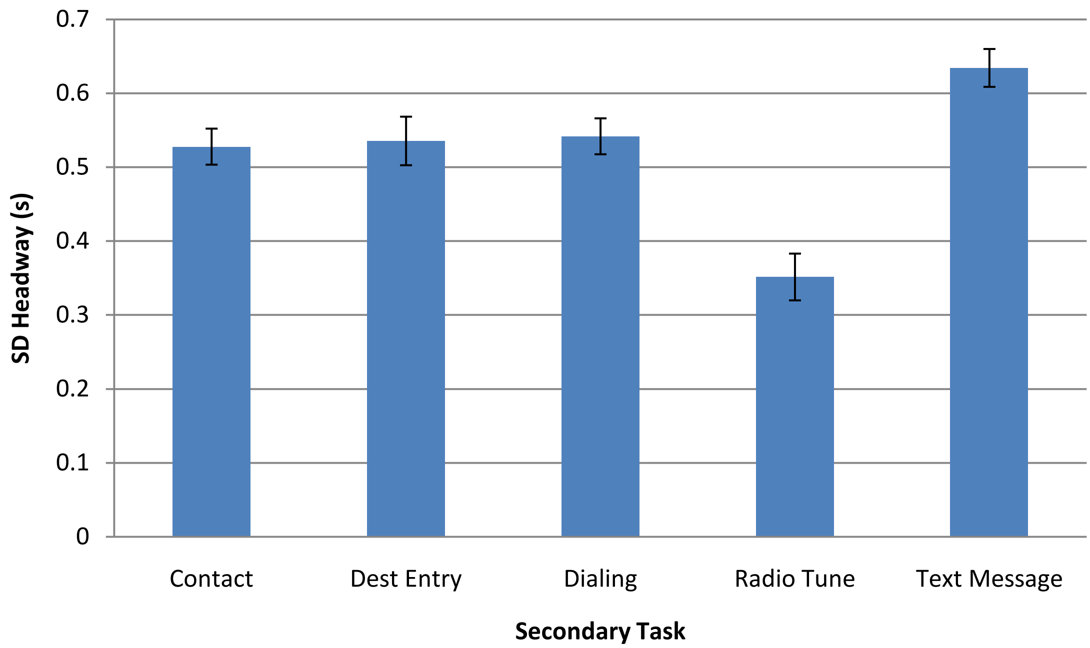


Figure 24.Mean (± Standard Error) Standard Deviation of Headway by Secondary Task: (N = 100, Single trial)

Table 20. Results of Planned Pairwise Comparisons: Standard Deviation of Headway by Secondary Task (N = 100, Single trial)

	Destination Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.86	.86	< .0001 *	.002*
Destination Entry		.54	< .0001 *	.03*
Dialing			< .0001 *	.01*
Radio Tuning				< .0001*

* Statistically significant difference ($p < .05$)
+ Marginally significant ($.05 < p < .10$)

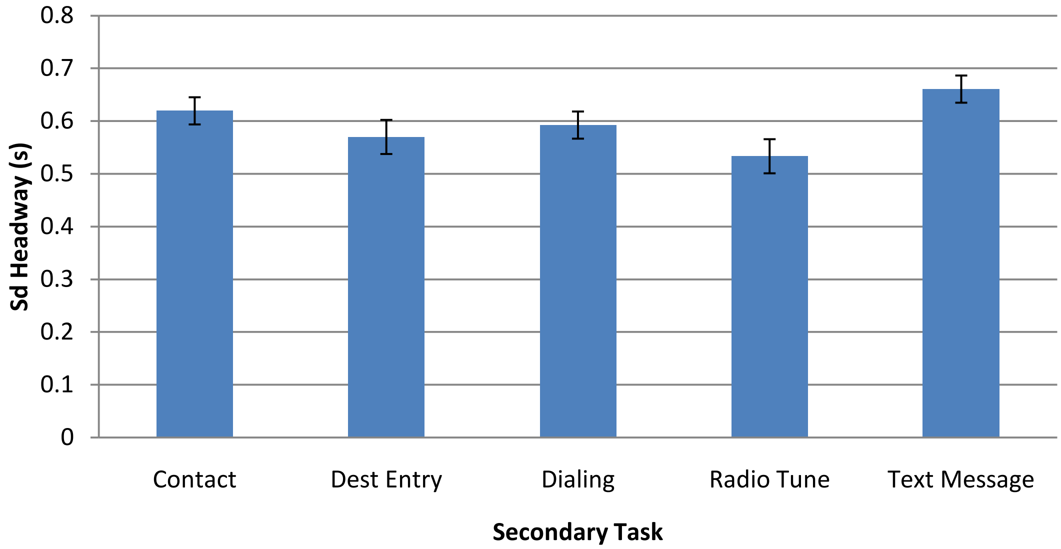


Figure 25.Mean (± Standard Error) Standard Deviation of Headway by Secondary Task (N=100, 2.5-minute drive)

Table 21. Results of Planned Pairwise Comparisons: Standard Deviation of Headway (N = 100, 2.5-minute drive)

	Destination Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.51	.51	.09+	.51
Destination Entry		.51	.51	.07+
Dialing			.49	.098+
Radio Tuning				.002*

* Statistically significant difference (p < .05)
\+ Marginally significant (.05 < p < .10)

When computed using data from the entire drive, only one pairwise comparison revealed statistical significance for this metric.

When task duration is included in the computation, radio tuning had consistently smaller headway variance than did all of the other secondary tasks. Again, this reflects the relatively short durations associated with radio tuning relative to the other secondary tasks.

3.6 Effects of Participant Selection Model and Sample Size

Specifications for the construction of five participant selection criteria models were presented in Table 4. Analyses were conducted to compare the outcomes of tests performed using different number of participants and samples with different mixes of participant ages. Results of these analyses are presented in Table 22. Numbers in parentheses following subtitles indicate the number of comparisons determined to be statistically significant for each sample. This comparison involved a single metric, detection task response time. The analysis followed the DFD protocol; data from the entire 2.5-minute drive were included.

Table 22. Detection Task Response Time: Effect of Different Sampling Models and Sample Sizes (2.5-minute drive)

(a) Representative Model: Ages 25-64 N = 40 (2)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.77	.28	.28	.28
Destination Entry		.13	.77	.11
Dialing			.007*	.88
Radio Tuning				.005*

(b) Alliance Model: Ages 45-64 N = 40 (4)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.89	.10	.89	.09+
Destination Entry		.04*	.89	.03*
Dialing			.02*	.89
Radio Tuning				.01*

(c) Alliance Small Sample Model: Ages 45-64 N = 20 (2)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.76	.36	.76	.05*
Destination Entry		.36	.76	.07+
Dialing			.10	.76
Radio Tuning				.01*

(d) All Participants: Ages 25-64 N = 100 (6)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.19	.19	.02*	.04*
Destination Entry		.05*	.18	.002*
Dialing			.0004*	.19
Radio Tuning				< .0001*

(e) Narrow Age Range: 35-44 N = 40 (0)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.28	.76	.72	.76
Destination Entry		.41	.76	.07+
Dialing			.76	.76
Radio Tuning				.28

(f) Medium Age Range: 35-54 N = 40 (3)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.11	.54	.54	.54
Destination Entry		.03*	.54	.003*
Dialing			.24	.54
Radio Tuning				.05*

* Statistically significant difference ($p < .05$)
+ Marginally significant ($.05 < p < .10$)

Three representative samples (ages 25-64) were constructed to compare the effects of individual differences on test outcome. Each sample had 40 participants. Two of the samples were independent, while the third was partially overlapping. Target detection response time was the metric. A summary of the differences is presented in Table 23.

Table 23. Detection Task Response Time: Effect of Different Samples (Ages 25-64, N = 40)

Sample (N = 40)	**Statistically Significant Differences**
1	Texting > Radio tune
2	None
3	Texting > Radio tune Dialing > Radio tune

Four smaller independent representative samples (ages 25-64) were also constructed. Each sample had 20 participants. The results of statistical tests showed that none of the comparisons was statistically significant for any of the four sets of analyses.

The following analyses examine the combined effects of reducing the sample size from 100 to 40 participants and narrowing the age range from 25-64 to 35-54. The comparisons were performed for each of the four primary DFD protocol metrics. The results are presented in Table 24.

Table 24. Effects of Sample Size and Sample Construction on Test Outcome: DFD Protocol Metrics: N = 40, Medium Age (35-54) vs. N = 100 (25-64)

(a) Detection Task Response Time, N = 40 (3)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.10	.53	.51	.51
Destination Entry		.03*	.53	.003*
Dialing			.25	.53
Radio Tuning				< .05*

(b) Detection Task Response Time, N = 100 (6)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.19	.19	.02*	.04*
Destination Entry		.05*	.18	.002*
Dialing			.0004*	.19
Radio Tuning				< .0001*

(c) Detection Task Proportion Correct, N = 40 (5)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.70	.35	.0008*	.003*
Destination Entry		.73	.0003*	.22
Dialing			< .0001*	.22
Radio Tuning				< .0001*

(d) Detection Task Proportion Correct, N = 100 (6)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.65	.11	.0001*	< .0001*
Destination Entry		.43	.0002*	.007*
Dialing			< .0001*	.06+
Radio Tuning				< .0001*

(e) Lane Position Variability, N = 40 (2)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.61	.55	.61	.006*
Destination Entry		.61	.55	.16
Dialing			.11	.37
Radio Tuning				.0008*

(f) Lane Position Variability, N = 100 (4)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.44	.18	.21	.0007*
Destination Entry		.08+	.44	.0006*
Dialing			.0032*	.21
Radio Tuning				<.0001*

(g) Car Following Delay, N = 40 (1)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.60	.60	.16	.60
Destination Entry		.52	.60	.60
Dialing			.02*	.60
Radio Tuning				.60

(h) Car Following Delay, N = 100 (2)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.64	.82	.004*	.64
Destination Entry		.64	.58	.82
Dialing			.007*	.64
Radio Tuning				.17

* Statistically significant difference ($p < .05$)
\+ Marginally significant ($.05 < p < .10$)

For all of the metrics, the number of differences determined to be statistically significant decreased with the smaller sample, relative to the full sample.

The following analysis compared the differences of test outcome using the Alliance sample construction (ages 45-64) with reduced sample size (N = 40) versus the entire sample. The two Alliance vehicle performance metrics (not the Alliance eye glance metrics) are used for this comparison. Results of this comparison are presented in Table 25.

Table 25. Alliance Metrics: N = 40, (45-64) vs. N = 100 (25-64)

(a) Lane Exceedance Count, N = 40 (3)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.44	.44	.44	< .0001*
Destination Entry		.44	.10	.06+
Dialing			.21	.0002*
Radio Tuning				< .0001*

(b) Lane Exceedance Count, N = 100 (6)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.07+	.25	.25	< .0001*
Destination Entry		.25	.005*	.003*
Dialing			.03*	< .0001*
Radio Tuning				< .0001*

(c) SD Headway, N = 40 (4)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.70	.70	< .0001 *	.70
Destination Entry		.70	.008 *	.70
Dialing			< .0001*	.70
Radio Tuning				< .0001 *

(d) SD Headway, N = 100 (4)

	Dest Entry	Dialing	Radio Tuning	Text Message
Contact	.64	.54	< .0001*	.12
Destination Entry		.54	< .0001*	.12
Dialing			< .0001*	.54
Radio Tuning				< .0001*

* Statistically significant difference ($p < .05$)
+ Marginally significant ($.05 < p < .10$)

3.7 Visual Performance Metrics

The percentage of time looking at the forward roadway was computed for each trial using data from the entire 2.5-minute car-following interval. Means are presented in Figure 26 by secondary task. Statistical test results are presented in Table 26.

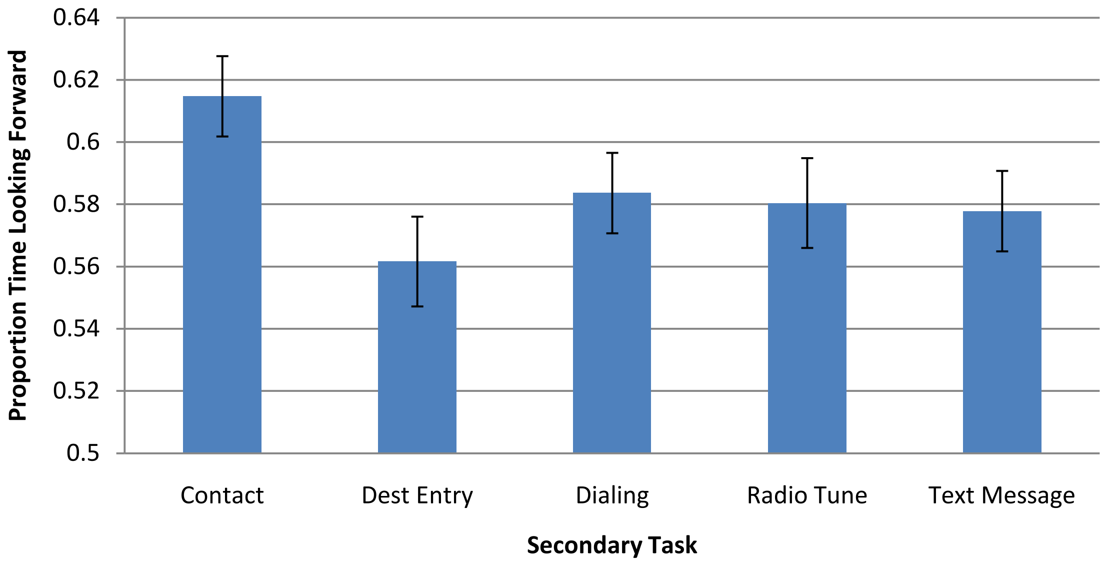


Figure 26. Visual Performance: Mean (± Standard Error) Percent Time Looking Forward by Secondary Task (N=100, 2.5-minute drive)

Table 26. Results of Planned Pairwise Comparisons: Percent Time Looking Forward (N = 100, 2.5-minute drive)

	Destination Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	< .0001*	.006*	.02*	.0007*
Destination Entry		.30	.60	.60
Dialing			.81	.81
Radio Tuning				.81

* Statistically significant difference (p < .05)
+ Marginally significant (.05 < p < .10)

It is of interest to determine the number of long glances required to perform each secondary task. Data from the first trial of each secondary task were analyzed for this purpose. The results are presented in Figure 27.

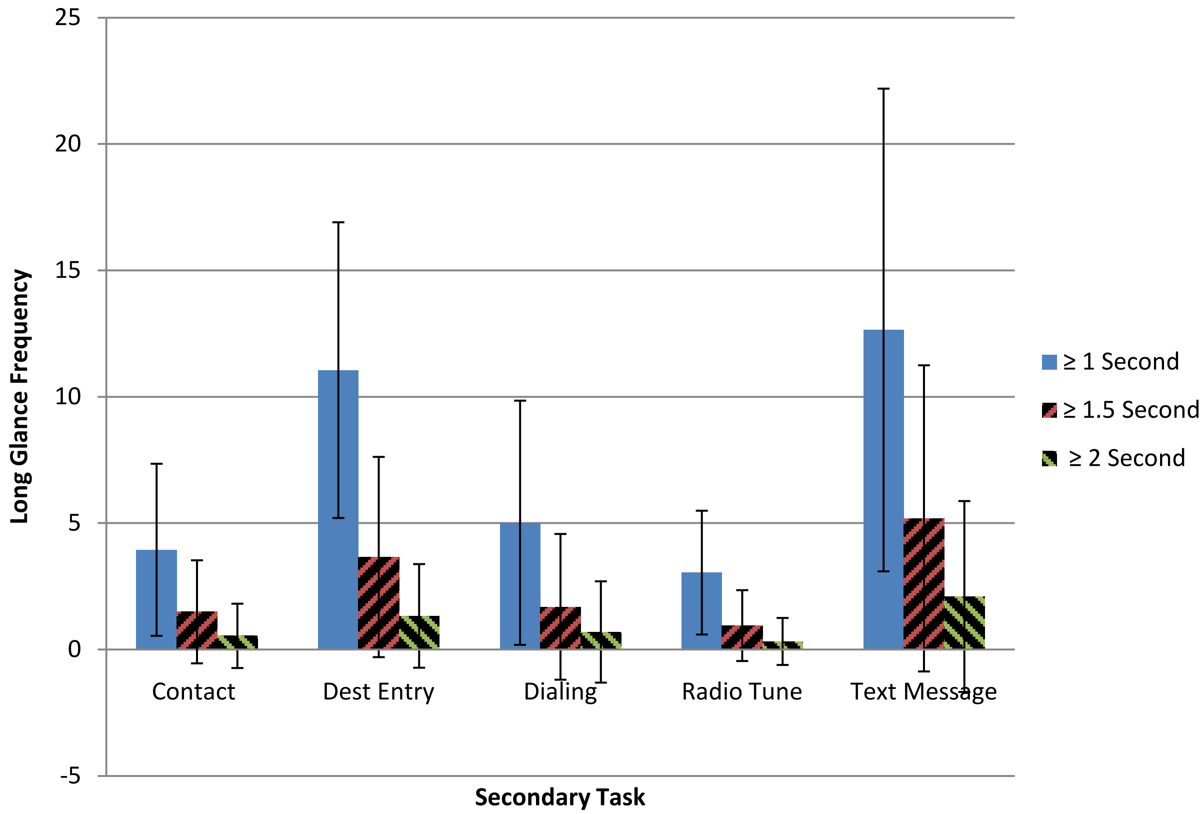


Figure 27.Mean (± Standard Error) Long Glance Frequencies by Secondary Task and Duration (N = 100, Single trial)

The frequencies of 1-second glances include all 1.5 and 2.0 second glances; similarly the frequencies of 1.5 second glances include all 2 second glances. On average, all tasks involve at least one glance away from the roadway with duration greater than 2 seconds.

Figure 28 presents the mean number of glances, of any duration, away from the forward view during one trial of each respective secondary task, as well as the mean number of glances directed toward the secondary region. Recall that both the primary and secondary regions were identified empirically using an exhaustive search algorithm.

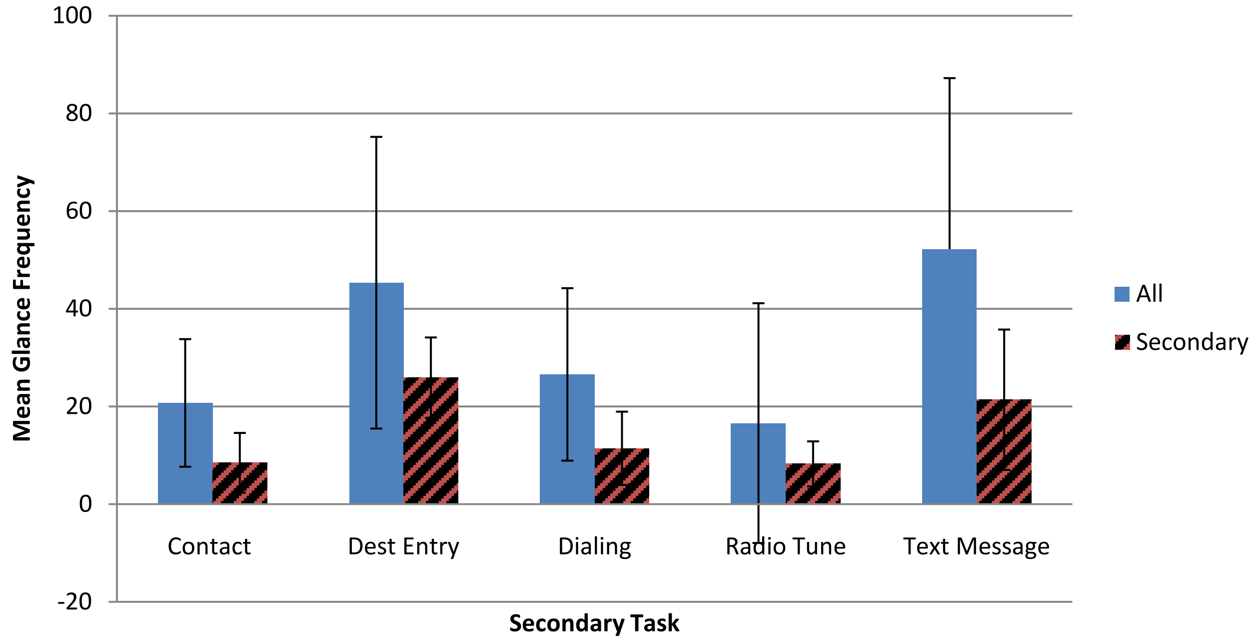


Figure 28.Mean (± Standard Error) Number of Glances Away from Roadway View and Portion Directed at Secondary Location (N = 100, Single trial)

The finding that less than 50 percent of the glances away were directed to the secondary location raises some concern about whether the secondary region actually represents the secondary task. This issue is discussed in greater detail in Section 4.4.6

The following figures (Figure 29 and Figure 30) present long glance frequencies for different age groups, focusing on the two long duration secondary tasks, destination entry and text messaging.

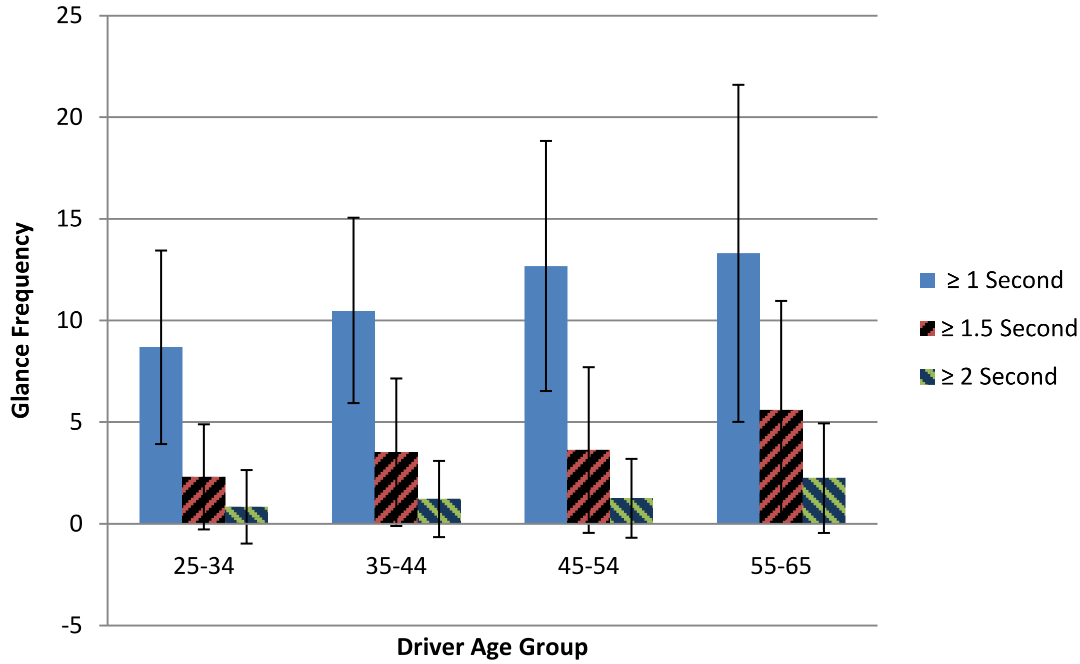


Figure 29.Mean (± Standard Error) Long Glance Frequency by Age Group: Destination Entry Task (N=100, Single trial)

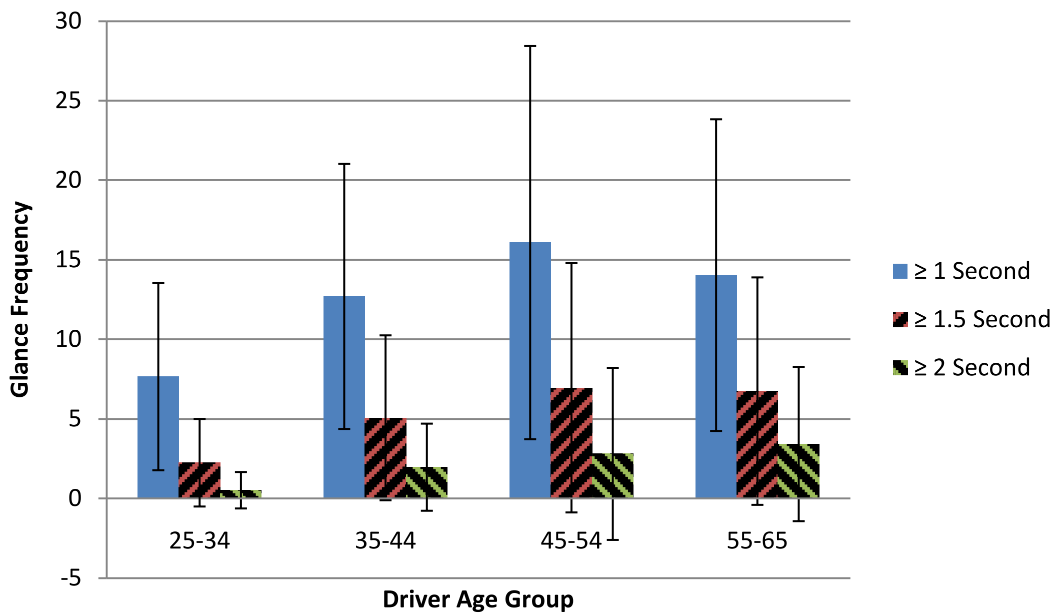


Figure 30.Mean (± Standard Error) Long Glance Frequency by Age Group: Text Message Task (N=100, Single trial)

The number of long glances increased with driver age for both tasks. Text messaging required more long glances on average than destination entry.

The next analyses examined the use of long glance frequency as a performance metric. These analyses are shown in Figure 31, Table 27, Figure 32, and Table 28.

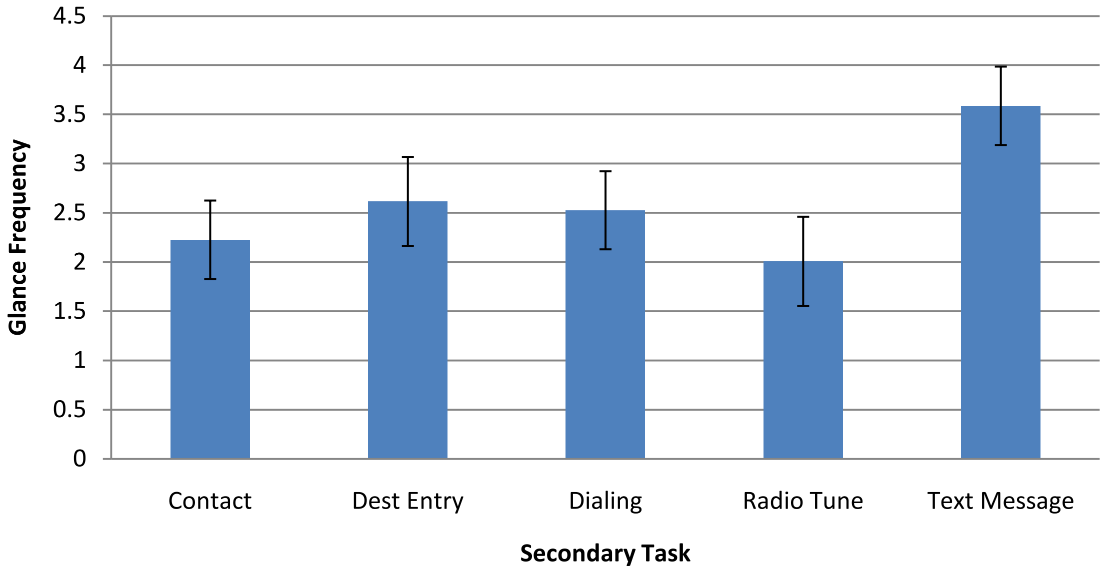


Figure 31.Mean (± Standard Error) Long (≥ 2.0 sec) Glance Frequency by Secondary Task (N=100, 2.5-minute drive)

Table 27. Results of Planned Pairwise Comparisons: Long Glance Frequency (N = 100)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.80	.80	.80	.001*
Destination Entry		.80	.80	.06+
Dialing			.80	.004*
Radio Tuning				.003*

* Statistically significant difference ($p < .05$)
\+ Marginally significant ($.05 < p < .10$)

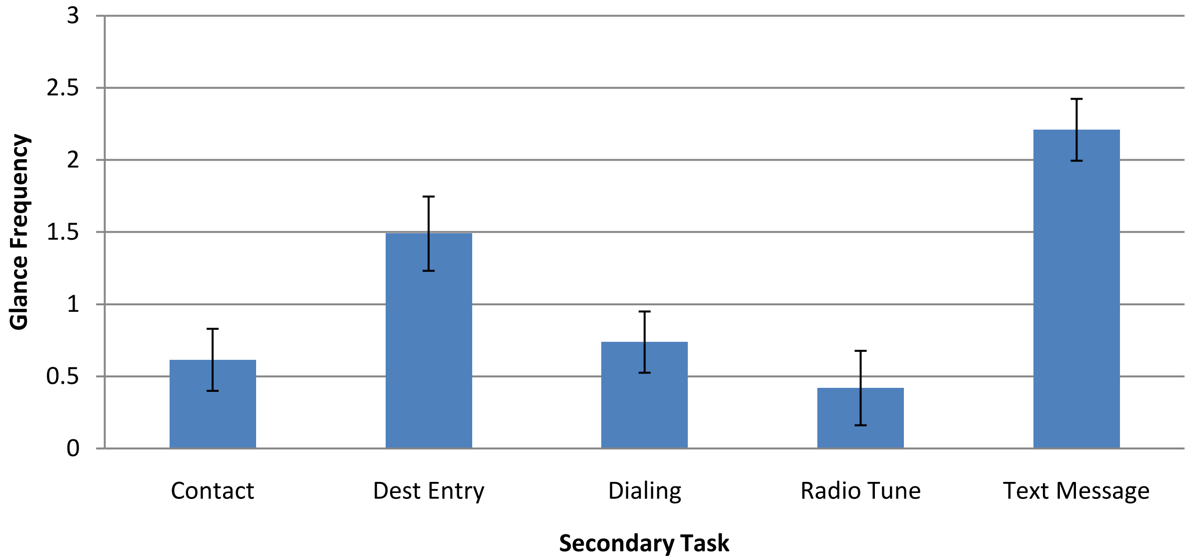


Figure 32.Mean (± Standard Error) Long (≥ 2.0 Sec) Glance Frequency by Secondary Task (N=100, single trial)

Table 28. Results of Planned Pairwise Comparisons: Long Glance Frequency (N = 100)

	Dest Entry	**Dialing**	**Radio Tuning**	**Text Message**
Contact	.003*	.54	.54	< .0001*
Destination Entry		.01*	.002*	.02*
Dialing			.54	< .0001*
Radio Tuning				< .0001*

* Statistically significant difference (p < .05)
+ Marginally significant (.05 < p < .10)

The analyses are consistent in revealing that text messaging required significantly more long glances than any of the other secondary tasks. The results of the first analysis indicate that this finding is independent of task duration, reflecting an inherent task characteristic. The second analysis, using data from single trials only revealed additional differences. Taken together, the results suggest that the second set of differences, particularly in which destination entry required significantly more long glances than all other secondary tasks, reflects primarily the effect of task duration.

The Alliance criterion for Total Glance Time to a device requires that 85 percent of participants complete the secondary task in less than 20 seconds. Figure 33 presents the proportion of trials requiring more than 20 seconds of time looking away from the forward roadway view.

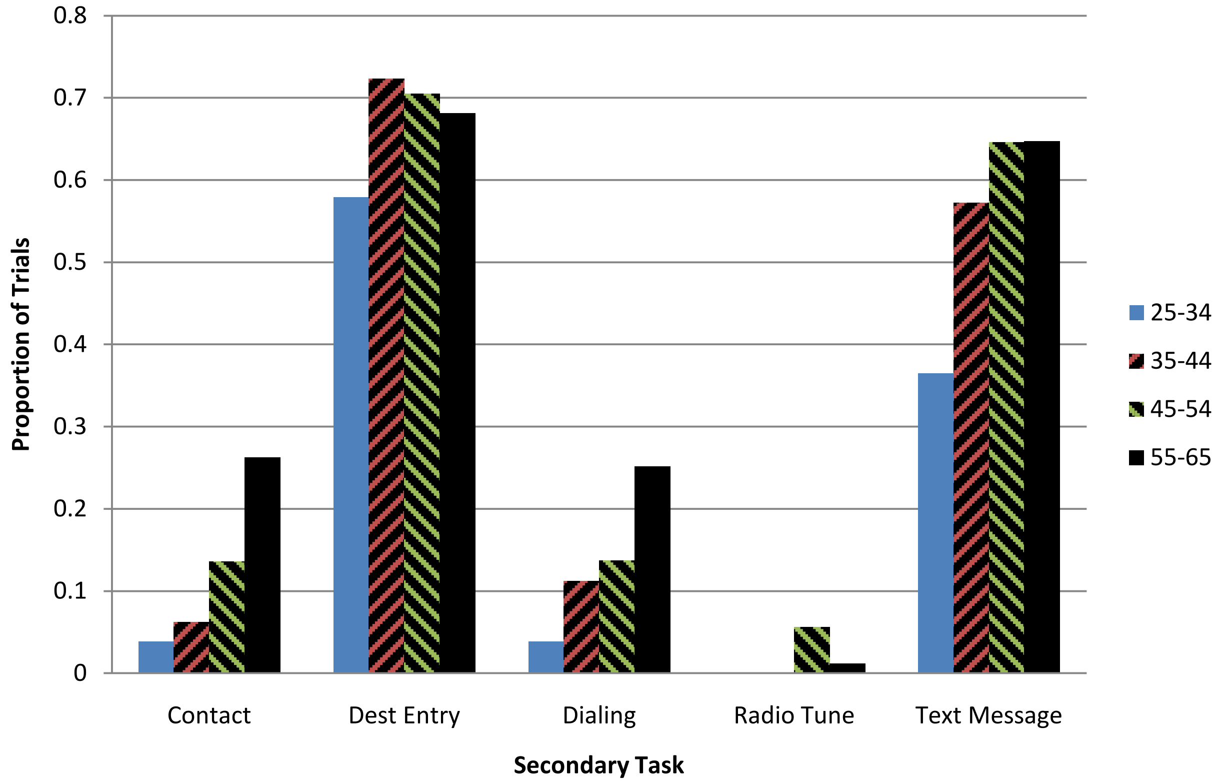


Figure 33.Proportion of Trials Requiring More Than 20 Seconds Looking Away from the Forward Roadway View by Task and Participant Age

The majority of destination entry and text messaging trials required more than 20 seconds of time looking away from the forward roadway view for all age groups. For the Contact and Dialing tasks, only the older drivers required more than 20 seconds for more than 15% of the trials. For Radio Tuning, no age group required more than 20 seconds for more than 15% of the trials.

4.0 DISCUSSION

4.1 Effects of Incentives on Driving Performance

In previous studies using the DFD protocol, performance incentives were used to establish priorities between the primary and secondary tasks. Monetary values were assigned to different levels of performance and the relative amounts of money were intended to define task priorities. This was considered necessary to compensate for the fact that driving in artificial situations eliminates drivers' natural priorities concerning the relative importance of safe and efficient transport versus secondary task performance. Without such guidance, it was expected that drivers would determine priorities based on differing perceptions of the purpose of the experiment and the result would be an unwelcome increase in unexplained variance in the resulting data. The Alliance protocol makes no mention of incentives and there was some concern expressed that the use of incentives could introduce bias into the data. To address this hypothesis, the effects of incentives were examined in this experiment. Half of the participants were given performance incentives; specific monetary rewards were associated with task performance levels and feedback was provided following each trial. The other half were given the generic instruction to give the highest priority to safe driving, without any specific details or performance feedback. To ensure that both groups received the same total compensation, the no-incentive group was given a completion bonus that was computed in the same manner as the performance incentives. The difference was thus in the amount of instruction and the feedback concerning performance.

The effects of incentives were examined using summary measures of primary, secondary and overall task performance, plus a measure that was intended to test the hypothesis that drivers' relative emphasis differed between conditions. The results revealed no consistent differences between incentive conditions; differences were observed among the two older age groups, but these differences were in different directions. Drivers aged 45-54 performed better in the no-incentive condition, while drivers aged 55-64 performed better in the incentive condition. There were no differences between conditions in the 25-34 and 35-44 age groups. There were no differences in the relative emphasis given to the primary task among any of the age groups. The results generally indicate that there were no strong and consistent differences between these conditions. Thus, while the present results did not find a bias, the importance of using performance incentives to enhance instructional clarity and reduce unwanted variance in experimental situations is argued in greater detail elsewhere (Ranney, 2011).

4.2 Effects of Planned Comparisons using DFD Protocol

The effects of the selected number and text entry tasks on driving performance were examined using 4 DFD metrics and 10 planned comparisons. The pattern of results associated with these comparisons is presented in Table 29. Table entries indicate whether the comparison was statistically significant (*) or not (ns). The Total column is the row total of significant results for each comparison.

Table 29. Results of Planned Comparisons using DFD metrics

	Comparison	SDLP	CF delay	DT % corr.	DT MRT	Total	Conclusion[+]
1	Contact vs. Destination entry	ns	ns	ns	ns	0	Contact = Destination entry
2	Contact vs. 10-digit dialing	ns	ns	ns	ns	0	Contact = 10-digit dialing
3	Contact vs. Radio tuning	ns	*	*	*	3	Contact > Radio tuning
4	Contact vs. Text messaging	*	ns	*	*	3	Contact < Text messaging
5	Destination entry vs. Dialing	ns	ns	ns	*	1	Destination entry = Dialing
6	Destination entry vs. Radio tuning	ns	ns	*	ns	1	Destination entry = Radio tuning
7	Destination entry vs. Text messaging	*	ns	*	*	3	Destination entry < Text messaging
8	Dialing vs. Radio tuning	*	*	*	*	4	Dialing > Radio tuning
9	Dialing vs. Text messaging	ns	ns	ns	ns	0	Dialing = Text messaging
10	Radio tuning vs. Text messaging	*	ns	*	*	3	Radio tuning < Text messaging

[+] a > b denotes that a has significantly greater level of distraction potential than b
* denotes statistically significant difference (p < .05)

In our interpretation of these differences, conclusions were based on the criterion that at least 3 of 4 metrics provided statistically significant results in the same direction. Five of the 10 planned comparisons revealed such patterns. The results of these comparisons support the following conclusions:

1. Text messaging was associated with the highest level of distraction potential
2. Radio tuning was associated with the lowest level of distraction potential

The remaining tasks were between these two extremes. Specifically, 10-digit dialing was closest to text messaging and destination entry was closest to radio tuning. These differences are based on the DFD metrics, which eliminate differences due to differences in task duration. Thus, while destination entry was not significantly more demanding than radio tuning on this basis, it does expose drivers to more risk than the radio tuning and phone tasks due to its consistently longer duration.

Although the pattern of differences is somewhat less consistent in this regard, the results also suggest that the tasks performed with the portable devices were more distracting than those performed using the integrated system.

For this type of work, the sample size used in this study (N = 100) was relatively large, although based on the power analysis conducted at the outset one could argue that it was no more than adequate to detect real differences with a probability of 0.8. Nevertheless, it is important to consider the practical implications of the magnitudes of differences observed to be statistically significant in the present study. One approach is to consider the present pattern of differences in relation to the expectations concerning differences between the secondary tasks used in this study. Based on public concern reflecting the emerging consensus that text messaging is more distracting than other phone tasks, we expected this task to be associated with higher levels of performance degradation than other tasks. Moreover, because text messaging shares basic task components with 10-digit dialing, the distraction potential associated with 10-digit dialing was expected to be similar to that associated with text messaging. However, the text messaging task was more engaging and demanding than 10-digit dialing. Based on our previous experience with this experimental protocol, it was uncertain whether the metrics would have sufficient sensitivity to detect these relatively subtle differences. At the other end of a hypothetical continuum of task difficulty, it was expected that radio tuning would be the least distracting task. Reflecting a separate emerging consensus that destination entry is too demanding for combination with driving, it was expected that this task would be more disruptive to driving performance than radio tuning.

The pattern of results is generally consistent with these expectations. The metrics revealed separation between text messaging, radio tuning, and the other tasks. The results did not reveal statistically significant differences between tasks for which there were no strong expectations of differences. The proportion of planned comparisons that revealed statistically significant differences, shown in Table 29, was less than half, considerably less than saturation, in which interpretation would have been made difficult by the fact that the majority of effects revealed statistically significant differences across metrics. Requiring 3 of 4 metrics to be statistically significant as a criterion for accepting a difference further reduced the likelihood of interpreting spurious effects as meaningful. Nevertheless, the magnitude of differences between conditions was relatively small for some effects. It is very difficult to determine a cutoff between differences that are likely to impact safety and those that are not. Anecdotal evidence often suggests that differences between near-misses and collisions involve response times of fractions of a second, gap sizes measured in inches, and the failure to detect a single event. Until results from naturalistic studies can provide information that can be used to differentiate safe versus unsafe situations, it will continue to be very difficult to determine what levels of missed target proportions, slowed responses, or increased lateral position variability are likely to impact safety. One strength of the current study was the decision to use a sample size sufficient to provide a level of statistical power that has long been recommended but is usually not attained in behavioral experiments (Cohen, 1988).

4.3 Comparison of DFD and Alliance Metrics and Decision Criteria for Two Specific Questions

Based on the foregoing analyses, the DFD and Alliance metrics and their respective decision criteria were used to answer two specific questions. The first question was whether text messaging is suitable for performing while driving; the second question was whether 10-digit dialing is suitable for performing while driving. For these comparisons, the representative sample (ages 25-64) including data from all (N = 100) participants was used. A second comparison used the representative sample with a reduced sample size (N = 40). Results for the first question are presented in 0.

Table 30. Effect of Sample Size and Construction on Test Outcome Concerning Suitability of Text Messaging while Driving

	Metric	**Criterion**	**Result (N = 100)**	**Result (N = 40)**
DFD Protocol	Detection Task Response Time	Significantly better than Dest Entry	Fail	Fail
DFD Protocol	Detection Task % Correct	Significantly better than Dest Entry	Fail	Fail
DFD Protocol	SD Lane Position	Significantly better than Dest Entry	Fail	Fail
DFD Protocol	Car-Following Delay	Significantly better than Dest Entry	Fail	Fail
Alliance Principle 2.1A	Total Glance Time	< 20 sec for 85% of participants	Fail	Fail
Alliance Principle 2.1A	Average Glance Duration	< 2.0 sec for 85% of participants	Pass	Pass
Alliance Principle 2.1B	SD Headway	No different from radio tuning	Fail	Fail
Alliance Principle 2.1B	Lane Departure Frequency	No different from radio tuning	Fail	Fail

The Alliance decision criteria allow use of either 2.1A or 2.1B. They further require that for a system to be acceptable for concurrent performance, the results for both criteria within the selected alternative (2.1A or 2.1B) be consistent. For the DFD protocol, destination entry has been proposed as a benchmark. No decision rules have been established, however, a criterion of consistent results from 3 of 4 metrics was shown above to provide reasonable results.

The results of this comparison reveal that text messaging was not significantly better than destination entry using the DFD protocol approach and that this was true for all four metrics. In contrast, one of the four Alliance metrics (mean glance duration) found text messaging to be acceptable; however, this result was not consistent with the other 2.1A criterion, which would lead to a “fail” outcome. Alliance Principle 2.1B metrics also led to this outcome. The effects of using a reduced sample size did not affect any test outcome for this question.

Results for the second question are presented in 0.

Table 31. Effect of Sample Size and Construction on Test Outcome Concerning Suitability of 10-Digit Dialing while Driving

	Metric	**Criterion**	**Result (N = 100)**	**Result (N = 40)**
DFD Protocol	Detection Task Response Time	Significantly better than Dest Entry	Fail	Fail
DFD Protocol	Detection Task % Correct	Significantly better than Dest Entry	Fail	Fail
DFD Protocol	SD Lane Position	Significantly better than Dest Entry	Fail	Fail
DFD Protocol	Car-Following Delay	Significantly better than Dest Entry	Fail	Fail
Alliance Principle 2.1A	Total Glance Time	< 20 sec for 85% of participants	Fail	Pass
Alliance Principle 2.1A	Average Glance Duration	< 2.0 sec for 85% of participants	Pass	Pass
Alliance Principle 2.1B	SD Headway	No different from radio tuning	Fail	Fail
Alliance Principle 2.1B	Lane Departure Frequency	No different from radio tuning	Fail	Fail

The pattern of results for the full sample (N = 100) is essentially identical to that presented above. All three assessment protocols conclude that 10-digit dialing is not suitable for performance while driving. However, the use of a reduced sample size did affect the outcome for Alliance Principle 2.1A. Specifically, with a reduced sample size (N = 40), both eye glance criteria result in Pass decisions. Thus, the use of different sample sizes could influence test outcome.

4.4 Guideline Development Issues

4.4.1 Differences between Metrics Based on Task Duration versus Average Level of Performance Degradation

There are two general approaches to the development of metrics to assess the distraction potential of secondary tasks performed with IVIS or portable devices. One approach is based largely on task duration, while the second approach is based on the average level of performance degradation associated with secondary task performance. These approaches provide complementary information. Unfortunately, there appears to be a lack of consensus among the scientists developing metrics as to the relative importance and how to combine the information provided by the two different approaches. Metrics specified in Alliance Principle 2.1 are primarily duration-based, computed using data from individual trials of a particular secondary task. Examples include the total amount of glance time required to perform a task or the total number of lane exceedances, both of which are correlated significantly and thus determined in part by task duration. In contrast, metrics derived from continuous task performance over an interval of fixed duration are independent of task duration. The mean values obtained using this approach represent the average magnitude of performance degradation for a given secondary task at any point in time. The DFD protocol metrics are of this type.

The use of duration-based metrics has two problems. First, the duration of task performance is not an invariant property of a task; rather the durations of tasks performed while driving are determined by the dynamics of the immediate driving situation and the driver's priorities. For some tasks, duration is determined by the specific content of the material to be entered or the size of the system database. For example, the duration of a destination entry task differs according to the number of letters and digits contained in the address as well as the similarity of the target address to others in the database, all of which affect the number of screens viewed and the number of keystrokes required. Destination entry by selecting a previous destination varies according to the size of the list that must be searched. Text messages are even less constrained than addresses, thus providing a much wider range of task durations. Establishing a valid characterization of task duration with tasks of this sort is difficult. Such variability will be evident in measures computed from individual trials, which differ in task duration. The second potential problem with duration-based metrics is the question of whether comparing performance (e.g., headway variability or lane position variability) across time intervals that differ, for example between 15 seconds and 90 seconds, is valid. The results of the present study demonstrate that metrics that control for differences in task duration may provide different results from the same metrics when used without such controls.

Measures that summarize driving or visual performance degradation over intervals of constant duration do not take task duration into consideration. By controlling for task duration, this approach chooses to focus on the average level of performance degradation associated with a given secondary task. In doing so, it addresses the main weakness of duration-based metrics, namely the confounding correlation between performance degradation and task duration. However, by eliminating the effects of task duration, this approach neglects the real-world impact of distraction potential, namely that task duration is a strong determinant of the driver's overall exposure to risk while performing secondary tasks. One possible approach toward integration of the information provided by these two groups of metrics would be to use the duration-controlled metrics to estimate the average level of performance degradation associated with a particular secondary task and multiply this estimate by the average or some specified percentile (e.g., 85^{th}) duration of the particular task to obtain an estimate of the total exposure to risk associated with performing the task one time.

The use of continuous performance over extended time intervals, which is the approach used in the present study to eliminate duration effects, raises questions about the effects of repeated secondary task performance. One question is whether repeated performance of a simple task may transform the composite task into one that is more complex and demanding than a single trial of the task. No previous evidence was found to support this suggestion and no analyses were conducted to test this hypothesis in the present study. However, while carryover effects are not likely to be due to information-processing or memory demands of task performance, which do not extend beyond individual trial boundaries, it is possible that fatigue may result from repeated performance of the same task over an extended interval that is considerably longer than one might be expected to perform during real-world driving. Inserting pauses between secondary task trials may reduce fatigue; however, this approach may introduce other potentially undesirable effects, such as changing the task from self-paced to externally-paced. The pause intervals may also be expected to disrupt the homogeneity of the resulting data. Learning effects may also be evident with repeated task performance, depending on the amount of practice given before testing. Additional experimental work is warranted to address these methodological concerns.

Exposure is a significant component in determining the crash risk associated with distraction due to performing secondary tasks while driving. Secondary tasks that require drivers to look away from the forward roadway view for longer periods of time expose drivers to a higher crash risk than those that require less time looking away. Implicit in any time-based conceptualization of exposure is the assumption that tasks are roughly equivalent in the amount of interference they cause per unit of time over their respective durations. Complex tasks, such as destination entry, have fluctuating task demands, which may result in momentary variability in the level of driving performance degradation. Carsten and Brookhuis (2005) suggested that distraction effects may begin with "poorer lateral performance during the initial visual phases of looking at a screen . . . followed by improved lateral performance as the information acquired is digested and interpreted." Another example of fluctuating task demands derives from the differing demands of tasks that alternate among user inputs, system responses, and system response delays. It is also possible that drivers are capable of trading time for different levels of concentration, such that highly concentrated attention to the secondary task may be more disruptive to driving than less concentrated attention. These possibilities have not been explored empirically, however, they appear sufficient to question the validity of the assumption that exposure is uniform across the duration of a task.

4.4.2 The Future of Metrics Based on Task Duration

Metrics based on task duration are most appropriate for evaluating tasks that involve a well-defined sequence of actions toward a specific goal. Examples include selecting a radio frequency, entering a specific destination or turning on the heat. However, as computing capabilities continue to migrate into the driving environment, we will likely see more examples of what Burnett et al., (2004) refer to as the desktop computing paradigm. This paradigm is characterized by essentially continuous performance of visually-oriented tasks such as scrolling through lists or menus. Secondary tasks that can be characterized as 'browsing' fall within this paradigm. It is conceivable that people may choose to do many of the tasks they now do routinely with their desktop or portable computers while driving. The practical problem associated with this trend is that it may become increasingly difficult to define the beginning and end points of new tasks performed with IVIS. This, in turn, would create problems for calculating metrics that depend on task duration.

4.4.3 Issues in Performing Distraction Testing for Complex Devices

The Alliance Guidelines were initially developed to evaluate the distraction potential of in-vehicle technologies, most of which had relatively simple interfaces. Moreover, while some devices may have provided the opportunity to complete tasks in several different ways, most in-vehicle interfaces have not allowed a wide range of configuration options, designed to allow users to customize the devices to their liking. Complex portable devices, such as the phones used in this research, provide such customization options and thus raise the question of how to specify parameters for testing. It was attempted to use them in their "out-of-the-box" state but this was difficult to define as there typically was no default set of conditions. Because the customization can affect device usability and thus the distraction potential, this raises concerns about how many different options should be included in the testing of complex devices. It was concluded that it is highly impractical to evaluate numerous configurations. To ensure a fair comparison among multiple devices, the Alliance Guidelines require use of participants without specific experience with the devices. This requirement seems inappropriate for testing complex devices, for which the distraction potential may be determined by the way in which users select and adapt to customization options over time. Using unfamiliar participants seems appropriate for ensuring a fair comparison between simple devices and tasks that can be quickly learned. However, adopting this same approach for complex devices with multiple settings that offer significant opportunities for personalization will likely provide results that do not generalize to real-world driving. However, selecting experienced users for testing may create different problems. For example, it is not clear how to control for positive or negative transfer between devices used by participants in the real world and those used in testing.

4.4.4 Benchmarks: Differences versus No Differences

The Alliance Guidelines use radio tuning as a benchmark in Principle 2.1B. Radio tuning is a non-trivial task that is generally considered acceptable to perform while driving. Accordingly, tasks that are more disruptive to driving than radio tuning are considered not acceptable to perform while driving. In the compliance context, the use of a benchmark that represents the upper limit of acceptable disruption requires logic that is not consistent with the hypothesis testing requirements of the scientific method. Specifically, the use of such a benchmark would require that tasks be no more disruptive to driving to be considered acceptable to perform while driving. Demonstrating compliance through equivalence is not consistent with the scientific method, which is designed to identify differences. It is therefore inappropriate to conclude that a task imposes equivalent demand on driving if the task shows no detectable difference from a benchmark that represents an acceptable level of distraction.

The emerging consensus that destination entry is unacceptable for performance while driving offers an opportunity for consensus-based compliance testing. Accordingly, a task would be considered acceptable to perform while driving if that task were demonstrably less distracting than destination entry. Requiring a positive difference for compliance is consistent with the logic of scientific hypothesis testing. This approach also provides an implicit incentive for the use of strong experimental methods for demonstrating the acceptability of new tasks. A test structure that requires no difference as a pass criterion would be more likely to (erroneously) reveal no differences due to reduced statistical power associated with smaller samples. In contrast, a test structure that requires a positive difference would motivate the use of larger sample sizes to maximize statistical power. By encouraging the use of larger sample sizes, a positive-difference benchmark thus increases the probability that the test outcome will correctly reflect the real-world situation.

Two potential problems remain. First, there is no standardized destination entry task. The Alliance devoted considerable effort to defining the standardized radio tuning task. No such effort has been undertaken for destination entry. For practical purposes, a portable destination entry task would be necessary since it would need to be used in multiple vehicles/testing situations. The second potential problem is that there is no consensus supporting the corollary conclusion that all tasks that are statistically less distracting than destination entry would be considered acceptable for performing while driving. Although no such evidence was found in the present study, there may be tasks that are both statistically less distracting than destination entry and statistically more distracting than radio tuning.

If destination entry were to be used as a benchmark, it would be helpful to demonstrate equivalence with respect to performance degradation among the various destination entry tasks that have been deemed by the manufacturers to be too demanding to allow in a moving vehicle. Unfortunately, such a demonstration of equivalence raises the above-mentioned problem of proving the null hypothesis. Conducting task analyses of the various locked-out systems could define the procedural steps required to select a portable device to serve as a benchmark.

4.4.5 Benchmarks versus Thresholds

Ideally, each metric would have an associated pass/fail threshold. In-vehicle tasks for which the associated level of performance degradation falls on one side of the threshold would be considered acceptable while those that fall on the other side would be considered unacceptable. The challenge is in setting the threshold, which essentially requires answering the question of how much driving performance degradation is acceptable. This is a perennially difficult question as the link between experimental studies involving simulated driving situations and real-world safety is very difficult to establish. Fortunately, the question of what constitutes an acceptable or unacceptable amount of distraction is not an issue in comparing benchmarks versus thresholds. Both approaches involve drawing a line between acceptable and unacceptable levels of performance degradation. The two approaches differ in the procedural implications of doing so. The use of an absolute threshold implies the existence of a well-established and commonly accepted criterion. Blood Alcohol Content is an example. It is well understood and can be used for communication of test results to a wide range of audiences. Once established, the use of an absolute threshold requires strict adherence to test and measurement specifications to ensure that the results are consistent across testing venues. Because the threshold will have been established using data from different individuals than those participating in any single test, subsequent tests will generally require larger samples to compensate for unexplained variability due to differences between groups or differences between test venues. In contrast, the use of benchmarks allows more flexibility to accommodate differences between test venues. The use of benchmarks is also more consistent with the use of within-subjects' designs, which are most appropriate to minimize the effects the variability inherent in human performance. Within-subjects' designs allow the experimenter to use participants as their own controls, comparing their performance on the task of interest to their own performance on the benchmark task. This ensures that differences are due primarily to the differences in task demands, not to differences between subject groups or test venues. The use of a benchmark requires a well-defined benchmark task.

4.4.6 Eye Glance Based Measures

Alliance Principle 2.1 Alternative A includes two criteria: (1) the durations of single glances to the task should generally not exceed 2 seconds; and (2) total glance time (TGT) should not exceed 20 seconds. One significant problem with the implementation of the first criterion is that the general criterion refers to the long glances, which populate the tail of a distribution of glance durations. However, in practice, the metric is defined with reference to the mean of the glance duration distribution. The operational definition thus appears inconsistent with the focus on excessively long glances, which is the commonly-accepted problem with performing difficult secondary tasks. It is desirable that the operational definition be reformulated so that it refers not to the distribution mean but to the outliers, i.e., the excessively long glances.

The second criterion in Alternative A refers to TGT directed to the secondary task. This metric may create problems for analyzing data obtained from eye tracking during actual or simulated driving. Direct measurement of eye glance behavior using an eye tracker, as was done in the present work, allows automated assessment of eye glance behavior, but there may be some uncertainty involved in determining exactly when the driver is looking at a secondary task display while driving. Because of the eye-tracking camera positions and the consistency of the driving task visual demands (e.g., no mirror glances were required), it was easier to determine when the driver was looking straight ahead and thus easier to determine the total eyes-off-road-time (EORT) associated with secondary task performance than the total amount of glance time (TGT) directed to the secondary task display. To examine the magnitude of this potential problem, eye-tracker-based estimates were compared with manually-reduced data obtained from the same trials. This was done for all destination entry trials. The mean total glance time results of this comparison are presented in Figure 34. Corresponding percentages of time are presented in Table 32.

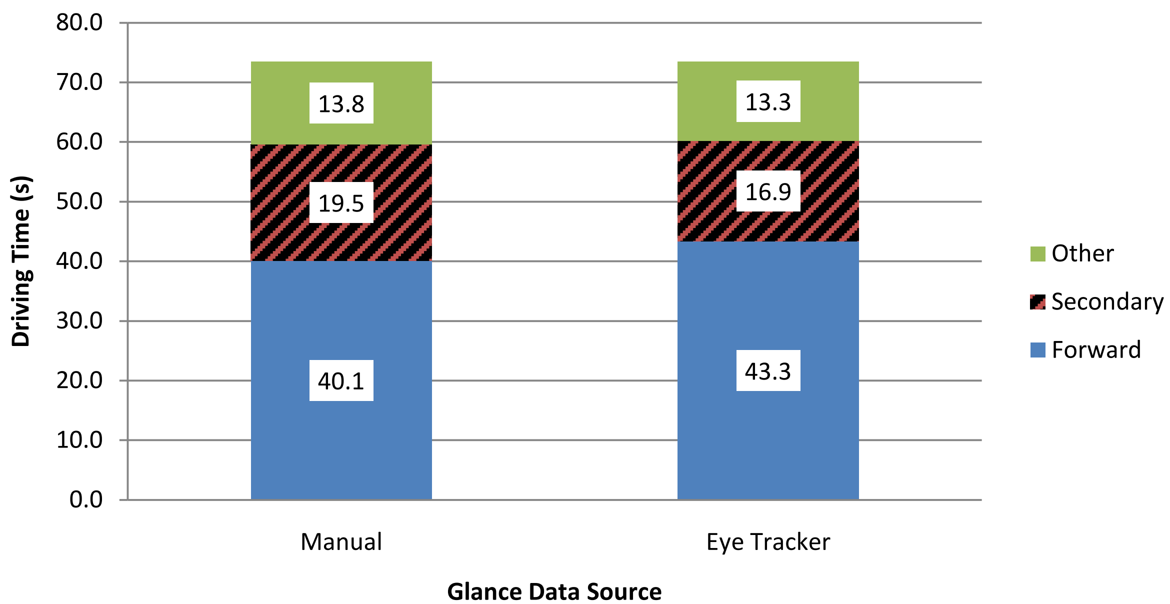


Figure 34.Mean Time (s) Drivers Spent Looking at Different Locations by Glance Data Source: Destination Entry Trials (Single Trial)

Table 32. Percentages of Time Looking Forward, at Secondary Task, and Elsewhere by Glance Data Source (Destination Entry trials)

Location	Manual Data	Eye Tracker Data
Forward	54.6	58.9
Secondary Task	26.6	23.0
Other	18.8	18.1
Total	100.0	100.0

The results of this comparison suggest that the search algorithms developed for automated analysis of eye tracker data provided comparable results to manual reduction of video data. Eye tracker results indicated a slightly higher percentage of time spent looking forward and correspondingly smaller percentage of time spent looking at the secondary task location. The correspondence may be expected to deteriorate somewhat for trials involving portable devices, for which there is no single fixed secondary task location. This comparison allows us to estimate the proportion of time looking away from the forward view that was devoted to secondary task performance. These estimates are presented in Table 33.

Table 33. Secondary Task Glance Time as a Percentage of Total Time Looking Away from the Forward Roadway View by Glance Data Source (Destination Entry trials)

Location	**Manual Data**	**Eye Tracker Data**
Secondary Task	58.6	56.0
Other	41.4	44.0
Total	100.0	100.0

Between 56 and 58.6 percent of the time looking away from the forward roadway view was spent looking at the secondary task display. As an illustrative example, if we assume that drivers spent on average 57 percent of the total EORT looking at the secondary task display and that the average duration of the secondary task trial was 72 seconds, then the product of these estimates provides an estimate (.57 x 72 = 41.0) of the TGT required to perform destination entry in this experiment. While the total EORT is perhaps more important from the perspective of overall road safety, it is fair to acknowledge that not all of this activity is related to secondary task performance. In more naturalistic settings, some percentage of total EORT is necessary to maintain situation awareness. Care must therefore be taken to ensure that the data obtained in driving test situations are comparable to data obtained in other venues, such as occlusion.

4.4.7 Comparison of DFD and Alliance Test Protocols

The Alliance Guidelines specify a car following task as part of their Principle 2.1B verification procedure. They do not specify the details of that task; however it is likely that if manufacturers implement this protocol, they will typically use a lead vehicle with a constant speed. In contrast, the DFD protocol has evolved using a car-following regimen suitable for measuring car-following delay. Most generally, the computation of delay requires variation in the lead-vehicle speed signal so that the analysis routines have some information when they match the two speed signals.

The differences between these two car-following tasks have implications for the potential outcomes of testing. Following a vehicle traveling at constant speed is considerably easier than following a vehicle that is accelerating and decelerating somewhat unpredictably. The dynamics of the simulator also can affect the difficulty of the following task. For example, unless there is some variable disturbance introduced into the simulated vehicle control, following a lead vehicle traveling at constant speed may involve little or no processing load. Theoretically, and with some experimental support from the HASTE project, a more difficult driving task leaves a driver with less spare processing capacity for a secondary task. This reduction in driver spare capacity increases the sensitivity of the test metrics by forcing performance degradation to occur at relatively lower levels of secondary task demand. In contrast, the relatively low demand associated with following a constant-speed lead vehicle affords drivers more spare capacity, which allows more demanding secondary tasks to be performed without observing performance degradation.

There is no established level of primary task demand that validly represents on-road driving. In fact, the demands of on-road driving differ considerably as a function of a number of situational factors. It is therefore impossible to determine whether a relatively easy primary driving task is more suitable than a relatively more difficult task for use in a test protocol. Researchers use different rationale to justify their selection of primary task demands; however, there remains a strong component of arbitrariness in the setting of this level. The fact that the level of primary task demand in such test protocols is inherently arbitrary implies that comparisons with benchmark tasks are better than the establishment of performance degradation thresholds that are not tied to a specific real-world task.

The Alliance Principle 2.1B uses headway variability as the single measure of longitudinal vehicle control. Based on the current results, headway variability is correlated with car-following delay ($r = .72$; r-squared $= .5$). This implies that these two measures are related but also represent different components of driving behavior. Car-following delay is more intuitive because it is a time-based measure, reflecting the generalized response delay in car following. Headway variability is less directly interpretable. Finally, the use of targeted incentives may improve sensitivity of car-following metrics. The generalized instruction to give priority to safe driving is likely to be less effective in focusing drivers' attention to the car following task per se.

5.0 CONCLUSIONS

The following conclusions are supported by this study's results:

1. Text messaging was associated with the highest level of distraction potential. Ten-digit phone dialing was the second most distracting task; radio tuning had the lowest level. Although destination entry was not consistently more demanding than radio tuning when compared using DFD metrics that eliminate duration effects, it exposes drivers to more risk than radio tuning and the phone tasks due to its considerably longer duration.

2. The use of a portable touch screen interface was slightly more distracting than use of a hard button interface on some measures; however, the differences were relatively small and were based only on drivers who had no prior experience with the devices used in the study.

3. The Alliance and DFD metrics and decision criteria both supported the conclusion that text messaging is not suitable for performing with driving. The same conclusion was reached using samples of 100 and 40 participants. However, the protocols led to different outcomes in response to the question of whether phone dialing is suitable for performance while driving. The different outcome was apparent only with the smaller sample size.

4. The results for the Alliance 2.1A long-glance metric were inconsistent with the results based on the other metrics. The operational definition of the long-glance metric appears inconsistent with its intent and was considerably weaker than the other metrics.

5. Differences in sample size and sample construction (age) had significant differences on test outcome. Samples of 20 participants did not provide sufficient statistical power using just vehicle performance metrics for detecting any of the differences that were apparent using larger sample sizes. Samples of 40 participants provided increased power, but the results differed considerably according to the construction of the sample. Samples of size 40 that were constructed in the same way also revealed different test outcomes. The results suggest the need for replication of test results, particularly if sample sizes of 40 or fewer participants are used. Different effects of sample size and construction might be seen using the eye glance metrics; however, those analyses have not yet been performed.

6. The Alliance's use of radio tuning as presenting a maximum level of acceptable distraction is appropriate for identifying tasks with excessive distraction potential indicating the need for redesign. This approach is not appropriate for compliance testing of finished products, if the goal is to demonstrate that tasks are acceptable to perform while driving. Requiring a positive difference from an established level of unacceptable distraction is consistent with the scientific method and could motivate the use of strong methods, thus reducing errors in which the failure to find differences may be due to the use of small samples rather than the absence of real differences.

6.0 REFERENCES

Alliance of Automobile Manufacturers (2006). Statement of Principles, Criteria and Verification Procedures on Driver Interactions with Advanced In-Vehicle Information and Communication Systems, Washington, D.C.: Alliance of Automobile Manufacturers, June 26.

Boer, E. R. (2000). Behavioral entropy as an index of workload. In Proceedings of the IEA 2000/HFES 2000 Congress (pp. 3-125-3-128).

Briem, V., and Hedman, L.R. (1995). Behavioural effects of mobile telephone use during simulated driving. *Ergonomics*, 38, 2536-2562.

Brookhuis, K. A., De Vries, G., and De Waard, D. (1991). The effects of mobile telephoning on driving performance. Accident Analysis and Prevention, 23, 309-316.

Brookhuis, K. A., Waard, D. d., and Mulder, B. (1994). Measuring driving performance by car-following in traffic. Ergonomics, 37, 427-434.

Burnett, G. E., Summerskill, S. J., and Porter, J. M. (2004). On-the-move destination entry for vehicle navigation systems: Unsafe by any means? *Behaviour and Information Technology*, 23, 265-272.

Carsten, O. and Brookhuis, K. (2005a). Issues arising from the HASTE experiments. Transportation Research Part F: Traffic Psychology and Behaviour, 8F, 191-196.

Chisholm, S.L., Caird, J.K., and Lockhart, J. (2008). The effects of practice with MP3 players on driving performance. *Accident Analysis and Prevention, 40*, 704-713.

Cohen, J. (1988). Power Analysis for the Behavioral Sciences, 2nd Ed. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Crisler, M. C., Brooks J. O., Ogle, J. H., Guirl, C. D., Alluri, P., and Dixon, K. K. (2008). Effect of wireless communication and entertainment devices on simulated driving performance. *Transportation Research Record, 2069*, 48-54.

Drews, F. A., Yazdani, H., Godfrey, C. N., Cooper, J. M., and Strayer, D. L. (2009). Text messaging during simulated driving. *Human Factors, 51*, 762-770.

Harms, L. and Patten, C. (2003). Peripheral detection as a measure of driver distraction. A study of memory-based versus system-based navigation in a built-up area. Transportation Research Part F: Traffic Psychology and Behaviour, 6, 23-36.

Hosking, S., Young, K., and Regan, M. (2006). The effects of text messaging on young novice driver performance. Report No. 246, Monash University Accident Research Centre.

Jenness, J.W., Lattanzio, R.J., O'Toole, M., Taylor, N., and Pax, C. (2002). Effects of manual versus voice-activated dialing during simulated driving. *Perceptual and Motor Skills,* 94, 363-379.

Kircher, A., Vogel, K., Bolling, A., Nillson, L., Patten, C., Malmstrom, T. and Ceci, R. (2004). Mobile telephone simulator study. Swedish National Road and Transport.

NHTSA (2000). Traffic Safety Facts 2000: Older Population. DOT HS 809 328, National Center for Statistics and Analysis, National Highway Traffic Safety Administration, Washington D.C.

Ranney, T.A.(2011) Psychological Fidelity: Perception of Risk. In D.L. Fisher, M. Rizzo, J. Caird and J.D. Lee (Eds.) *Handbook of Driving Simulation for Engineering, Medicine, and Psychology,* New York: CRC Press.

Ranney, T. A., Baldwin, G. H. S., Parmer, E., Domeyer, J., and Mazzae, E. N. (2011). Developing a Test to Measure Distraction Potential of IVIS Tasks in Production Vehicles. (Rep. No. DOT HS- not released). Washington, D.C.: U.S. Department of Transportation: National Highway Traffic Safety Administration.

Ranney, T. A., Baldwin, G. H. S., Vasko, S. M., and Mazzae, E. N. (2009). Attentional Demands of Operating In-Vehicle Devices: Establishing Best Practices (Rep. No. DOT HS 811 231). Washington, D.C.: U.S. Department of Transportation: National Highway Traffic Safety Administration.

Ranney, T. A., Harbluk, J. L., and Noy, Y. I. (2005). Effects of voice technology on test track driving performance: Implications for driver distraction. *Human Factors, 47,* 439-454.

Ranney, T. A., Mazzae, E., Baldwin, G. H. S., and Salaani, K. (2007). Characteristics of voice-based interfaces for in-vehicle systems and their effects on driving performance (Rep. No. DOT HS 810 867). Washington, D.C.: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Reed, M.P., and Green, P.A. (1999). Comparison of driving performance on-road and in a low-cost simulator using a concurrent dialing task. *Ergonomics, 42*, 1015-1037.

Reed, N., and Robbins, R. (2008). The effect of text messaging on driver behavior: A simulator study. Transportation Research Laboratory (Rep. No. PPR 367).

Shinar, D.N., Tractinsky, N. and Compton, R.P. (2005). Effects of practice, age, and task demands, on interference from a phone task while driving. *Accident Analysis and Prevention, 37*, 315-326.

Shinar, David (2007).Traffic Safety and Human Behavior: Bingley, UK: Emerald Group Publishing Limited.

Westfall, P. H., Tobias, R. D., Rom, D., Wolfinger, R. D., and Hochberg, Y. (2003). Multiple Comparisons and Multiple Tests Using SAS. Cary, North Carolina: SAS Institute Inc.

Appendix A: Visual Detection Task Components

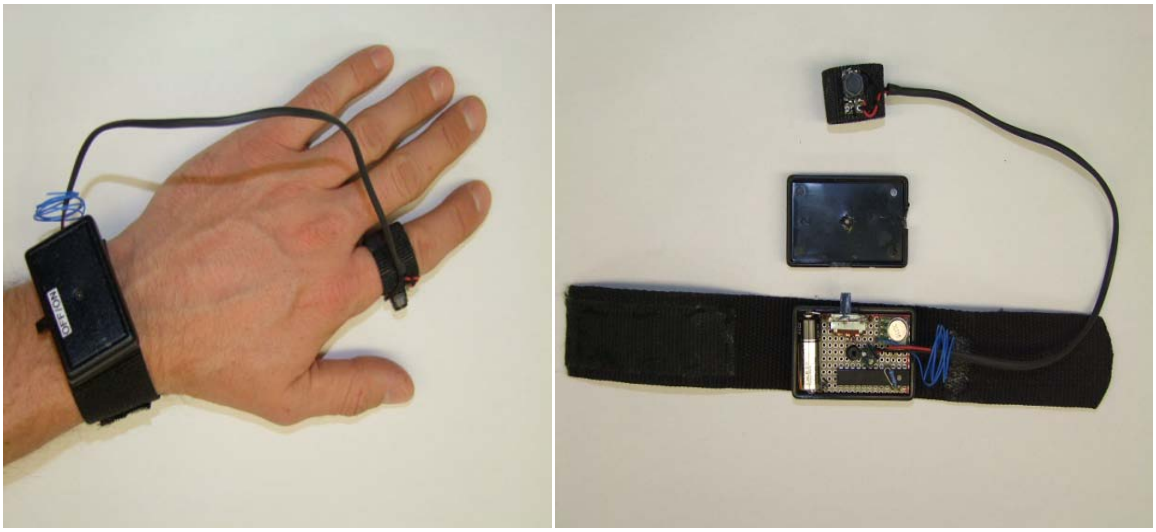


Figure 35. Visual Target Detection Task Response Button

The transmitter and receiver components for the visual target detection task response button include:

<u>Transmitter:</u>

- TWS-434A
- HT-640 Encoder IC (8 bit)
- Small Push Button (P12969SCT-ND) mounted to proto board, sewed to a Hook and Loop strap (TTS-20R0)
- Small ABS enclosure

<u>Receiver</u>:

- RWS-434
- HT-648L Decoder IC (8 Bit)
- Soap Box (Enclosure)

The receiver was housed inside a soap box, as shown in Figure 36.

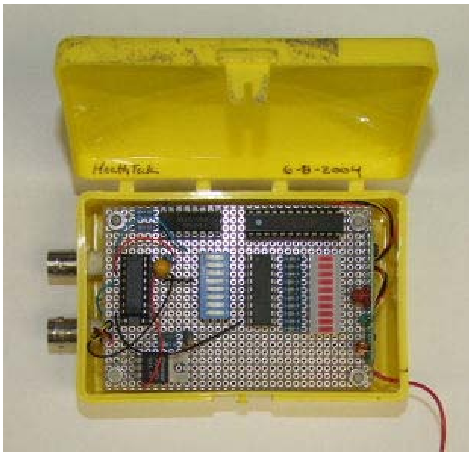


Figure 36. Receiver Components for Visual Target Detection Task

Appendix B: Text Messaging Tasks Used in Previous Experiments

Table 34. Summary of Previous Text Messaging Tasks

Study	**Task**	**Task Description**	**Comment**
Shutko et al. 2009	Canned outgoing messages	Retrieved and reviewed existing text messages. (Does not specify contents.)	System precluded generation of unique outgoing messages.
Drews et al. 2009	Friend dyads	Participants were given information and were required to plan a trip with their partner.	Naturalistic task, not suitable to control pace or content.
Hosking et al. 2006	Preloaded messages	Computer signaled participants when they were allowed to interact with the phone. Text messages required one-word answers (i.e. "What day is it?").	Too rudimentary to be engaging. External pace and one-word answers not sufficiently demanding.
Reed and Robbins 2008	Message reproduction	Participants listened to an audio recording then reproduced message verbatim.	No reading component. Text generation OK, but verbatim reproduction eliminates cognitive demand of real text generation.
Crisler et al. 2008	Canned incoming messages plus word game	Participants received a text message and were required to respond to it. Example message: "What do you plan on doing tomorrow afternoon?" Word game: type a word with the same letter as the stimulus letter.	Relatively good realism for Q and A; Word game probably too rudimentary to be engaging. One-word response too short.

References

Crisler, M. C., Brooks J. O., Ogle, J. H., Guirl, C. D., Alluri, P., and Dixon, K. K. (2008). Effect of wireless communication and entertainment devices on simulated driving performance. *Transportation Research Record, 2069*, 48-54.

Drews, F. A., Yazdani, H., Godfrey, C. N., Cooper, J. M., and Strayer, D. L. (2009). Text messaging during simulated driving. *Human Factors, 51*, 762-770.

Hosking, S., Young, K., and Regan, M. (2006). The effects of text messaging on young novice driver performance. Report No. 246, Monash University Accident Research Centre.

Reed, N., and Robbins, R. (2008). The effect of text messaging on driver behavior: A simulator study. Transportation Research Laboratory (Rep. No. PPR 367).

Shutko, J., Mayer, K., Laansoo, E., and Tijerina, L. (2009). Driver workload effects of cell phone, music player, and text messaging tasks with Ford SYNC voice interfaces versus handheld visual-manual interfaces. (SAE 2009-01-0786). SAE International.

Appendix C: Participant Information Summary for Simulator Protocols

STUDY: Distraction Effect of Number and Text Entry
STERLING IRB ID: 3603-001
DATE OF IRB REVIEW: 09/23/10
DATE REVISED: 10/11/10

PARTICIPANT INFORMED CONSENT FORM

STUDY TITLE: Distraction Effects of Number and Text Entry

STUDY INVESTIGATOR: Thomas A. Ranney, Ph.D.

STUDY SITE: Transportation Research Center Inc.
10820 State Route 347
East Liberty, OH, 43319

TELEPHONE: 1-800-262-8309

SPONSOR: U.S. Department of Transportation
National Highway Traffic Safety Administration (NHTSA)

You are being asked to participate in a research study. Your participation in this research is strictly voluntary, meaning that you may or may not choose to take part. To decide whether or not you want to be part of this research, the risks and possible benefits of this study are described in this form so that you can make an informed decision. This process is known as informed consent. This consent form describes the purpose, procedures, possible benefits and risks of the study. This form also explains how your information will be used and who may see it. You are being asked to take part in this study because the study investigator feels that you meet the qualifications of the study.

The study investigator or study staff will answer any questions you may have about this form or about the study. Please read this document carefully and do not hesitate to ask anything about this information. This form may contain words that you do not understand. Please ask the study investigator or study staff to explain the words or information that you do not understand. After reading the consent form, if you would like to participate, you will be asked to sign this form. You will be given a signed copy of your consent to take home and keep for your records.

PURPOSE

This research study is being conducted by the National Highway Traffic Safety Administration (NHTSA). The purpose of this study is to evaluate the different tools that researchers use to measure the level of distraction caused by "in-vehicle technologies" and portable devices such as cell phones. The latest in-vehicle technologies and some cell phones provide services such as access to the Internet and navigation systems (for maps and driving directions), as well as the ability to send and receive e-mails and text messages. As new in-vehicle technologies are developed and marketed, there is a concern that these systems may interfere with driving. NHTSA is conducting this research study to determine the best way to collect data (information) on the use of in-vehicle technologies while driving.

Participant's Initials ___________

STUDY REQUIREMENTS

You are being asked to participate in this research study because:

- You are 25 – 65 years of age,
- You have a valid, unrestricted U. S. driver's license (except for restrictions concerning corrective eyeglasses and contact lenses),
- You have a minimum of two years driving experience,
- You drive at least 7,000 miles per year, and
- You are in good general health.

NUMBER OF STUDY SITES AND STUDY PARTICIPANTS

This study will take place at one research site (Transportation Research Center Inc.) and will include approximately 80 men and women.

STUDY PROCEDURES

Before participating in this research study, you will be asked to read this Participant Informed Consent Form in its entirety. After all of your questions have been answered, you will be asked to sign this form to show that you voluntarily consent to participate in this research study.

Your participation in this research study will consist of one session lasting approximately 5 hours. During this session you will be asked to complete specific driving objectives while performing different in-vehicle tasks. A member of the study staff will give you detailed instructions and will accompany you at all times during your participation in this research study.

Simulated Driving:

During your session you will be asked to drive a fixed-base simulator. A fixed-based simulator is a machine that imitates the conditions of driving in real life, but does not move. The simulator will be connected to the study vehicle, which will be a recent model-year passenger vehicle (sedan, minivan, or SUV). While driving the simulator, you will sit in the driver's seat of the study vehicle. The study vehicle will have its engine turned off. You will control the simulator by moving the steering wheel and the gas and brake pedals of the study vehicle.

The study vehicle will be equipped with sensors to collect information on your steering, braking and gas pedal usage. The sensors are located so that they will not affect your driving. The information collected by these sensors is recorded so that it can be analyzed at a later time. A large screen in front of the study vehicle will display a computer-generated image of the virtual road on which you will be driving.

Participant's Initials ___________

Driving Objectives:

While operating the simulator, you will be asked to perform specific driving tasks. These tasks will involve activities such as following a car and detecting simple targets that appear on the computer-generated roadway image.

In-Vehicle Tasks:

While completing the driving objectives you will be asked to perform specific in-vehicle tasks. The in-vehicle tasks will consist both of tasks using the integrated stereo and navigation system in the study vehicle and tasks using cell phones.

Eye Movement Recording and Monitoring:

Video cameras will be used to monitor your eye movements while operating the driving simulator and performing the in-vehicle tasks. The video cameras are located so that they will not affect your driving. The information collected using these video cameras is recorded so that it can be analyzed at a later time.

There are certain requirements for accurately recording your eye movements while driving. These requirements are as follows:

- Your entire face must be clearly visible while driving. If your hair hangs in your face, you may be asked to use clips or a rubber band to keep it out of your face.
- If you require corrective lenses and have contact lenses, you will be asked to wear them rather than glasses.
- You will not be permitted to wear sunglasses while driving.
- To help the eye tracking system better identify and track your facial features, you will be required to wear several small stickers on your face. The stickers will be put on before you begin driving and cannot be removed or moved until a member of the study staff informs you that you are finished driving. As a result you may be wearing the stickers for up to 3 hours.

Summary of Study Procedures:

The following procedures will take place at your session:

- After signing this consent form, you will be given instructions, training, and practice time for driving the simulator and performing the in-vehicle tasks.
- You will then complete a number of short tests, each lasting approximately 3 minutes. Each test will involve a different combination of driving objectives and in-vehicle tasks. You will be asked to complete approximately 20 tests (including all tests completed during training and practice).
- At the conclusion of the tests, you will be asked to answer brief questions about the tasks that you performed.

Participant's Initials ____________

- After completing the questions, the session will end and your participation in this research study will be complete.

NEW INFORMATION

We do not anticipate that any changes to procedures will take place during this study. However, any new information developed during the course of the research that may affect your willingness to participate will be provided to you.

RISKS

Most people enjoy driving in the simulator and do not experience any discomfort. However, a small number of participants experience symptoms of discomfort associated with simulator disorientation. Previous studies with similar driving intensities and simulator setups have produced mild to moderate disorientation effects such as slight uneasiness, warmth, or eyestrain for a small number of participants. These effects typically last for only a short time, usually 10 – 15 minutes after leaving the simulator. If you ask to quit driving as a result of discomfort, you will be allowed to quit at once. You will be asked to sit and rest before leaving, while consuming a beverage and a snack. There is no evidence that driving ability is hampered in any way; therefore, if you show minimal or no signs of discomfort, you should be able to drive home. If you experience anything other than slight effects, transportation will be arranged through other means. This outcome is considered unlikely since studies in similar devices have shown only mild effects in recent investigations and evidence shows that symptoms decrease rapidly after simulator exposure is complete.

You will be asked to wear several small latex stickers on your face while driving. These stickers may cause skin irritation in people with an allergy to latex. Allergic reaction may be mild (rash, hives) to severe (difficulty breathing, or a collapse of blood circulation and breathing systems). A severe allergic reaction, which is extremely unlikely, would require immediate medical treatment and could result in permanent disability or death.

There are no known physical or psychological risks associated with participation in this study beyond those described above.

BENEFITS

This research study will provide data on driver behavior and in-vehicle task performance that will be used by researchers to provide a scientific basis for developing recommendations or standards for performing in-vehicle tasks while driving. Your participation in this study will provide data that may help develop these recommendations or standards.

You are not expected to receive direct benefit from your participation in this research study.

Participant's Initials ____________

ALTERNATIVES

This study is for research purposes only. Your alternative is to not participate.

CONDITIONS OF PARTICPATION, WITHDRAWAL, AND TERMINATION

Participation in this research is voluntary. By agreeing to participate, you agree to operate the research vehicle in accordance with all instructions provided by the study staff. If you fail to follow instructions, or if you behave in a dangerous manner, you may be terminated from the study. You may withdraw your consent and discontinue participation in the study at any time without penalty.

Regarding employees who participate in the study, there will be no privilege given for participating in this research study. Likewise, there will be no penalty or drawbacks associated with not participating. Participation is strictly voluntary and will not be tied to any preferential treatment or promotion within the company.

COSTS TO YOU

Other that the time you contribute, there will be no costs to you.

COMPENSATION

You will receive $31.00 per hour for the time you spend at the data collection facility. You will also have the opportunity to receive an additional amount of up to $36.00 based on your performance on the driving and in-vehicle tasks. You may receive up to a total of $175.00 if you complete the study.

You will receive reimbursement for mileage to and from the data collection site.

If you voluntarily withdraw or are terminated from this study, you will be compensated for the number of hours that you participated in the study.

USE OF INFORMATION COLLECTED

In the course of this study, the following data will be collected:

- Engineering data (such as the information recorded by the study vehicle sensors)
- Video/audio data (such as the information recorded by the video cameras)

Participant's Initials ____________

Information NHTSA may release:

The **engineering data** collected and recorded in this study will include performance scores based on the data. This data will be analyzed along with data gathered from other participants. NHTSA may publicly release this data in final reports or other publication or media for scientific, education, research, or outreach purposes.

The **video/audio data** recorded in this study includes your video-recorded likeness and all in-vehicle audio (including your voice). The video/audio data may include information regarding your driving performance. Video and in-vehicle audio will be used to examine your driving performance and other task performance while driving. NHTSA may publicly release video image data (in continuous video or still formats) and associated audio data, either separately or in association with the appropriate engineering data for scientific, educational, research or outreach purposes.

Information NHTSA may not release:

Any release of **engineering data** or **video/audio data** shall not include release of your name. However, in the event of a court action, NHTSA may not be able to prevent release of your name or other personal identifying information. NHTSA will not release any information collected regarding your health and driving record.

QUESTIONS

Any questions you have about the study can be answered by Thomas Ranney, Ph.D., or the study staff by calling 1-800-262-8309.

If you have any questions regarding your rights as a research participant, or if you have questions, concerns, complaints about the research, would like information, or would like to offer input, you may contact: Rev. Paul E. Gamber, J.D., Chairman of Sterling Institutional Review Board, 6300 Powers Ferry Road, Suite 600-351, Atlanta, Georgia 30339 (mailing address) at telephone number 1-888-636-1062 (toll free).

INFORMED CONSENT

By signing the informed consent statement contained in this document, you agree that your participation is voluntary and that the terms of this agreement have been explained to you. Also, by signing the informed consent statement, you agree to operate the study vehicle in accordance with all instructions provided by the study staff. You may withdraw your consent and discontinue participation in the study at any time without penalty.

NHTSA will retain a signed copy of this Informed Consent form. A copy of this form will also be provided to you.

Participant's Initials ____________

INFORMED CONSENT STATEMENT

I certify that:

- I have a valid, U. S. driver's license.
- All personal and vehicle information as well as information regarding my normal daily driving habits provided by me to NHTSA, and/or Transportation Research Center Inc. (TRC) employees associated with this study during the pre-participation phone interview and the introductory briefing was true and accurate to the best of my knowledge.
- I have been informed about the study in which I am about to participate.
- I have been told how much time and compensation are involved.
- I have been told that the purpose of this study is to evaluate the tools that researchers use to measure driving and in-vehicle task performance.
- I agree to operate the research vehicle in accordance with all instructions provided to me by the study staff.

I have been told that:

- The study will be conducted on a fixed-base driving simulator and that the risk of discomfort associated with simulator disorientation is minimal.
- For scientific, educational, research, or outreach purposes, video images of my driving, which will contain views of my face and accompanying audio data, may be used or disclosed by NHTSA, but my name and any health data or driving record information will not be used or disclosed by NHTSA.
- My participation is voluntary and I may refuse to participate or withdraw my consent and stop taking part at any time without penalty or loss of benefits to which I may be entitled.
- I have the right to ask questions at any time and that I may contact the study investigator, Thomas Ranney, Ph.D., or the study staff at 800-262-8309 for information about the study and my rights.
- I have been given adequate time to read this informed consent form. I hereby consent to take part in this research study.

I, ____, voluntarily consent to participate.
(*Printed Name of Participant*)

____

Signature of Participant Date

____

Signature of Person Explaining Consent Date

Participant's Initials ____________

INFORMATION DISCLOSURE

By signing the information disclosure statement contained in this document, you agree that the National Highway Traffic Safety Administration (NHTSA) and its authorized contractors and agents will have the right to use the NHTSA engineering data and the NHTSA video data for scientific, educational, research, or outreach purposes, including dissemination or publication of your likeness in video or still photo format, but that neither NHTSA nor its authorized contractors or agents shall release your name; and you have been told that, in the event of court action, NHTSA may not be able to prevent release of your name or other personal identifying information. NTHSA will not release any information collected regarding your health and driving record, either by questionnaire or medical examination. Your permission to disclose this information will not expire on a specific date.

I, ____, grant permission to
(Printed Name of Participant)
the National Highway Traffic Safety Administration (NHTSA) to use, publish, or otherwise disseminate NHTSA engineering data and NHTSA video image data, as defined in the Participant Informed Consent Form (including continuous video and still photo formats derived from the video recording), and associated with the appropriate engineering data for scientific, educational, research, or outreach purposes. I have been told that such use may involve widespread distribution to the public and may involve dissemination of my likeness in video or still photo formats, but will not result in release of my name or other identifying personal information by NHTSA or its authorized contractors or agents. I have been told that my permission to disclose this information will not expire on a specific date.

____
Signature of Participant Date

____
Signature of Person Explaining Consent Date

Participant's Initials __________

Appendix D: Rating Scale Mental Effort (RSME)

Instructions

We are interested not only in assessing your performance but also the experiences you will have during the different task conditions. Right now I will describe the technique that will be used to examine your experiences.

Most importantly, we want to assess the mental effort you experience. Mental effort is a difficult concept to define precisely, but a simple one to understand generally. The factors that influence your experience of mental effort may come from the task itself, your feelings about your own performance, how much effort you put in, or the stress and frustration you felt. The mental effort contributed by different task elements may change as you get more familiar with a task, perform easier or harder versions of it, or move from one task to another.

Since mental effort is something experienced individually by each person, there are no effective "rules" that can be used to estimate the mental effort of different activities. One way to find out about mental effort is to ask people to describe the feelings they experienced. We will be using a rating scale to assess your mental effort. Please read the definition of the scale carefully. If you have a question about the scale, please ask me about it. It is extremely important that it is clear to you. The description will be made available to you for reference during the experiment.

Rating Scale Definition
Mental Effort: How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving? How hard did you have to work mentally? How much time pressure did you feel?

After performing a set of tasks, you will be instructed to bring the vehicle to a stop at a specified location. While the vehicle is stopped, the rating scale will be presented to you. You will evaluate the tasks performed (some combination of car following, light detection and phone tasks) since the time when the previous rating scale was administered, by telling the in-vehicle experimenter the number on the scale at the point that matches your experience. Please consider your responses carefully in distinguishing among the different task conditions. Your ratings will play an important role in the evaluation being conducted, thus your active participation is essential to the success of this experiment, and is greatly appreciated.

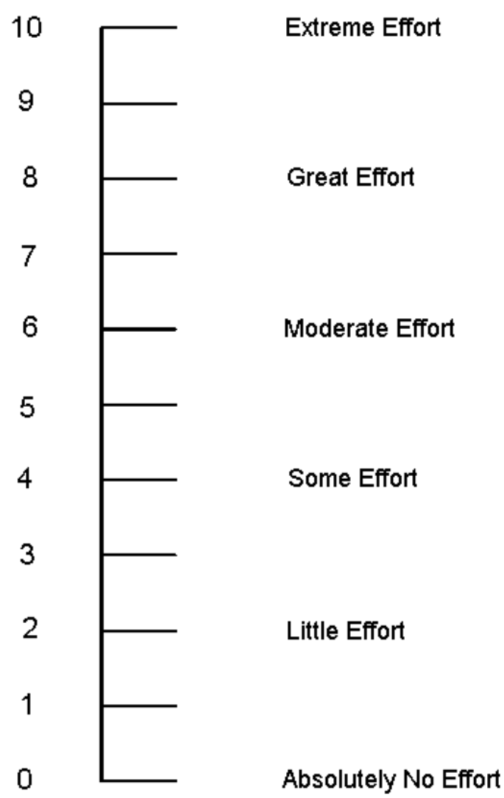
Subject: Date:

Condition: Exp:

Rating Scale Mental Effort

Modified 8/25/03

Please indicate, by marking the scale below, how much effort it took for you to perform the task you just completed



Rating Scale Definition
Mental Effort: How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving? How hard did you have to work mentally? How much time pressure did you feel?

Appendix E: Simulator Sickness Questionnaire

Directions: Circle one option for each symptom to indicate whether that symptom applies to you right now.

1. General Discomfort.................... None................ Slight................ Moderate.......... Severe
2. Fatigue .... None................ Slight................ Moderate.......... Severe
3. Headache .... None................ Slight................ Moderate.......... Severe
4. Eye Strain .... None................ Slight................ Moderate.......... Severe
5. Difficulty Focusing .... None................ Slight................ Moderate.......... Severe
6. Salivation Increased .... None................ Slight................ Moderate.......... Severe
7. Sweating .... None................ Slight................ Moderate.......... Severe
8. Nausea .... None................ Slight................ Moderate.......... Severe
9. Difficulty Concentrating .... None................ Slight................ Moderate.......... Severe
10. "Fullness of the Head" .... None................ Slight................ Moderate.......... Severe
11. Blurred Vision .... None................ Slight................ Moderate.......... Severe
12. Dizziness with Eyes Open .... None................ Slight................ Moderate.......... Severe
13. Dizziness with Eyes Closed ...... None................ Slight................ Moderate.......... Severe
14. *Vertigo .... None................ Slight................ Moderate.......... Severe
15. **Stomach Awareness .... None................ Slight................ Moderate.......... Severe
16. Burping .... No .... Yes................... If yes, no. of times ___
17. Vomiting.................................... No .... Yes................... If yes, no. of times ___
18. Other ____________________________________

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Appendix F: Post Test Questionnaire

Post Test Questionnaire Participant #: ______

1. How comfortable did you feel while performing each of the basic tasks in the experiment you just completed? (Check the most appropriate answer for each condition)

	Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
Driving simulator	☐	☐	☐	☐
Following lead	☐	☐	☐	☐
Target detection	☐	☐	☐	☐
Car following plus target detection	☐	☐	☐	☐

2. How comfortable did you feel while performing each of the following secondary tasks WHILE DRIVING THE SIMULATOR AND PERFORMING TARGET DETECTION in the experiment you just completed? (Check the most appropriate answer for each condition)

	Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
Radio tuning	☐	☐	☐	☐
Destination entry	☐	☐	☐	☐
10 digit phone dialing	☐	☐	☐	☐
Phone dialing using contacts	☐	☐	☐	☐
Text message task	☐	☐	☐	☐

3. How likely would you be to perform each of these same secondary tasks while driving in the real world? (Check the most appropriate answer for each condition)

	Never	Sometimes	Often	Always
Radio tuning	☐	☐	☐	☐
Destination entry	☐	☐	☐	☐
10-digit phone dialing	☐	☐	☐	☐
Phone dialing using contacts	☐	☐	☐	☐
Text message task	☐	☐	☐	☐

4. This question asks about the differences between the two phones used in the experiment and your experience with your own phone. How comfortable did/do you feel while performing each of the following secondary tasks on the specific device indicated (WHILE DRIVING) (Check the most appropriate answer for each condition)

	Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
Blackberry: 10-digit phone dialing	☐	☐	☐	☐	☐
Blackberry: Contact dialing	☐	☐	☐	☐	☐
Blackberry: Text messaging	☐	☐	☐	☐	☐
iPhone: 10-digit phone dialing	☐	☐	☐	☐	☐
iPhone: Contact dialing	☐	☐	☐	☐	☐
iPhone: Text messaging	☐	☐	☐	☐	☐
Your personal phone: 10-digit phone dialing	☐	☐	☐	☐	☐
Your personal phone: Contact dialing	☐	☐	☐	☐	☐
Your personal phone: Text messaging	☐	☐	☐	☐	☐

5. On a scale of 0 to 10, please rate the operational similarity of the two phones used in the Experiment relative to any phone that you currently use or have used regularly in the recent past. Use 0 to indicate no similarity; use 10 to indicate that you use or have used a phone that is identical.

   Similarity of Blackberry phone to your phone ______

   Similarity of iPhone to your phone ______

6. Before the experiment, you were given instructions concerning the relative priority to give to car following/target detection versus secondary task performance? Based on these instructions approximately what percentage of your attention did you devote to each of these tasks? (Please record two numbers that add to 100%).

Car following/ Target detection	_____%
Secondary Task	_____%
Total	100%

7. In your everyday driving, if you perform secondary tasks like those used in the experiment, approximately what percentage of your attention would you typically devote to these tasks and what percentage to driving? (Numbers in each row should add to 100%)

	% Secondary Task	% Driving	Total
Radio tuning	______%	______%	100%
Destination entry	______%	______%	100%
10-digit phone dialing	______%	______%	100%
Phone dialing using contacts	______%	______%	100%
Text message task	______%	______%	100%

Comments about the study, including the realism of the driving simulator, the realism of the secondary tasks:

Appendix G: Post Test Questionnaire Results

The post test questionnaire (shown in Appendix F) provided basic information about the participants' experiences, both in the study and in comparison to everyday life. The tables below attempt to quantify that information for all the participants, while providing a breakdown of the information by age group and incentives. The total possible number of respondents for each of the seven questions is shown in Table 35 below. In some cases, a few participants chose not to answer certain questions, resulting in a number slightly lower than the expected totals.

Table 35. Total Number of Participants by Age and Incentive Groups

Age Group	**Incentives**	**Number of Participants Who Received Questionnaire (N)**	
All (N=100)	**Incentives**	50	100
	No Incentives	50	
25 to 34	**Incentives**	10	20
	No Incentives	10	
35 to 44	**Incentives**	20	40
	No Incentives	20	
45 to 54	**Incentives**	10	20
	No Incentives	10	
55 to 64	**Incentives**	10	20
	No Incentives	10	

Table 36 through Table 39 show summary data for question one: "How comfortable did you feel while performing each of the basic tasks in the experiment you just completed?" This question uses a 4-point scale ranging from "Very Comfortable" to "Very Uncomfortable" to describe participant comfort level with the simulator, as well as, the primary tasks of car following and target detection.

Table 36. Comfort Level with Driving Simulator

Age Group	Incentives	Driving Simulator Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	**Incentives**	43	7	0	0
	No Incentives	34	15	1	0
25 to 34	**Incentives**	8	2	0	0
	No Incentives	6	4	0	0
35 to 44	**Incentives**	18	2	0	0
	No Incentives	14	5	1	0
45 to 54	**Incentives**	9	1	0	0
	No Incentives	9	1	0	0
55 to 64	**Incentives**	8	2	0	0
	No Incentives	5	5	0	0

Table 37. Comfort Level with Following the Lead Vehicle

Age Group	Incentives	Car Following Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	**Incentives**	25	20	5	0
	No Incentives	21	27	2	0
25 to 34	**Incentives**	4	5	1	0
	No Incentives	5	4	1	0
35 to 44	**Incentives**	12	6	2	0
	No Incentives	7	12	1	0
45 to 54	**Incentives**	4	6	0	0
	No Incentives	5	5	0	0
55 to 64	**Incentives**	5	3	2	0
	No Incentives	4	6	0	0

Table 38. Comfort Level with Performing the Target Detection Task

Age Group	Incentives	Target Detection Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	Incentives	41	8	1	0
	No Incentives	32	16	2	0
25 to 34	Incentives	8	2	0	0
	No Incentives	6	2	2	0
35 to 44	Incentives	18	1	1	0
	No Incentives	12	8	0	0
45 to 54	Incentives	8	2	0	0
	No Incentives	7	3	0	0
55 to 64	Incentives	7	3	0	0
	No Incentives	7	3	0	0

Table 39. Comfort Level with Following the Lead Vehicle While Performing the Target Detection Task

Age Group	Incentives	Car Following Plus Target Detection Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	Incentives	23	22	5	0
	No Incentives	19	22	9	0
25 to 34	Incentives	4	4	2	0
	No Incentives	4	1	5	0
35 to 44	Incentives	10	9	1	0
	No Incentives	7	10	3	0
45 to 54	Incentives	4	5	1	0
	No Incentives	3	6	1	0
55 to 64	Incentives	5	4	1	0
	No Incentives	5	5	0	0

Table 40 through Table 44 show summary data for question two: "How comfortable did you feel while performing each of the following secondary tasks WHILE DRIVING THE SIMULATOR AND PERFORMING TARGET DETECTION in the experiment you just completed?" This question uses a 4-point scale ranging from "Very Comfortable" to "Very Uncomfortable" to describe participant comfort level with performing the secondary tasks while performing the primary tasks of car following and target detection.

Table 40. Comfort Level Performing Radio Tuning with Car Following / Target Detection

Age Group	Incentives	Radio Tuning Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	Incentives	13	26	9	2
	No Incentives	17	23	8	2
25 to 34	Incentives	5	2	2	1
	No Incentives	4	4	2	0
35 to 44	Incentives	5	14	1	0
	No Incentives	8	8	3	1
45 to 54	Incentives	1	7	1	1
	No Incentives	4	4	1	1
55 to 64	Incentives	2	3	5	0
	No Incentives	1	7	2	0

Table 41. Comfort Level Performing Destination Entry with Car Following / Target Detection

Age Group	Incentives	Destination Entry Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	Incentives	3	22	16	9
	No Incentives	4	15	22	9
25 to 34	Incentives	2	3	3	2
	No Incentives	1	1	5	3
35 to 44	Incentives	0	12	6	2
	No Incentives	2	6	8	4
45 to 54	Incentives	1	4	4	1
	No Incentives	0	5	4	1
55 to 64	Incentives	0	3	3	4
	No Incentives	1	3	5	1

Table 42. Comfort Level Performing 10-Digit Phone Number Dialing with Car Following / Target Detection

Age Group	Incentives	10-Digit Phone Number Dialing Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	**Incentives**	4	17	19	9
	No Incentives	2	24	20	4
25 to 34	**Incentives**	2	5	2	1
	No Incentives	2	4	3	1
35 to 44	**Incentives**	2	7	7	4
	No Incentives	0	11	8	1
45 to 54	**Incentives**	0	4	5	0
	No Incentives	0	4	5	1
55 to 64	**Incentives**	0	1	5	4
	No Incentives	0	5	4	1

Table 43. Comfort Level Performing Phone Dialing Using a Contact List with Car Following / Target Detection

Age Group	Incentives	Phone Dialing Using a Contact List Comfort Level (Number of Responses)			
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable
All	**Incentives**	5	19	16	10
	No Incentives	5	26	15	4
25 to 34	**Incentives**	4	3	2	1
	No Incentives	3	4	2	1
35 to 44	**Incentives**	1	10	5	4
	No Incentives	2	11	6	1
45 to 54	**Incentives**	0	4	4	2
	No Incentives	0	4	5	1
55 to 64	**Incentives**	0	2	5	3
	No Incentives	0	7	2	1

Table 44. Comfort Level Performing Text Message Task with Car Following / Target Detection

Age Group	Incentives	Text Message Task Comfort Level (Number of Responses)			
		Very Comfortable	**Slightly Comfortable**	**Slightly Uncomfortable**	**Very Uncomfortable**
All	**Incentives**	1	6	20	23
	No Incentives	1	12	17	20
25 to 34	**Incentives**	1	1	5	3
	No Incentives	1	3	3	3
35 to 44	**Incentives**	0	4	6	10
	No Incentives	0	5	7	8
45 to 54	**Incentives**	0	1	4	5
	No Incentives	0	1	3	6
55 to 64	**Incentives**	0	0	5	5
	No Incentives	0	3	4	3

Table 45 through Table 49 show summary data for question three: "How likely would you be to perform each of these same secondary tasks while driving in the real world?" This question uses a 4-point scale ranging from "Never" to "Always" to assess how likely participants would be to perform these secondary tasks in the real world.

Table 45. Likelihood of Performing Radio Tuning in Real World

Age Group	Incentives	Likelihood of Performing Radio Tuning in Real World (Number of Responses)			
		Never	**Sometimes**	**Often**	**Always**
All	**Incentives**	0	14	22	14
	No Incentives	2	11	11	26
25 to 34	**Incentives**	0	3	3	4
	No Incentives	0	2	3	5
35 to 44	**Incentives**	0	4	9	7
	No Incentives	1	3	3	13
45 to 54	**Incentives**	0	4	4	2
	No Incentives	1	2	4	3
55 to 64	**Incentives**	0	3	6	1
	No Incentives	0	4	1	5

Table 46. Likelihood of Performing Destination Entry in Real World

Age Group	Incentives	Likelihood of Performing Destination Entry in Real World (Number of Responses)			
		Never	Sometimes	Often	Always
All	Incentives	15	29	3	3
	No Incentives	17	21	10	2
25 to 34	Incentives	2	6	1	1
	No Incentives	5	3	2	0
35 to 44	Incentives	6	12	1	1
	No Incentives	5	8	6	1
45 to 54	Incentives	3	6	0	1
	No Incentives	4	4	2	0
55 to 64	Incentives	4	5	1	0
	No Incentives	3	6	0	1

Table 47. Likelihood of Performing 10-Digit Phone Number Dialing in Real World

Age Group	Incentives	Likelihood of Performing 10-Digit Phone Number Dialing in Real World (Number of Responses)			
		Never	Sometimes	Often	Always
All	Incentives	7	28	10	5
	No Incentives	1	32	12	5
25 to 34	Incentives	1	4	2	3
	No Incentives	0	7	2	1
35 to 44	Incentives	3	13	3	1
	No Incentives	0	12	4	4
45 to 54	Incentives	1	4	4	1
	No Incentives	1	7	2	0
55 to 64	Incentives	2	7	1	0
	No Incentives	0	6	4	0

Table 48. Likelihood of Performing Phone Dialing Using a Contact List in Real World

Age Group	Incentives	Likelihood of Performing Phone Dialing Using a Contact List in Real World (Number of Responses)			
		Never	Sometimes	Often	Always
All	Incentives	5	17	17	11
	No Incentives	3	13	22	12
25 to 34	Incentives	0	4	1	5
	No Incentives	1	1	3	5
35 to 44	Incentives	3	5	9	3
	No Incentives	0	7	7	6
45 to 54	Incentives	1	4	3	2
	No Incentives	2	3	4	1
55 to 64	Incentives	1	4	4	1
	No Incentives	0	2	8	0

Table 49. Likelihood of Performing Text Messaging in Real World

Age Group	Incentives	Likelihood of Performing Text Messaging in Real World (Number of Responses)			
		Never	Sometimes	Often	Always
All	Incentives	15	23	8	4
	No Incentives	10	27	5	8
25 to 34	Incentives	1	4	3	2
	No Incentives	1	4	2	3
35 to 44	Incentives	7	9	3	1
	No Incentives	5	10	1	4
45 to 54	Incentives	4	5	0	1
	No Incentives	3	6	0	1
55 to 64	Incentives	3	5	2	0
	No Incentives	1	7	2	0

Table 50 through Table 58 show summary data for question four: "This question asks about the differences between the two phones used in the experiment and your experience with your own phone. How comfortable did/do you feel while performing each of the following secondary tasks on the specific device indicated (WHILE DRIVING)?" This question uses a scale ranging from "Very Comfortable" to "Very Uncomfortable" along with "Not Applicable".

Table 50. Comfort Level Using Blackberry for 10-Digit Dialing

Age Group	Incentives	Blackberry: 10-Digit Dialing While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	Incentives	4	12	15	19	0
	No Incentives	4	11	17	17	1
25 to 34	Incentives	2	3	3	2	0
	No Incentives	1	5	3	1	0
35 to 44	Incentives	2	7	5	6	0
	No Incentives	1	3	5	10	1
45 to 54	Incentives	0	2	5	3	0
	No Incentives	2	2	4	2	0
55 to 64	Incentives	0	0	2	8	0
	No Incentives	0	1	5	4	0

Table 51. Comfort Level Using Blackberry for Contact Dialing

Age Group	Incentives	Blackberry: Contact Dialing While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	Incentives	7	10	18	15	0
	No Incentives	2	13	24	10	0
25 to 34	Incentives	2	3	4	1	0
	No Incentives	0	4	5	1	0
35 to 44	Incentives	3	4	9	4	0
	No Incentives	1	4	9	5	0
45 to 54	Incentives	1	2	3	4	0
	No Incentives	1	3	4	2	0
55 to 64	Incentives	1	1	2	6	0
	No Incentives	0	2	6	2	0

Table 52. Comfort Level Using Blackberry for Text Messaging

Age Group	Incentives	Blackberry: Text Messaging While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	**Incentives**	2	8	14	26	0
	No Incentives	3	6	15	26	0
25 to 34	**Incentives**	0	2	5	3	0
	No Incentives	0	4	4	2	0
35 to 44	**Incentives**	2	5	6	7	0
	No Incentives	2	1	6	11	0
45 to 54	**Incentives**	0	1	2	7	0
	No Incentives	1	0	3	6	0
55 to 64	**Incentives**	0	0	1	9	0
	No Incentives	0	1	2	7	0

Table 53. Comfort Level Using iPhone for 10-Digit Dialing

Age Group	Incentives	iPhone: 10-Digit Dialing While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	**Incentives**	7	17	17	8	0
	No Incentives	8	17	16	9	0
25 to 34	**Incentives**	4	2	1	3	0
	No Incentives	3	4	2	1	0
35 to 44	**Incentives**	1	9	7	2	0
	No Incentives	3	8	7	2	0
45 to 54	**Incentives**	1	4	3	2	0
	No Incentives	1	1	5	3	0
55 to 64	**Incentives**	1	2	6	1	0
	No Incentives	1	4	2	3	0

Table 54. Comfort Level Using iPhone for Contact Dialing

Age Group	Incentives	iPhone: Contact Dialing While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	**Incentives**	5	15	21	9	0
	No Incentives	8	20	14	8	0
25 to 34	**Incentives**	3	1	2	4	0
	No Incentives	4	1	4	1	0
35 to 44	**Incentives**	1	7	10	2	0
	No Incentives	3	10	4	3	0
45 to 54	**Incentives**	1	2	5	2	0
	No Incentives	1	1	6	2	0
55 to 64	**Incentives**	0	5	4	1	0
	No Incentives	0	8	0	2	0

Table 55. Comfort Level Using iPhone for Text Messaging

Age Group	Incentives	iPhone: Text Messaging While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	**Incentives**	2	8	16	24	0
	No Incentives	4	9	18	19	0
25 to 34	**Incentives**	2	3	0	5	0
	No Incentives	2	1	5	2	0
35 to 44	**Incentives**	0	4	7	9	0
	No Incentives	2	4	8	6	0
45 to 54	**Incentives**	0	0	5	5	0
	No Incentives	0	1	1	8	0
55 to 64	**Incentives**	0	1	4	5	0
	No Incentives	0	3	4	3	0

Table 56. Comfort Level Using Your Personal Phone for 10-Digit Dialing

Age Group	Incentives	Personal Phone: 10-Digit Dialing While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	Incentives	16	25	6	0	3
	No Incentives	21	20	8	1	0
25 to 34	Incentives	2	5	2	0	1
	No Incentives	6	3	1	0	0
35 to 44	Incentives	7	9	3	0	1
	No Incentives	5	11	3	1	0
45 to 54	Incentives	6	3	1	0	0
	No Incentives	4	4	2	0	0
55 to 64	Incentives	1	8	0	0	1
	No Incentives	6	2	2	0	0

Table 57. Comfort Level Using Your Personal Phone for Contact Dialing

Age Group	Incentives	Personal Phone: Contact Dialing While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	Incentives	27	17	4	0	2
	No Incentives	32	12	5	1	0
25 to 34	Incentives	3	5	1	0	1
	No Incentives	8	1	1	0	0
35 to 44	Incentives	12	7	1	0	0
	No Incentives	11	6	2	1	0
45 to 54	Incentives	7	2	1	0	0
	No Incentives	7	2	1	0	0
55 to 64	Incentives	5	3	1	0	1
	No Incentives	6	3	1	0	0

Table 58. Comfort Level Using Your Personal Phone for Text Messaging

Age Group	Incentives	Personal Phone: Text Messaging While Driving (Number of Responses)				
		Very Comfortable	Slightly Comfortable	Slightly Uncomfortable	Very Uncomfortable	Not Applicable
All	Incentives	10	18	17	3	2
	No Incentives	15	18	8	8	1
25 to 34	Incentives	2	6	1	0	1
	No Incentives	6	3	0	1	0
35 to 44	Incentives	5	4	10	1	0
	No Incentives	5	7	4	3	1
45 to 54	Incentives	2	5	3	0	0
	No Incentives	2	2	3	3	0
55 to 64	Incentives	1	3	3	2	1
	No Incentives	2	6	1	1	0

Table 59 and Table 60 show summary data for question five: "On a scale of 0 to 10, please rate the operational similarity of the two phones used in the Experiment relative to any phone that you currently use or have used regularly in the recent past. Use 0 to indicate no similarity; use 10 to indicate that you use or have used a phone that is identical."

Table 59. Similarity of Blackberry Phone to Your Phone

Age Group	Incentives	Similarity of Blackberry to Your Phone, 0 to 10 Scale (Number of Responses)										
		0	1	2	3	4	5	6	7	8	9	10
All	Incentives	16	0	7	8	1	5	1	3	2	1	5
	No Incentives	18	3	11	4	3	5	1	1	2	1	1
25 to 34	Incentives	4	0	0	0	1	1	1	0	0	0	3
	No Incentives	3	1	1	1	0	2	0	1	1	0	0
35 to 44	Incentives	4	0	4	4	0	3	0	2	1	0	2
	No Incentives	9	0	6	1	1	2	0	0	0	1	0
45 to 54	Incentives	5	0	0	1	0	0	0	1	1	1	0
	No Incentives	1	1	3	2	2	0	0	0	0	0	1
55 to 64	Incentives	3	0	3	3	0	1	0	0	0	0	0
	No Incentives	5	1	1	0	0	1	1	0	1	0	0

Table 60. Similarity of iPhone to Your Phone

Age Group	Incentives	Similarity of iPhone to Your Phone, 0 to 10 Scale (Number of Responses)										
		0	1	2	3	4	5	6	7	8	9	10
All	Incentives	18	3	5	7	1	4	0	2	3	2	4
	No Incentives	18	5	3	2	2	3	3	1	4	1	8
25 to 34	Incentives	2	0	1	1	0	3	0	0	1	0	2
	No Incentives	5	1	0	0	0	0	0	1	0	0	3
35 to 44	Incentives	9	2	1	2	1	0	0	0	1	2	2
	No Incentives	7	0	2	2	0	2	1	0	3	1	2
45 to 54	Incentives	5	0	1	3	0	0	0	0	0	0	0
	No Incentives	3	3	1	0	1	0	2	0	0	0	0
55 to 64	Incentives	2	1	2	1	0	1	0	2	1	0	0
	No Incentives	3	1	0	0	1	1	0	0	1	0	3

Table 61 shows summary data for question six: "Before the experiment, you were given instructions concerning the relative priority to give to car following / target detection versus secondary task performance? Based on these instructions approximately what percentage of your attention did you devote to each of these tasks? (Please record two numbers that add to 100%.)"

Table 61. Percentage of Attention Devoted to Each Task in the Experiment

Age Group	Incentives	Average Percentage of Attention to Primary and Secondary Tasks	
		CF / DT	Secondary Tasks
All	Incentives	66.7 %	33.3 %
	No Incentives	61.6 %	38.4 %
25 to 34	Incentives	58.5 %	41.5 %
	No Incentives	54.5 %	45.5 %
35 to 44	Incentives	69.3 %	30.8 %
	No Incentives	56.5 %	43.5 %
45 to 54	Incentives	68.5 %	31.5 %
	No Incentives	66.1 %	33.9 %
55 to 64	Incentives	68.0 %	32.0 %
	No Incentives	73.0 %	27.0 %

Table 62 through Table 66 shows summary data for question seven: "In your everyday driving, if you perform secondary tasks like those used in the experiment, approximately what percentage of your attention would you typically devote to these tasks and what percentage to driving? (Numbers in each row should add to 100 %.)"

Table 62. Percentage of Attention Devoted to Radio Tuning in Everyday Driving

Age Group	Incentives	Average Percentage of Attention to Secondary Task in Everyday Driving	
		Radio Tuning	**Driving**
All	**Incentives**	16.7 %	83.3 %
	No Incentives	17.7 %	82.3 %
25 to 34	**Incentives**	18.5 %	81.5 %
	No Incentives	26.0 %	74.0 %
35 to 44	**Incentives**	16.5 %	83.5 %
	No Incentives	18.8 %	81.3 %
45 to 54	**Incentives**	21.5 %	78.5 %
	No Incentives	14.0 %	86.0 %
55 to 64	**Incentives**	10.3 %	89.7 %
	No Incentives	11.0 %	89.0 %

Table 63. Percentage of Attention Devoted to Destination Entry in Everyday Driving

Age Group	Incentives	Average Percentage of Attention to Secondary Task in Everyday Driving	
		Destination Entry	**Driving**
All	**Incentives**	16.1 %	83.9 %
	No Incentives	17.7 %	80.0 %
25 to 34	**Incentives**	17.5 %	82.5 %
	No Incentives	27.8 %	72.2 %
35 to 44	**Incentives**	13.3 %	86.7 %
	No Incentives	16.3 %	83.7 %
45 to 54	**Incentives**	23.4 %	76.6 %
	No Incentives	7.9 %	92.1 %
55 to 64	**Incentives**	12.1 %	87.9 %
	No Incentives	18.6 %	67.1 %

Table 64. Percentage of Attention Devoted to 10-Digit Phone Dialing in Everyday Driving

Age Group	Incentives	Average Percentage of Attention to Secondary Task in Everyday Driving	
		10-Digit Dialing	**Driving**
All	**Incentives**	18.8 %	81.2 %
	No Incentives	22.4 %	77.8 %
25 to 34	**Incentives**	16.5 %	83.5 %
	No Incentives	33.5 %	66.5 %
35 to 44	**Incentives**	20.8 %	79.4 %
	No Incentives	23.1 %	77.4 %
45 to 54	**Incentives**	20.1 %	79.9 %
	No Incentives	10.6 %	89.4 %
55 to 64	**Incentives**	16.0 %	84.0 %
	No Incentives	20.5 %	79.5 %

Table 65. Percentage of Attention Devoted to Contact Dialing in Everyday Driving

Age Group	Incentives	Average Percentage of Attention to Secondary Task in Everyday Driving	
		Contact Dialing	**Driving**
All	**Incentives**	21.2 %	78.8 %
	No Incentives	23.4 %	76.4 %
25 to 34	**Incentives**	30.0 %	70.0 %
	No Incentives	36.5 %	63.5 %
35 to 44	**Incentives**	20.3 %	79.8 %
	No Incentives	28.0 %	72.0 %
45 to 54	**Incentives**	20.3 %	79.8 %
	No Incentives	12.0 %	88.0 %
55 to 64	**Incentives**	14.4 %	85.6 %
	No Incentives	12.5 %	86.5 %

Table 66. Percentage of Attention Devoted to Text Messaging in Everyday Driving

Age Group	Incentives	Average Percentage of Attention to Secondary Task in Everyday Driving	
		Text Messaging	Driving
All	**Incentives**	24.0 %	75.4 %
	No Incentives	29.1 %	71.1 %
25 to 34	**Incentives**	30.5 %	69.5 %
	No Incentives	38.0 %	62.0 %
35 to 44	**Incentives**	23.3 %	76.7 %
	No Incentives	30.0 %	70.0 %
45 to 54	**Incentives**	23.0 %	74.0 %
	No Incentives	24.5 %	76.5 %
55 to 64	**Incentives**	18.9 %	81.3 %
	No Incentives	23.0 %	77.0 %

Appendix H: Subject Characteristic Data

The phone / internet screening tool provided basic information about the participants, as well as, some information about their respective experiences with cell phones, navigation systems and texting. The tables below attempt to quantify that information reported by the participants during the phone or internet screening interviews. The information is quantified for all participants, showing a breakdown by age group.

Table 67 shows a breakdown of participant age information.

Table 67. Participant Age Information

	Participant Age Information (Years)		
Age Group (n)	**Mean**	**SD**	**Range**
All (100)	42.7	9.7	(25, 60)
25 to 34 (20)	29.5	3.2	(25, 34)
35 to 44 (40)	39.3	3.1	(35, 44)
45 to 54 (20)	48.3	2.8	(45, 54)
55 to 64 (20)	57.0	1.7	(55, 60)

Table 68 shows a breakdown of participant height information.

Table 68. Participant Height Information

	Participant Height Information (Inches)		
Age Group (n)	**Mean**	**SD**	**Range**
All (100)	68	3.9	(60, 77)
25 to 34 (20)	69	4.4	(63, 77)
35 to 44 (40)	68	3.6	(61, 74)
45 to 54 (20)	68	3.4	(62, 74)
55 to 64 (20)	68	4.3	(60, 75)

Table 69 shows whether or not the participant's job involves any type of driving.

Table 69. Does Your Job Involve Any Type of Driving

	Participants Whose Job Involves Driving	
Age Group (n)	**Yes**	**No**
All (100)	48	52
25 to 34 (20)	8	12
35 to 44 (40)	21	19
45 to 54 (20)	11	9
55 to 64 (20)	8	12

Table 70 shows the approximate number of years of driving experience. Eighteen participants did not report an exact number of years of driving experience, but clarified that it was definitely more than the two years required for study participation.

Table 70. Number of Years of Driving Experience

	Driving Experience (Years)		
Age Group (n)	**Mean**	**SD**	**Range**
All (82)	26	10	(7, 44)
25 to 34 (18)	13	3	(9, 18)
35 to 44 (32)	22	4	(7, 28)
45 to 54 (15)	33	3	(30, 38)
55 to 64 (17)	40	2	(34, 44)

Table 71 shows the approximate number of miles driven per year.

Table 71. Approximate Number of Miles Driven Each Year

	Driving Experience (Miles Per Year)		
Age Group (n)	**Mean**	**SD**	**Range**
All (100)	20,690	10,977	(8000, 70000)
25 to 34 (20)	19,900	8,608	(10000, 40000)
35 to 44 (40)	21,288	12,871	(8000, 70000)
45 to 54 (20)	23,575	10,917	(13000, 50000)
55 to 64 (20)	17,400	8,539	(8000, 35000)

Table 72 shows the number of participants who wear prescription glasses or contacts while driving. Most of these participants were able to wear contacts for the study, to help eye tracker data quality.

Table 72. Number of Participants Who Wear Prescription Glasses / Contacts While Driving

	Use Prescription Glasses or Contacts While Driving	
Age Group (n)	**Yes**	**No**
All (100)	32	68
25 to 34 (20)	6	14
35 to 44 (40)	13	27
45 to 54 (20)	3	17
55 to 64 (20)	10	10

Participants were asked how comfortable they were with multi-tasking while driving, using a scale from 0 to 10, with 0 being the least comfortable. Table 73 shows those results.

Table 73. Comfort Level Associated with Multi-Tasking While Driving

	Multi-Tasking Comfort Level (0 to 10 scale, 0 = Least Comfortable)		
Age Group (n)	**Mean**	**SD**	**Range**
All (100)	8.3	1.6	(4, 10)
25 to 34 (20)	8.8	1.4	(5, 10)
35 to 44 (40)	8.2	1.6	(5, 10)
45 to 54 (20)	8.4	1.7	(4, 10)
55 to 64 (20)	8.2	1.7	(5, 10)

Table 74 shows whether or not the participants use a cell phone while driving.

Table 74. Do You Use a Cellular Phone While Driving

	Use Cell Phone While Driving	
Age Group (n)	**Yes**	**No**
All (100)	100	0
25 to 34 (20)	20	0
35 to 44 (40)	40	0
45 to 54 (20)	20	0
55 to 64 (20)	20	0

Participants were asked how long they have used a cellular phone while driving. Table 75 shows those results. Nine participants did not report the number of years of phone use while driving. Instead, they provided responses such as ‘Many’ or ‘Forever’, suggesting they have been using cellular phones for a long time (in some cases, since cellular phones first entered the market). Those nine participants were not included in the table since they did not provide a numerical response.

Table 75. Number of Years Using Cellular Phone While Driving

	Cell Phone While Driving (Years)		
Age Group (n)	**Mean**	**SD**	**Range**
All (91)	7.8	3.5	(0.8, 20)
25 to 34 (18)	7.3	3.8	(0.8, 16)
35 to 44 (36)	8.0	3.0	(2, 15)
45 to 54 (19)	7.6	3.8	(1.5, 17.5)
55 to 64 (18)	8.2	3.9	(4, 20)

Participants were asked what percentage of their normal driving time was spent using a cellular phone. Table 76 shows those results.

Table 76. Percentage of Time Using Cellular Phone During Normal Driving

	Percentage of Time Using Phone During Normal Driving		
Age Group (n)	**Mean**	**SD**	**Range**
All (100)	38 %	23 %	(5 %, 95 %)
25 to 34 (20)	50 %	30 %	(10 %, 95 %)
35 to 44 (40)	41 %	21 %	(15 %, 90 %)
45 to 54 (20)	33 %	19 %	(5 %, 80 %)
55 to 64 (20)	27 %	14 %	(5 %, 50 %)

Table 77 shows whether or not the participants regularly communicate using text messages. This was intended to be a "Yes" or "No" question, however, a few participants chose to qualify their answer with the following other responses: "Occasionally", "Rarely" and "Sometimes".

Table 77. Do You Regularly Communicate Using Text Messages

	Communicate Regularly Using Text Messages		
Age Group (n)	**Yes**	**No**	**Occasionally, Rarely, Sometimes**
All (100)	91	1	8
25 to 34 (20)	18	0	2
35 to 44 (40)	36	0	4
45 to 54 (20)	17	1	2
55 to 64 (20)	20	0	0

Participants were asked how many text messages they send on an average day. Table 78 shows those results. One participant did not text, and therefore, is not included in Table 78.

Table 78. Average Number of Texts Sent Each Day

	Number of Texts Sent Per Day		
Age Group (n)	**Mean**	**SD**	**Range**
All (99)	40.2	53.5	(3, 300)
25 to 34 (20)	64.8	72.7	(15, 300)
35 to 44 (40)	47.0	53.3	(5, 200)
45 to 54 (19)	29.4	45.2	(3, 200)
55 to 64 (20)	12.4	5.6	(3.5, 20)

Table 79 shows whether or not the participants are comfortable creating text messages while driving. This question received mostly a "Yes" or "No" response, however, some participants chose to qualify their answer with the following other responses: "Somewhat" and "Sometimes".

Table 79. Comfortable Creating Text Messages While Driving

	Comfortable Texting While Driving		
Age Group (n)	**Yes**	**No**	**Somewhat, Sometimes**
All (100)	81	2	17
25 to 34 (20)	16	1	3
35 to 44 (40)	34	0	6
45 to 54 (20)	14	1	5
55 to 64 (20)	17	0	3

Table 80 shows what type of keyboard (full QWERTY keyboard or numeric keypad) participants normally use for creating text messages.

Table 80. Type of Keyboard Participants Normally Use For Creating Text Messages

	Type of Keyboard Used for Texting		
Age Group (n)	**QWERTY**	**Number**	**Both**
All (100)	48	48	4
25 to 34 (20)	12	8	0
35 to 44 (40)	21	16	3
45 to 54 (20)	9	11	0
55 to 64 (20)	6	13	1

Table 81 shows whether the participants keyboard on their phones are comprised of hard buttons or a touch screen.

Table 81. Keyboard Interface on Personal Phone

	Keyboard Interface on Personal Phone		
Age Group (n)	**Buttons**	**Touch Screen**	**Both**
All (100)	84	11	5
25 to 34 (20)	15	4	1
35 to 44 (40)	32	4	4
45 to 54 (20)	20	0	0
55 to 64 (20)	17	3	0

Table 82 shows whether the participants typically use one or two hands when creating text messages while driving. One participant responded only with “it depends”.

Table 82. Use One or Two Hands for Texting

	Number of Hands Used for Texting		
Age Group (n)	**One Hand**	**Two Hands**	**Depends**
All (100)	60	39	1
25 to 34 (20)	11	9	0
35 to 44 (40)	25	14	1
45 to 54 (20)	13	7	0
55 to 64 (20)	11	9	0

Table 83 shows the number of participants who use a navigation system, computer or other similar device in their personal vehicles.

Table 83. Use Navigation System, Computer or Similar Device in Personal Vehicle

	Navigation System, Computer or Similar Device in Personal Vehicle	
Age Group (n)	**Yes**	**No**
All (100)	67	33
25 to 34 (20)	14	6
35 to 44 (40)	26	14
45 to 54 (20)	14	6
55 to 64 (20)	13	7

Table 84 shows the number of participants who have used a navigation system to obtain route guidance directions while driving.

Table 84. Used Navigation System to Obtain Route Guidance Directions While Driving

	Obtained Route Guidance Directions While Driving	
Age Group (n)	**Yes**	**No**
All (100)	77	23
25 to 34 (20)	17	3
35 to 44 (40)	32	8
45 to 54 (20)	15	5
55 to 64 (20)	13	7

Appendix I: Simulation Parameters

The following is a list of scenario, roadway and vehicle parameters contained within the STISIM configuration file that was used for this experiment.

STISIM Drive Configuration:
Configuration file: Number and Text Entry Experiment

Dynamics Settings:
- Yaw rate scale factor = .00008
- Oversteer coefficient = 0
- Acceleration limit = .5
- Deceleration limit = -.65
- Coefficient of drag = .0001
- Yaw instability = .1
- Speed instability = 0
- Steering dead band = 1
- Yaw instability lag = .25
- Idle throttle setting = 0
- Power train parameters:
  - Transmission type = Automatic
  - Clutch required = On
  - Use automatic transmission shifter = Off
  - Use E Shift manual shifting = Off
  - Engine idle gain = 185
  - Linear engine torque gain = .25
  - Second order engine torque gain = -.0001
  - Engine drag coefficient = -.3
  - Engine idle RPM = 1000
  - Clutch pedal input byte = 0
  - Reverse:
    - Gear ratio = 1.5
    - Up-shift = 130
    - Maximum tachometer value = 4000
    - Gear byte value = 0
  - Gear 1:
    - Gear ratio = 1.5
    - Up-shift = 25
    - Maximum tachometer value = 5000
    - Gear byte value = 0
  - Gear 2:
    - Gear ratio = .8
    - Up-shift = 40
    - Maximum tachometer value = 5000
    - Gear byte value = 0
  - Gear 3:
    - Gear ratio = .75
    - Up-shift = 53
    - Maximum tachometer value = 5000
    - Gear byte value = 0
  - Gear 4:
    - Gear ratio = .7

Up-shift = 130
Maximum tachometer value = 6000
Gear byte value = 0
Steering feel and output gains:
Steering feel - Disabled
Speedometer gain = .0625
Tachometer gain = 7.1428E-04

Graphics Settings:
Desired frame rate - 30
Screen resolution - 1024 x 768
Display option - Single monitor
Monitor startup delay = 0
Far clipping plane = 2500
Center system screen sizing:
Left = .01
Right = .99
Top = .85
Bottom = .18

Initialize Settings:
Speed limit = 55
Lateral position = 18
Maximum divided attention display time = 5
Maximum digital input response time = 5
Longitudinal offset distance at start of run = 0
Warm up distance = 0
Distance off road before crash occurs = 90
Sign post lateral position = 3
Crash buffer distance = 25
Random option = completely random

I/O Control Settings:
Digital I/O - Disabled
Controller type - Analog
Steering axis - 1
Throttle axis - 3
Braking axis - 2
Steering gain = .005921
Minimum throttle count = 63000
Maximum throttle count = 35000
Minimum brake count = 10000
Maximum brake count = 25000
Inactivity shutdown time = 1200

Divided attention horn = 247
Divided attention left = 239
Divided attention right = 191
Vehicle Horn = 253
Left turn indicator = 254
Right turn indicator = 251
View left = 223

View right = 127
Drive/Reverse = 231
Pause = 20
Cruise control = 20
Start button = Left turn indicator
Maximum view angle = 90
View angle rate = 180

Other Settings:
Parameter units - English
Driver's side of road - Right
System priority - High
Collect time to collision data - Enabled
Prompt for driver information - Disabled
Data file directory - C:\STISIM\Projects\Distraction10Exp1\DataExp1\
Driver information directory name - C:\STISIM\
Startup instructions bitmap file - C:\Stisim\Data\Miscellaneous\Startup.gif
Auditory startup instructions -
Volume = 10
Divided attention symbols - Disabled
Serial communication data:
Communication Port - COM1
Baud rate - 19200
Parity - None
Data bits - 8
Stop bits - 1
Open Module Parameters:
Module name = C:\STISIM\Projects\Distraction10Exp1\OM_COMBO.dll
Parameter file = C:\STISIM\Projects\Distraction10Exp1\MDT_prof2.Om

Post Run Settings:
Display data header - Enabled
Display divided attention data - Enabled
Display performance data - Enabled
Display mistakes - Enabled
Display individual mistakes - Enabled
Exit program after run - Disabled
Display pass/fail screen - Disabled
Display summary at end of run - Disabled
Print summary at end of run - Disabled
Organization name = none
Simulation reference time = 100
Run completion reward = 10
Reference time reward/penalty = 1
Accident penalties = 1
Ticket penalties = 1
Divided attention reward/penalty = .25
Mean divided attention response time = 2.5

Roadway Scenery Settings:
Background - Clouds
Ambient lighting = 1

Diffuse lighting = .5
Gamma correction = 2
Atmospheric conditions - Disabled

Sound Settings:
Master volume - 75
WAV file volume - 50
Crash auditory - Enabled
Crash file - C:\STISIM\Sound\car_crash.wav
Volume = 3
Crash reset - Position and speed
Siren file - C:\STISIM\Sound\Siren1.wav
Speeding - Off
Stop signs - Off
Traffic lights - Off
Only with police - Off
Volume = 4
Engine - Enabled
Engine file - C:\STISIM\Sound\RPM1400.wav
Volume = 7
Brake tire screech - Enabled
Brake tire screech file - C:\STISIM\Sound\screech2.wav
Volume = 0
Screech threshold = .9
Cornering tire screech - Enabled
Cornering tire screech file - C:\STISIM\Sound\screech3.wav
Volume = 0
Screech threshold = .6
Off road - Disabled
Horn - Enabled
Horn file - C:\STISIM\Sound\Horn.wav
Volume = 10

Vehicle Settings:
Speedometer - Digital
Vehicle cab option - None
Vehicle cab motion - Enabled
U Turns - Disabled
Drive/Reverse indicator - Disabled
Width = 5
Length = 15
Maximum speed = 180
Time display - Enabled
Display on the left
Small font size
Center mirror - Enabled
Left = .58
Right = .88
Top = .99
Bottom = .8
Horizontal angle = 0
Vertical angle = 0

X position = .5
Y position = 0
Z position = 3.5
Field of view = 18
Left mirror - Disabled
Right mirror - Disabled
Turn signals - Enabled
Blink rate = .67
Minimum display time = 1.3
Top position = .25
Left position = .05
Right position = .85
Sound file = C:\STISIM\Sound\TurnSignal.Wav
Volume setting = 10

View and Playback Settings:
Driver's eye position and orientation:
Longitudinal = 0
Lateral =-1.25
Vertical = 3.5
Heading = 0
Pitch = 0
Alternate eye position and orientation:
Longitudinal = 0
Lateral = 0
Vertical = 250
Heading = 0
Pitch = 0
Translate with vehicle = Enabled
View locked to vehicle = Disabled
Initial view at start = Driver

Simulation Colors (Red, Green, Blue attributes):
Color 1 = 0, 0, 0
Color 2 = 0, 0, 128
Color 3 = 0, 128, 0
Color 4 = 0, 128, 128
Color 5 = 128, 0, 0
Color 6 = 128, 0, 128
Color 7 = 128, 128, 0
Color 8 = 192, 192, 192
Color 9 = 128, 128, 128
Color 10 = 0, 0, 255
Color 11 = 0, 255, 0
Color 12 = 0, 255, 255
Color 13 = 255, 0, 0
Color 14 = 255, 0, 255
Color 15 = 255, 255, 0
Color 16 = 255, 255, 255
Color 17 = 222, 222, 222
Color 18 = 90, 50, 0
Color 19 = 0, 88, 0

Color 20 = 0, 0, 0
Color 21 = 0, 0, 0
Color 22 = 0, 0, 0
Color 23 = 0, 0, 0
Color 24 = 0, 0, 0
Color 25 = 0, 0, 0
Color 26 = 0, 0, 0
Color 27 = 0, 0, 0
Color 28 = 0, 0, 0
Color 29 = 0, 0, 0
Color 30 = 0, 0, 0
Color 31 = 0, 0, 0
Color 32 = 0, 0, 0
Color 33 = 0, 0, 0
Color 34 = 0, 0, 0
Color 35 = 0, 0, 0
Color 36 = 0, 0, 0
Color 37 = 0, 0, 0
Color 38 = 0, 0, 0
Color 39 = 0, 0, 0
Color 40 = 0, 0, 0
Color 41 = 0, 0, 0
Color 42 = 0, 0, 0
Color 43 = 0, 0, 0
Color 44 = 0, 0, 0
Color 45 = 0, 0, 0
Color 46 = 0, 0, 0
Color 47 = 0, 0, 0
Color 48 = 0, 0, 0
Color 49 = 0, 0, 0
Color 50 = 0, 0, 0
Color 51 = 0, 0, 0
Color 52 = 0, 0, 0
Color 53 = 0, 0, 0
Color 54 = 0, 0, 0
Color 55 = 0, 0, 0
Color 56 = 0, 0, 0
Color 57 = 0, 0, 0
Color 58 = 0, 0, 0
Color 59 = 0, 0, 0
Color 60 = 0, 0, 0
Color 61 = 0, 0, 0
Color 62 = 0, 0, 0
Color 63 = 0, 0, 0
Color 64 = 0, 0, 11

Object Colors and Textures (Color or Texture, Width):

Fog = 8
Ground = C:\Stisim\Data\Textures\Grass08.Jpg, 25
Roadway = C:\Stisim\Data\Textures\Road01.Jpg, 12
Roadway centerline = 15
Roadway lane markers = 16
Roadway edge lines = 16

Speedometer bar = 10
Hood = 13
Divided attention boxes = 8
Divided attention symbols = 13
Speedometer text = 16
Speedometer text background = 1
Roadway shoulder = C:\Stisim\Data\Textures\Dirt01.Jpg, 6
Roadway fore slope = C:\Stisim\Data\Textures\Grass05.Jpg, 6
Roadway median = 1
Turn signal indicators = 11
Far ground = 3

General Settings:
Display collision blocks = Enabled
Disable output file warning = Disabled

Target detection task target locations based on STISIM 2D graphics coordinate system are presented in the following table.

Table 85. STISIM 2D Graphics Coordinates for Target Detection Task Target Locations

Target ID	X position	Y position
0	0.1	0.55
1	0.216667	0.55
2	0.333333	0.55
3	0.666666	0.55
4	0.783333	0.55
5	0.9	0.55

Appendix J: Instruction Materials, Scripts, and Task Stimuli

[The following are instruction scripts read to participants by the experimenters.]

SIMULATOR ORIENTATION

This vehicle is a Toyota Prius, which has been modified to collect driving performance data. You will be sitting in this vehicle today to drive a driving simulator. Please get into the driver's seat and adjust the seat to your comfort level. You should also make sure that you can reach the buttons on the center console and the task screen located to your right. The seat controls are under the front and on the lower left side of the seat. There is no need to adjust the mirrors as you will not be using them for this experiment.

We have added sensors to the steering wheel, accelerator and brake pedals. These sensors allow us to run the driving simulator without having the vehicle turned on. Your control inputs are recorded by these sensors and input to the simulator to change the roadway image projected on the screen in front of you.

DRIVING TASK INSTRUCTIONS

The STISIM is a fixed-base driving simulator. Fixed-base means that the simulator does not have motion. The simulated driving environment will be a 4-lane roadway with a lead vehicle traveling in front of you and occasional oncoming traffic.

When the roadway image first appears, your vehicle will be stopped. When instructed to begin driving, you should accelerate to 55 mph and maintain that speed. Within a few seconds, a lead vehicle will appear ahead of you in your travel lane. We call this the "lead vehicle" because it is leading you in the car-following task. Your task is to follow that vehicle, adjusting your speed as necessary to maintain a constant following distance behind the lead vehicle. The initial distance at which the vehicle appears ahead of you is the desired following distance. You should try to maintain this following distance throughout the entire drive. Please be sure to note this distance when the lead vehicle first appears on the screen because after several seconds the lead vehicle speed will change.

This task is intended to simulate car following on a moderately congested freeway. The lead vehicle speed will change frequently and you should change your speed as necessary to maintain the same following distance. You should continue following at this distance until the lead vehicle disappears.

If your following distance increases beyond an acceptable range, an auditory warning tone will sound to indicate that you should speed up and follow more closely. This alarm will sound every five seconds until you get within an acceptable range of the lead vehicle.
While driving in the simulator, you should also try to keep the vehicle centered within the travel lane at all times because lane keeping performance will be measured.

Each drive will last about 3 to 4 minutes. Any questions about the driving simulator or car-following tasks?

Target Detection Task Description

While driving the simulator, you will be asked to perform a visual target-detection task, which requires you to respond to a sequence of simple targets that appear one at a time on the roadway display. You will respond to a target by pressing a micro-switch that will be attached to your finger. The micro-switch is attached by wire to a small transmitter box that you will wear on your wrist. This equipment allows us to record the time at which each response is made.

The targets are red dots that appear along the horizon at different distances from the center of the roadway, as seen in the example on the screen. When you see a target appear, you should respond as quickly as possible by pressing the micro switch attached to your finger. A target will appear every 3 to 5 seconds and will remain on until the button is pressed, or remain on for about 1.5 seconds if no response is made. You will be scored based on your speed and accuracy in detecting the targets while driving.

Detection Task Instruction and Practice – Stationary Vehicle

First, please place the response button on your left index finger and attach the transmitter box to your wrist so that it is comfortable and the button can be pressed while you are holding the steering wheel.

(Exp: Make sure transmitter box and wire are positioned correctly.)

Later in the experiment you will also be using a phone so make sure you can press the button comfortably while holding a phone. Now, please try a few button presses in response to the targets. If you press the button quickly, the target will disappear. If you do not respond quickly, it goes out after 1.5 seconds.

Any questions about this task?

SECONDARY TASK INSTRUCTIONS (overview script)

While driving, you will be asked to perform a series of tasks, which we call "Secondary Tasks." We refer to driving (car following) as the "Primary Task" because safe control of the vehicle is more important than performing the secondary tasks.

Secondary tasks will be performed either with the integrated system in the Prius or with a portable phone. For example:

- Radio tuning and Navigation system destination entry will be performed using the Prius navigation system.
- Phone dialing and Text messaging will be performed using two different portable phones.

Performing secondary tasks can interfere with car following and target detection but it is important that you don't let primary task performance deteriorate too much while performing the secondary tasks. Each drive will involve one secondary task. You will perform the specified secondary task repeatedly during the drive when the lead vehicle is present. The specific secondary task details will be presented before each drive. At this time I will explain the way in which the secondary task information is provided to you. Let's take radio tuning as an example. In this task you will be asked to tune the radio to different stations. We will tell you which stations to select; this information will be presented on the computer screen located to the right of the center console. We call this the Task Screen. The Task Screen is a "touch screen," which means that you will touch or press it when you complete each task. The computer records the time of each touch and this is how we measure the amount of time it takes to tune the radio to a given station.

When you are driving, the first radio frequency will appear automatically on the Task Screen shortly after the lead vehicle appears. It will be accompanied by an auditory signal to indicate the task has started. When this occurs, you should work as quickly and accurately as possible to complete the secondary task without letting driving task performance deteriorate too much. When you have entered the first radio frequency, you should press the "DONE" button on the Task Screen to register the task completion time. Pressing the "DONE" button will also cause the next radio frequency to appear and you should again work as quickly and accurately as possible to select this frequency on the radio. When the lead vehicle disappears at the end of the trial, you can stop working on the secondary task.

The same procedure will be used to present information for each of the secondary tasks. The time required to complete a single "trial" will be measured from the time at which the trial's information appears on the Task Screen until the time at which you press the "DONE" button on the Task Screen.

I want to say a few words about errors: Mistakes are inevitable. If you make a mistake while performing a secondary task, please try to correct the error before moving on. We will provide specific information about how to recover from errors for each secondary task. It is important that you try to complete each task if possible. It is also important that you work continuously on secondary tasks during the entire drive. Any questions?

[Secondary tasks are trained in randomized orders, based on experimenter test sheets.]

Radio Tuning

In this task you will tune the radio to a designated frequency by using the tuning knob at the upper right corner of the radio/navigation module. This vehicle has buttons on the steering wheel for this purpose, but we want you to use the knob on the console at all times. During the drive, you will select several different radio frequencies, one at a time. The frequency will be presented on the Task Screen. The trial will require that you complete as many radio tuning tasks as possible.

(Start on CD or Aux) > Audio > AM or FM > Frequency Up / Down

1) The first frequency will appear shortly after the lead vehicle first appears. It will be accompanied by an auditory signal to indicate the task has started. The others will appear one at a time after each press of the "DONE" button on the Task Screen. Each display will include the band (AM or FM) and the frequency.
2) Press the "Audio" button at the bottom of the column of buttons to the left of the Prius video screen. The audio display will then appear on the video screen. Note that the Prius video screen is also a touch screen.
3) Select the frequency band by pressing the AM or FM tab at the upper left of the video screen. The current frequency is displayed on the upper right. If you select the wrong band, press the tab for the appropriate band. (After about 20 seconds of inactivity, the display will revert to the MAP display. If this occurs, press the "Audio" button again to return to the audio screen.)
4) Use the tuning knob, to the upper right of the screen, to adjust the frequency. When you have reached the frequency presented on the task screen press the "DONE" button on the task screen and the next frequency will appear.
5) If you make an error, you can always return to the main audio screen by pressing the "Audio" button and the frequency band (AM or FM) that you need.

If you make an error, but have already pressed the "DONE" button, continue to the new frequency displayed on the Task Screen.

Any questions before we practice this task?

Navigation System Destination Entry by Address

In this task you will enter destinations into the navigation system by specifying the city, street name, and house number. The destinations will be presented on the Task Screen. Each trial will require that you complete as many destination entry tasks as possible.

1) The first destination will appear on the Task Screen shortly after the lead vehicle appears. It will be accompanied by an auditory signal to indicate the task has started. Other destinations will appear one at a time after each press of the "DONE" button on the Task Screen.
2) Press the "DEST" icon to the right of Prius video screen. Four icons will be displayed in the middle of the screen.
3) Press the icon labeled "Address". The system will display three options for destination entry.
4) We will always enter the city first. Press the "City" button. A keyboard will appear on the screen. Enter the city name on the on-screen keyboard until the system displays a list. Select the city from the list by pressing the bar on which the city name is displayed. If the list has more than 5 matches and the target city is not displayed, you will use the arrow buttons located to the right of the list to move up or down in the list to find the correct city. If the system does not display a list after you've typed the full city name, press the 'OK' button on the lower right of the display and then select the city from the resulting list.
5) Two buttons can help you correct errors. If you make an error during keyboard entry, pressing the "Delete" button (a left-pointing arrow in the upper right portion of the on-screen keyboard) will erase the most recently entered letter, one at a time. If the system has already generated a list, pressing the "Back" button (a U-shaped arrow pointing left at the top right portion of the screen) will allow you to go back to the previous screen. This "Back" button is available on every screen.
6) Once you have selected a city, the Street Name screen will appear. Enter the street name on the on-screen keyboard. As you enter the letters a list of streets will appear. Select the correct street name from the list by pressing the bar on which the street name is displayed. If the wrong list appears, use the "Back" and "Delete" buttons to correct any errors.
7) Once you have selected a street, the House Number screen will appear. Enter the house number on the numeric keyboard. Press the "OK" button.
8) A map screen containing the address and an "info" button at the top will appear. Press the "info" button to look at the full address and verify that the city, street and house number match those on the Task Screen. If it is correct, press "DONE" on the Task Screen to complete the task. Otherwise use the "Back" and "Delete" buttons to go back and correct any mistakes.

A note about street names: many street names will include designations like North, South, East, West or Road, Street, Avenue, Boulevard, Place, and Highway. You do not need to enter these designations. Just enter the name of the street. When you have entered the full address, the system will present a list of valid matches and prompt you to select one. If the address matching that on the task screen does not appear, use the "Back and "Delete" buttons to fix the error.

Any questions before we practice this task?

Transition to Training on 1^{st} System

Now we will start training on today's first portable device. We will work with this device until we've completed the main trials for all of the tasks. After training, you will be given practice, followed by the main trial for each secondary task. If there is another task to be completed with the same device, it will be presented in the subsequent trial. Then, we will switch devices and follow the same format with the next portable device.

The first device is _________________________.

iPhone 10-Digit Dialing Task

In this task, you will use the iPhone to dial 10-digit phone numbers. The phone numbers will be presented on the Task Screen either as a 10-digit number or as a label that will prompt you to enter a well-known10-digit number. For example, a label could be "Call Home." We will use only labels that you have provided to us. In either case, you should enter a 10-digit phone number starting with the 3-digit area code followed by the 7-digit number. Each trial will require that you complete as many phone dialing tasks as possible.

1) The first phone number will appear on the Task Screen shortly after the lead vehicle appears. It will be accompanied by an auditory signal to indicate the task has started.
2) If the phone is locked or displays a blank screen, unlock the phone by pressing the button below the screen (that has a rounded square symbol on it). Next, place your thumb on the arrow on the screen and slide it all the way to the right. A set of icons will appear. If the icons do not appear, press the same button at any time to display the main icon screen. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Touch the "Phone" icon located at the lower left of the touch screen. A numeric keypad will appear.
4) Dial the 10-digit number using this numeric keypad.
    a. If you make an error use the "Delete" icon on the screen (just to the right of the green "Call" icon) to erase an incorrect number or numbers. If the keypad disappears, touch the "Keypad" icon (a drawing of nine squares) on the bottom row of the screen.
5) If the number is correct, touch the green "Call" icon and then immediately touch the red "End Call" icon which will appear at the bottom of the screen. Press the rounded square button below the screen to return to the main icon screen.
6) At this point the task is complete and you should immediately press the "Done" button on the Task Screen to display the next phone number to be dialed.
7) Continue performing the task in this manner until the lead vehicle disappears.

If you make an error, press the rounded square button below the screen to return to the main icon screen and start over. If the screen goes blank, press the same button, then place your thumb on the arrow on the screen and slide it all the way to the right to unlock the screen.

Any questions before we practice this task?

<u>iPhone Contact Calling Task</u>

In this task, you will use the iPhone to dial a phone number by selecting a designated contact. The contact names are fictitious and are preloaded into the phone. Names of contacts will be presented on the Task Screen. Each trial will require that you complete as many contact calling tasks as possible.

1) The first contact will appear on the Task Screen shortly after the lead vehicle appears. It will be accompanied by an auditory signal to indicate the task has started.
2) If the phone is locked or displays a blank screen, unlock the phone by pressing the button below the screen (that has a rounded square symbol on it). Next, place your thumb on the arrow on the screen and slide it all the way to the right. A set of icons will appear. If the icons do not appear, press the same button at any time to display the main icon screen. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Touch the "Contacts" icon located near the bottom center of the screen. This will open a list of contacts, which is organized alphabetically by last name and then first name. You will need to scroll through this list to find the correct contact.
4) When you have located the name that is shown on the Task Screen, open the contact by touching the name. If you select the wrong contact, you can return to the list by touching the "All Contacts" list at the top of the screen.
5) Beneath the contact's name is a phone number. Touch the number to dial it. A screen will appear saying "[contact name] Calling Mobile". Once you see this, you can immediately touch the red 'End Call' icon and then press the "All Contacts" button to return to the list for next time, and then press the rounded square button below the screen to return to the main icon screen.
6) At this point the task is complete and you should immediately press the "Done" button on the Task Screen to display the next contact to be called.
7) Continue performing the task in this way until the lead vehicle disappears.

If you make an error, press the rounded square button below the screen to return to the main icon screen and start over. If the screen goes blank, press the same button, then place your thumb on the arrow on the screen and slide it all the way to the right to unlock the screen.

Any questions before we practice this task?

iPhone Text Messaging Task

In this task, you will use the iPhone for text messaging. You will perform this task by retrieving a text message, and creating a text message in reply to it. Each trial will require that you complete as many text message tasks as possible.

1) Shortly after the lead vehicle appears, the task screen will display the name of a contact whose text message you are to read. It will be accompanied by an auditory signal to indicate the task has started.
2) If the phone is locked or displays a blank screen, unlock the phone by pressing the button below the screen (that has a rounded square symbol on it). Next, place your thumb on the arrow on the screen and slide it all the way to the right. A set of icons will appear. If the icons do not appear, press the same button at any time to display the main icon screen. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Touch the "Messages" icon at the bottom of the screen. This icon is green and shows a white cartoon balloon. A list of messages will appear.
4) Touch the message specified by the Task Screen. The messages will be identified by the names of the fictitious senders of the message. The message will contain a well known phrase which is missing one or more key words. The task is to determine what word or words are missing and then reply to the message by supplying the missing words required to complete the well known phrase.
    a. If you don't know the answer, please create a reply message that says something like "Don't know" or "Not sure." It is important that you reply in some way to each message.
    b. If you select the wrong message, you can return to the list by touching the "Messages" icon at the upper left of the screen.
5) At the bottom of the screen, left of the blue "Send" icon is a white space. Touch this white space and a keyboard will appear. Enter the missing words and then touch the blue "Send" icon located to the right of the text you have entered.
    a. If you make an error use the "Delete" icon on the screen (just to the right of the bottom row of letters). You need not type the entire phrase, but only those words which are missing.
6) After sending each message, touch the blue "Messages" icon at the upper left of the screen to return to the initial message screen and then press the rounded square button below the screen to return to the main icon screen.
7) At this point the task is complete and you should immediately press the "Done" button on the Task Screen to display the next message identifier.
8) Continue performing the task in this manner until the lead vehicle disappears.

If you make an error, press the rounded square button below the screen to return to the main icon screen and start over. If the screen goes blank, press the same button, then place your thumb on the arrow on the screen and slide it all the way to the right to unlock the screen.

Any questions before we practice this task?

Blackberry 10-Digit Dialing Task

In this task, you will use the Blackberry phone to dial 10-digit phone numbers. The phone numbers will be presented on the Task Screen either as the 10-digit number or as a label that will prompt you to enter a well-known10-digit number. For example, a label could be "Call Home." We will use only labels that you have provided to us. In either case, you should enter a 10-digit phone number starting with the 3-digit area code followed by the 7-digit number. Each trial will require that you complete as many phone dialing tasks as possible.

1) The first phone number will appear on the Task Screen shortly after the lead vehicle appears. It will be accompanied by an auditory signal to indicate the task has started.
2) If the phone is locked, unlock the phone by pressing the button with the red handset icon at the upper right of the array of buttons. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Dial the 10-digit number using the digit buttons on the left-hand side of the keyboard.
    a. If you make an error, use the "Delete" button on the right-hand side of the keyboard to erase an incorrect number or numbers.
4) Press the "Call" button (the green handset button) located on the left side of the phone. Then immediately press the 'End Call' button (the red handset button) at the upper right. This is the same button you used to unlock the phone. Once the call has ended, press the red handset button again to return to the main menu.
5) At this point the task is complete and you should immediately press the "Done" button on the Task Screen to display the next phone number to be dialed.
6) Continue performing the task in this manner until the lead vehicle disappears.

If at any time the screen goes blank, unlock the phone by pressing the red handset button at the upper right of the array of buttons. If you make an error, you can always press the "Back" button or the red handset button at any time to return to the main menu.

Any questions before we practice this task?

Blackberry Contact Calling Task

In this task, you will use the Blackberry phone to dial a phone number by selecting a designated contact. The contact names are fictitious and are preloaded into the phone. Names of contacts will be presented on the Task Screen. Each trial will require that you complete as many contact calling tasks as possible.

1) The first contact will appear on the Task Screen shortly after the lead vehicle appears. It will be accompanied by an auditory signal to indicate the task has started.
2) If the phone is locked, unlock the phone by pressing the button with the red handset icon at the upper right of the array of buttons. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Select "Address Book" (located on the left side of the top row of on-screen icons). To do so, use the scroll ball in the center of the phone. Move your thumb across it to highlight the "Address Book" icon, and then press the scroll ball to select it. This will open a list of contacts, which is organized alphabetically by first name and then last name. You will need to use the scroll ball to scroll through this list to find the correct contact.
4) When you have located the name that is shown on the Task Screen, scroll down the list to highlight the contact.
5) Once the correct contact is highlighted, press the "Call" button (the green handset button) to initiate the phone call. Then immediately press the "End Call" button (red handset button) to end the call. This is the same button you used to unlock the phone. Once the call has ended, press the red handset button again to return to the main menu.
6) At this point the task is complete and you should immediately press the "Done" button on the Task Screen to display the next contact to be called.
7) Continue performing the task in this manner until the lead vehicle disappears.

If at any time the screen goes blank, unlock the phone by pressing the red handset button at the upper right of the array of buttons. If you make an error, you can always press the "Back" button or the red handset button at any time to return to the main menu.

Any questions before we practice this task?

Blackberry Text Messaging Task

In this task, you will use the Blackberry phone for text messaging. You will perform this task by retrieving a text message, and creating a text message in reply to it. Each trial will require that you complete as many text message tasks as possible.

1) Shortly after the lead vehicle appears, the task screen will display the name of a contact whose text message you are to read. It will be accompanied by an auditory signal to indicate the task has started.
2) If the phone is locked, unlock the phone by pressing the button with the red handset icon at the upper right of the array of buttons. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Select the "Messages" icon which is located in the upper left of the screen. To do so, use the scroll ball in the center of the phone. Move your finger across it to highlight the "Messages" icon, and then press the scroll ball to select it. A list of messages will appear.
4) Choose the message specified by the Task Screen and open it by highlighting it with the scroll ball then clicking the scroll ball to open it. The messages will be identified by the names of the fictitious senders of the message. The message will contain a well known phrase which is missing one or more key words. The task is to determine what word or words are missing and then reply to the message by supplying the missing words required to complete the well known phrase.
    a. If you don't know the answer, please create a reply message that says something like "Don't know" or "Not sure." It is important that you reply in some way to each message.
    b. If you select the wrong message, you can return to the list by pressing the "Back" button.
5) To reply to the message, click the scroll ball and select "Reply" from the dropdown menu by highlighting it and clicking it. Enter the missing words in the subject line and click the scroll ball and select "Send" from the dropdown menu by highlighting and clicking it. Then, press the red handset button at the upper right of the array of buttons to return to the main menu.
6) At this point the task is complete and you should immediately press the "Done" button on the Task Screen to display the next message identifier.
7) Continue performing the task in this manner until the lead vehicle disappears.

If at any time the screen goes blank, unlock the phone by pressing the red handset button at the upper right of the array of buttons. If you make an error, you can always press the "Back" button or the red handset button at any time to return to the main menu.

Any questions before we practice this task?

[The following is an experimenter checklist showing the steps followed during a typical test session, including when the preceding instruction scripts are read.]

Task Type	Training Description	Completed
Overview Training	*Complete Participant Information Summary (ICF)*	√
	Read Simulator Orientation	√
Monetary Rewards <u>(Not for All)</u>	***(IF APPLICABLE, Incentivized Participant (Y/N): _________)*** *Read Monetary Rewards (give copy to participant to look at)* *Not incentivized: no other Instructions.*	√
RSME	*Read Rating Scale Mental Effort (RSME) Instructions (show scale to participant, scale stays in vehicle)*	√
Eye Tracker Calibration, Boxology	Start eye tracker setup process to adjust cameras, adds stickers, and so on (use ET document / instructions)	√
	Read Boxology Calibration Instructions	√
	Record Boxology file with participant	√
DT Training	*Read Target Detection Task (DT) Instructions. Example STI files on screen:* ***ALL_ON.Om, FAM150.evt***	√
	Practice Target Detection Task (30 sec, stationary). STI files for practice: **MDT_prof1.Om, FAM150.evt**	√
CF Training	*Read Driving Task Instructions (this covers car following too)*	√
STI Familiarization Drive	**Scenario file: FAM150.evt; parameter file: MDT_prof1_no_sound.Om; Output: Test.dat**. (Drive straight for 1 minute, stop & starts but no need to do DT yet, start responding to DT after 1st minute when you hear "*<u>BEGIN DETECTION TASK NOW</u>*", then do straight for 2 more minutes with DT practice.)	√
Car Following Familiarization Drive, STI	**Scenario: PRAC150.evt; parameter: no_dt.Om; Output: Test.dat.** (Now we're adding car following, **(**No DT) Practice car following on straight for 1.5 minutes.)	√
CF & DT Familiarization Drive, STI	**Scenario: PRAC150.evt; parameter: MDT_prof1.Om; Output: Test.dat.** (Practice car following and detection task combination, 1.5 minutes.)	√
RSME / Feedback	Ask sub to provide RSME number ____, then provide feedback on CF and DT ____________________	√
Break	Participant can take break if needed	√
Boxology	Record Boxology file with participant; ***Start logging eye tracker***	√
<u>Use Experimenter Sheet</u> to determine Baseline / Secondary Task Main Trial Order. If Baseline Main Trial, then there is no secondary task instructions or practice, just run practice/main trials on exp sheet (take Breaks when most appropriate, after the blocks of trials).		
<u>If Break Needed After a Block of Main Trials (Below)</u>	After block of main trials, offer participant a Break. If Break taken: stop eye tracker logging, take break, and then do boxology and ***start logging again*** after the break. Otherwise, move on to next block of tasks, not stopping eye tracker.	√
	(If Break taken) Record Boxology file with participant	√
	(If Break taken) ***Start logging eye tracker*** again	√
1st Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial ________________*	√
2nd Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial ________________*	√
3rd Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial ________________*	√
4th Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial ________________*	√
5th Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial ________________*	√
6th Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial ________________*	√

7th Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial* ________________	√
8th Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial* ________________	√
9th Main Trial	*Secondary Task Instructions, Stationary Practice, Practice Trial, then Main Trial* ________________	√
Eye Tracker Logging, Boxology	Stop eye tracker logging	√
	Record final Boxology file with participant	√
Wrap Up	Simulator Sickness Questionnaire, Post-Test Questionnaire, Copy of ICF, Payment review and signed Receipt of Payment (for accounting purposes)	√

[The following is a reduced example of an experimenter sheet used for setup and tracking of practice and main trials (inputs, outputs and performance).]

Male, Age Range: 25 - 34, Incentives: YES, Subject 01												
Name: , Date: , Root Video Name:									**Performance Ratings [1=Poor, 2=Acceptable, 3=Good]**			
Trial	Device	2ndary	2ndary Input	Scenario File	Param. File	STIfile Out	2ndary Out	RSME	CF	DT	2ndary	Pay
Make sure Eye Tracker & video are logging. Refresh power to car before radio/navi tasks (car shuts off 1hr.)												
P	None	None	None	PRAC150	MDTprof1	Test	None				None	
1	None	None	Baseline	CF150	MDTprof2	S01M01	None				None	
P	Radio	Tuning	PracRADIO	PRAC150	MDTprof1	Test	S01P_02					
2	Radio	Tuning	mRADIO	CF150	MDTprof2	S01M02	S01M_02					
P	Navi	Address	PracADD	PRAC150	MDTprof1	Test	S01P_03					
3	Navi	Address	mADD	CF150	MDTprof2	S01M03	S01M_03					
P	iPhone	Dialing	PracDIAL01M	PRAC150	MDTprof1	Test	S01P_04					
4	iPhone	Dialing	mDIALI01M	CF150	MDTprof2	S01M04	S01M_04					
P	iPhone	Contact	PracCONT	PRAC150	MDTprof1	Test	S01P_05					
5	iPhone	Contact	mCONTACTI	CF150	MDTprof2	S01M05	S01M_05					
P	iPhone	Text	PracTEXT	PRAC150	MDTprof1	Test	S01P_06					
6	iPhone	Text	mTEXTI	CF150	MDTprof2	S01M06	S01M_06					
P	Berry	Text	PracTEXT	PRAC150	MDTprof1	Test	S01P_07					
7	Berry	Text	mTEXTB	CF150	MDTprof2	S01M07	S01M_07					
P	Berry	Dialing	PracDIAL01M	PRAC150	MDTprof1	Test	S01P_08					
8	Berry	Dialing	mDIALB01M	CF150	MDTprof2	S01M08	S01M_08					
P	Berry	Contact	PracCONT	PRAC150	MDTprof1	Test	S01P_09					
9	Berry	Contact	mCONTACTB	CF150	MDTprof2	S01M09	S01M_09					
Turn off eye tracker logging / tracking event to save main test series file, record another boxology, simulator questionnaire, post-test questionnaire, pay participant, make sure they have copy of ICF, make sure we have a receipt of payment signed.												

[The following is a datasheet used by the experimenters to track participant performance.]

Participant Number: ____________ Date: ____

Main Trials	CF %	Hdwy	Hdwy SD	2ndary Completed	2ndary Errors	DT Button / Target	DT Incorrect	DT Miss	Notes
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Practice	**CF %**	**Hdwy**	**Hdwy SD**	**2ndary Completed**	**2ndary Errors**	**DT Button / Target**	**DT Incorrect**	**DT Miss**	**Notes**
P1									
P2									
P3									
P4									
P5									
P6									
P7									
P8									
P9									
P10									

[The following are the main trial stimuli for each of the secondary tasks.]

Based on the instructions provided to the participants, their goal was to complete as many tasks as possible in the timeframe allotted during the main trials. Thus, these task stimuli would have been presented by the Task Screen to participants one at a time in the order shown. Upon pressing the 'Done' button on the Task Screen, a participant would see the next secondary task stimuli in the list of the task type he / she was working on for a particular main trial.

Main Trials, Task Type	**Stimuli Order**	**Main Trial Stimuli**
Radio Tuning	1	AM 630
	2	FM 93.1
	3	AM 870
	4	FM 88.3
	5	AM 1110
	6	FM 97.9
	7	AM 1350
	8	FM 102.7
	9	AM 1590
	10	FM 107.5
	11	AM 1230
	12	FM 105.1
	13	AM 990
	14	FM 102.3
Destination Entry	1	50 Holmes Ct, Champaign, IL
	2	8590 Winton Rd, Cincinnati, OH
	3	602 State Ave, Cincinnati, OH
	4	951 Chicago Ave, Oak Park, IL
	5	345 Olentangy St, Columbus, OH
10-Digit Dialing, iPhone	1-14	Stimuli alternated between dialing real numbers provided/known by the participant (listed as 'Labels' on Task Screen) and dialing real 10-digit local numbers (Labels and numbers not listed here for confidentiality purposes.)
Contact Dialing, iPhone	1	Anthony Brown
	2	Christopher Davis
	3	David Johnson
	4	Elizabeth Davis
	5	Eric Johnson
	6	Louis Jones
	7	Linda Johnson
	8	Rhonda Jones
	9	Ann Smith
	10	Anthony Miller
	11	Brian Smith
	12	David Williams
	13	David Smith
	14	Eric Williams

Text Messaging, iPhone	1	Raymond Thompson – 'getting away with ******'
	2	Donna Harris – 'time ***** when you're having fun'
	3	Maria Garcia – 'whatever ****** your boat'
	4	Henry Martin – 'little red ****** hood'
	5	Dennis White – 'the wicked ***** of the west'
	6	Ronald Jackson – 'hook line and ******'
	7	Kevin Moore – 'finders keepers losers *******'
10-Digit Dialing, Blackberry	1-14	Stimuli alternated between dialing real 10-digit local numbers and real numbers provided/known by the participant (listed as 'Labels' on Task Screen) (Labels and numbers not listed here for confidentiality purposes.)
Contact Dialing, Blackberry	1	John Anderson
	2	Louis Brown
	3	Robert Davis
	4	Rhonda Brown
	5	Ann Johnson
	6	Carol Jones
	7	Brian Johnson
	8	Dorothy Jones
	9	Jennifer Miller
	10	Jennifer Jones
	11	Louis Miller
	12	Paul Smith
	13	Rhonda Miller
	14	Ann Williams
Text Messaging, Blackberry	1	Cynthia Lopez – 'signed sealed ********* I'm yours'
	2	Sarah Taylor – '******** is a virtue'
	3	Juan Martinez – 'willy wonka's ********* factory'
	4	Kevin Moore – 'finders keepers losers *******'
	5	Ronald Jackson – 'hook line and ******'
	6	Dennis White – 'the wicked ***** of the west'
	7	Henry Martin – 'little red ****** hood'

DOT HS 811 510
August 2011

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