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16. Abstract

Text messaging is no longer limited to manual-entry. There are several mobile applications that aim to assist the driver in sending and receiving text messages by incorporating a voice-to-text component. To date, there has been no published research that evaluates the impact of voice-to-text mobile applications on driver behavior and safety. To address this issue, 43 participants drove an instrumented vehicle on a closed course for a baseline as well as three texting conditions: manual-entry, using Siri, and using Vlingo. Results indicate that driver reaction times were nearly two times slower than the baseline condition, no matter which texting method was used. Eye gazes to the forward roadway also significantly decreased compared to baseline, no matter which texting method was used. Additionally, it took drivers longer to complete the same texting task using the voice-to-text applications than it did when texting manually, though Siri produced the fewest errors. Self-assessment feedback revealed that participants felt less safe using any of the three texting methods compared to the baseline, but felt safer using either voice-to-text application than when manually texting. These results have immediate implications for improving our understanding of the dangers of texting while driving and the potential safety improvements of using voice-to-text options.

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An Evaluation of the Effectiveness of Voice-to-Text Programs at Reducing Incidences of Distracted Driving

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ABSTRACT

Text messaging is no longer limited to manual-entry. There are several mobile applications that aim to assist the driver in sending and receiving text messages by incorporating a voice-to-text component. To date, there has been no published research that evaluates the impact of voice-to-text mobile applications on driver behavior and safety. To address this issue, 43 participants drove an instrumented vehicle on a closed course for a baseline as well as three texting conditions: manual-entry, using Siri, and using Vlingo. Results indicate that driver reaction times were nearly two times slower than the baseline condition, no matter which texting method was used. Eye gazes to the forward roadway also significantly decreased compared to baseline, no matter which texting method was used. Additionally, it took drivers longer to complete the same texting task using the voice-to-text applications than it did when texting manually, though Siri produced the fewest errors. Self-assessment feedback revealed that participants felt less safe using any of the three texting methods compared to the baseline, but felt safer using either voice-to-text application than when manually texting. These results have immediate implications for improving our understanding of the dangers of texting while driving and the potential safety improvements of using voice-to-text options.

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EXECUTIVE SUMMARY

Driver distraction is not a new issue, but it is a continually renewing one due to the advances in technology of both mobile devices and vehicle instrumentation. According to the Cellular Telecommunications Industry Association, the average number of text messages sent in the U.S. *per day* exploded from 31 million in 2002 to 6.1 billion in 2012. To put that into context, if one text message sent per day in the U.S. represented one mile, then in 2002, the number of texts sent per day would represent circling the earth at the equator over 1,200 times. But in 2012, the number of texts sent per day would circle the earth almost 247,000 times! In January 2013, the AAA Foundation for Traffic Safety reported survey results that found that nearly 35% of drivers admitted to reading a text or email while driving in the past month and over 26% admitted to typing one. With the growing burst in smartphone technology, these trends are likely to continue.

Previous research analyzing the effects of manually texting while driving report delayed driver response times, impaired speed maintenance and lateral lane position, significantly less time looking at the forward roadway, and an increase in the number of crash events when texting than when not texting.

As new technology continued to emerge and smartphones became widely prevalent, the use of mobile devices while driving followed suit. Wireless providers and mobile application developers have created voice-to-text software with the intention of reducing the effects of manual-entry texting. However, the driver safety impacts of these types of mobile device voice-to-text applications is unknown. To date, there have been no published research studies that evaluate voice-to-text mobile application technologies for the purpose of text messaging while driving, let alone their impact on driver behavior and safety. The primary objective of this research was to evaluate the effectiveness of these voice-to-text applications at reducing incidences of distracted driving.

In order to pursue the primary objective, researchers selected two different voice-to-text mobile applications for empirical testing: Siri (iPhone) and Vlingo (Android smartphones). Forty-three participants drove an instrumented vehicle on a closed course while sending and receiving text messages according to four different experimental conditions: a baseline, manual texting, texting with Siri, and texting with Vlingo. The order that participants completed each

experimental condition was counterbalanced. In every experimental condition, participants were instructed to maintain a speed of 30 mph, drive straight in their lane, and respond to a periodically illuminating light. In order to be eligible to participate in the driving study, participants had to verify that they were 16 years of age or older, have a valid U.S. driver's license, be fluent in English, and be very familiar with sending/receiving text messages on a smartphone.

During each texting condition, the participant was instructed to complete the same five text messaging tasks: a send-only task, three "read and reply" tasks, and a read-only task. Each task was initiated at the same physical location along the closed course. The text messaging tasks consisted of short phrases to mimic everyday text messaging conversations, and the same script was used for all three texting conditions. Participants were instructed to send the text message generated by the voice-to-text application, whether it correctly heard their speech or not, in order to determine how accurately the software detects the driver's speech.

Performance metrics that were recorded during the driving study for each participant included driver response times, eye gazes to the forward roadway, accuracy of and length of time to complete each text messaging task, and self-performance ratings.

Results were analyzed using SPSS and Excel to perform the analysis of variance. Following each overall F-test, pairwise t-tests were used to compare the mean (average) values between each experimental condition using an alpha = 0.05. The resulting p values and summary statistics were then reported.

Compared to the baseline condition, driver response times were approximately two times slower in any of the three texting conditions, no matter which texting method was used. The mean percentages of eye gazes to the forward roadway were significantly fewer, no matter which texting method was used, when compared to the baseline condition. On average, driver speeds slowed during any of the three texting conditions when compared to the baseline, with the manual texting condition having more speed fluctuations than all other driving conditions. Specifically comparing the two voice-to-text driving conditions to the manual-entry texting condition, in every case it took more time for the driver to complete the same text messaging task using the voice-to-text applications than it did when texting manually. However, the number of errors produced using either voice-to-text application was less than when texting manually, with Siri producing the fewest errors. Self-assessment feedback from participants revealed that

participants felt less safe when engaging in any of the three texting conditions compared to the baseline, but felt safer using either voice-to-text application than when manually texting.

These findings suggest that using voice-to-text applications to send and receive text messages while driving do not increase driver safety compared to manual texting. But as with any research, there is need to investigate this relationship further. However, it was clear that driving performance suffered in any of the texting conditions compared to the baseline condition, which means that texting is not an activity that should be coupled with driving.

INTRODUCTION

According to the Cellular Telecommunications Industry Association, the average number of text messages sent in the U.S. *per day* exploded from 31 million in 2002 to 6.1 billion in 2012 (1). To put that into context, if one text message sent per day in the U.S. represented one mile, then in 2002, the number of texts sent per day would represent circling the earth at the equator over 1,200 times. But in 2012, the number of texts sent per day would circle the earth almost 247,000 times! In January 2013, the AAA Foundation for Traffic Safety reported survey results that found that nearly 35% of drivers admitted to reading a text or email while driving in the past month and over 26% admitted to typing one (2). Another shocking statistic revealed in an AT&T Mobile Safety Study in 2012 is that the average age a person receives his/her first cellular phone is 12.1 years old—in the U.S. this age is typically found to be a 6th grader (3). With the growing burst in smartphone technology, these trends are likely to continue.

Driver distraction is not a new issue in the research community, but it is a continually renewing one due to the advances in technology of both mobile devices and vehicle instrumentation. Previous research has investigated the effects on driver safety of dialing and talking on cellular phones. A study as early as 1991 by Brookhuis et al., as well as a 2005 study by Törnros and Bolling, evaluated the effects of dialing and talking on a cellular phone either handheld or hands-free (4, 5). Their results indicated that talking on a hands-free device yielded slightly better vehicular control than the handheld conditions, but both scenarios showed more impairment than the no-talking condition. Klauer et al. found in their 2006 naturalistic driving study that dialing on a handheld phone increases the driver's crash risk by 2.8 times, and talking or listening on a handheld phone increases crash risk by 1.3 times (6).

Once texting became more prevalent, many studies endeavored to analyze the effects of manually texting while driving. One such study conducted in 2009 by Hosking et al. used a driving simulator programmed with various emerging threat events, a lane change task, and a car following event (7). Twenty participants sent and received text messages while driving the simulated course. The results of this study indicated that lateral lane position and response time to the emerging events and traffic signs were impaired when either sending or receiving text messages. In addition, their study revealed that drivers spent up to 400 percent more time *not* looking at the forward roadway when texting than when not texting. Another 2009 driving

simulator study by Drews et al. analyzed the simulated driving performance of 40 participants (8). Results indicated texting while driving led to slower response times to a braking vehicle, impairments in speed and lateral lane control, and an increase in the number of crash events when compared to the no-texting condition. A 2011 study by Cooper et al. investigated the effects of reading and writing text-based messages while driving an instrumented vehicle on a closed course (9). Their results indicated that reading or manually entering text while driving led to a reduction in driver reaction time, impairments in the ability to maintain lateral lane position and speed, fewer glances to the forward roadway, and an increase in the overall likelihood of a missed response event when compared to the no-texting condition.

As new technology continued to emerge and smartphones became widely prevalent, the driver-vehicle interaction followed suit. There have been several texting mechanisms recently developed with the intention of reducing the effects of manual-entry texting. For example, automobile manufacturers have developed in-vehicle sync systems like the Ford SYNC and Toyota Entune that have the ability to sync a driver's mobile device to the vehicle's computer system. Although additional research in this area is needed, in-vehicle sync systems are not within the scope of this work (10, 11). Wireless providers and mobile application developers have also created voice-to-text software aimed at alleviating the manual-entry associated with texting. Perhaps the most popular example of this technology at the present time is Siri, which was developed for the iPhone 4S and later models. The software is intended to be the "hands-free" option of the iPhone. A driver can tell Siri to send a text message to a person, and then speak the message to be sent. However, the driver safety impacts of these types of mobile device voice-to-text applications is unknown.

To date, there have been few studies that evaluate manual versus voice-activated in-vehicle tasks, but none have included the task of sending or receiving text messages. In 2004, Jamson et al. studied how driver behavior in a driving simulator was impacted by an email retrieval system (12). The email system would read an email message aloud either automatically or when the driver requested email retrieval. Compared to the driving-only condition, drivers exhibited longer headways, increased response times to roadway events, and shorter times to collisions when engaging in the email-reading task. Also in 2004, Tsimhoni et al. studied how simulated driving behavior was affected by entering an address into a navigational device either by speech recognition or manual typing (13). The results indicated that manual address entry

yielded an increase in the standard deviation of lane position when compared with the speech recognition. Even though the speech recognition had less driver impairment than the manual-entry, results still showed some driver impairment with speech recognition when compared with the driving-only condition. A 2006 literature overview by Barón and Green summarized results from 15 papers that studied the use of speech interfaces for in-vehicle music selection, email processing, dialing, and destination entry (14). Although none of these studies observed speech interfaces for texting while driving, the general results were that participants drove the same or better when using speech interfaces than when using manual interfaces, but that even speech interfaces produced more driver impairment than driving-only conditions.

At the present time, there have been no published research studies that evaluate voice-to-text mobile application technologies for the purpose of text messaging while driving, let alone their impact on driver behavior and safety. Have newer mobile device technologies, such as the increased prevalence of smartphones, led to an increase in texting and driving behavior or changed the way in which drivers send/receive text messages? Of the people who choose to text and drive, what method are they using to accomplish that task? If a driver were to send/receive text messages using a voice-to-text application, is that any safer than manual-entry texting and how does it compare to a no-texting condition?

The primary objective of this research is to evaluate the effectiveness of these voice-to-text applications at reducing incidences of distracted driving. In order to pursue this objective, reasearchers selected two different voice-to-text mobile applications for empirical testing. Drivers operated an instrumented vehicle on a closed course while sending and receiving text messages via different methods. An online survey was also administered to gather information on common methods drivers use to text and to learn about their attitudes regarding texting while driving.

METHODOLOGY

Text messaging mechanisms have expanded in recent years as a result of the increased prevalence of smartphones. The standard flip phone with raised button keys is outdated, and has been predominantly replaced with a touchscreen interface. Furthermore, there is a mobile application for virtually anything a user might think of, from navigational assistance to an application that tells you if a watermelon is perfectly ripe based on the sound it makes when thumped. Included in the pool of available applications are ones that aim to assist the driver in sending and receiving text messages by incorporating a voice-to-text component.

In order to address the primary objective of this research, the project team first developed a text messaging user online survey to determine the most commonly used voice-to-text mobile applications. In addition, this survey gathered feedback on how prevalent text messaging while driving is, and associated attitudes toward this behavior. Once the survey results identified common voice-to-text applications, the project team selected two of these applications to use for a closed course driving study. A closed course driving study was selected over a driving simulator study in order to more closely model normal driving behavior while still maintaining a relatively high level of experimental control and safety for the driver.

The primary research questions that the project team strove to answer were:

- When texting using a voice-to-text application, does driving impairment improve, remain the same, or increase when compared to manual-entry texting and the baseline?
- Are there any significant differences in performance between the two types of voice-to-text applications that were tested?
- How do driver perceptions toward texting while driving compare to their actual performance?

Online Survey

The online survey was created using Survey Monkey® and contained the following sections:

- Introduction and Participant Eligibility
- Demographic Questions
- Driver and Mobile Device Information

- Texting Behavior
- Feelings About Texting While Driving
- Cell Phone Capabilities
- Using Voice-to-Text on Your Cell Phone (If Applicable)
- Vehicle Capabilities
- Using Voice-to-Text in Your Vehicle (If Applicable)
- Opinions About the Safety of Texting While Driving

The full version of the online survey is provided in Appendix A.

Recruiting and Eligibility

The survey was launched on August 9, 2012, and closed on January 4, 2013, and was completed by 239 participants.

The unique survey URL was emailed to multiple contacts from the Texas A&M Transportation Institute's (TTI) participant database, and the researchers requested that they forward the link to anyone they thought would be interested. This method allowed for people from all over the U.S. to participate in the survey. In order to help incentivize participation, the project team issued a raffle drawing for ten $50 Amazon.com online gift card codes. Any participant who completed the survey and voluntarily provided an email address was an eligible entry, and 10 winners were randomly selected and received their prizes.

In order to be eligible to participate in the online survey, participants had to verify that they:

- Are 18 years of age or older
- Have a valid U.S. driver's license
- Are fluent in English
- Have a mobile device capable of sending and receiving text messages

Demographics

Table 1 shows the age and gender demographics of the 239 respondents, where 61% were female and 39% were male.

Table 1. Summary of the demographics for online survey respondents

	18-24	25-29	30-39	40-49	50-59	60 or older	TOTAL
Female	19	21	39	18	33	16	*146*
Male	14	20	23	12	14	10	*93*
TOTAL	*33*	*41*	*62*	*30*	*47*	*26*	***239***

The results of the online survey are presented in the "Findings" section of this report.

Closed Course Testing

Based on the results from the online survey, the two most commonly used voice-to-text mobile applications were Siri (iPhone) and Vlingo (Android smartphones). Therefore, the project team selected these two mobile applications for closed course testing, and purchased an iPhone 4S and a Samsung Galaxy Stellar for the participants to use during the study.

The closed course testing was conducted at Texas A&M University's Riverside Campus, which is a 2000-acre complex of research and training facilities situated 10 miles northwest of Texas A&M University's main campus. The site, formerly an Air Force Base, has large expanses of concrete runways and taxiways that are ideally suited for experimental research and testing in the areas of vehicle performance and handling, visibility, distracted driving, and driver training. Participants drove a closed course along one taxiway and a straight runway at the Riverside Campus and maintained widely paved boundaries for additional safety.

Figure 1. Map of the closed course route

The total distance of the route was 3.8 miles (1.9 miles each direction). Participants began at the start point as shown in Figure 1, drove to the far end of the course, made a U-turn, and ended the course at the same location where they began. This round trip took approximately 8 minutes to complete and participants were instructed to drive 30 mph for each experimental condition.

In order to address the research questions, the experiment was divided into four experimental conditions:

- **Baseline:** The driver was instructed to not send or receive any text messages, but to solely focus on maintaining a speed of 30 mph, drive straight in the marked lane, and respond to the light response task (explained below).

- **Manual Texting:** In addition to driving at 30 mph, staying straight in the marked lane, and responding to the light response task, the driver was also instructed to send and receive text messages using manual-entry.
- **Texting with Siri:** In addition to driving at 30 mph, staying straight in the marked lane, and responding to the light response task, the driver was also instructed to send and receive text messages using the iPhone's Siri voice-to-text program.
- **Texting with Vlingo:** In addition to driving at 30 mph, staying straight in the marked lane, and responding to the light response task, the driver was also instructed to send and receive text messages using the Vlingo voice-to-text program on the Samsung phone.

The order that participants completed each experimental condition was counterbalanced to reduce potential learning biases (Appendix B). Prior to beginning the first experimental condition, each participant was instructed to drive the entire course as a warm-up/practice lap while no data was recorded. This warm-up was meant to ensure that participants were familiar with the route and to reduce the number of interruptions from the experimenter during the recorded laps. After the completion of each experimental condition, the participant answered self-performance rating questions and provided feedback about the driving experience. The data sheet used to record these ratings, comments, and experimenter notes is shown in Appendix C.

Performance metrics that were recorded during the driving study for each participant included:

- Driver response times
- Speed
- GPS (used to measure changes in lateral lane position)
- Gaze tracking
- Accuracy of and length of time to complete text messaging tasks
- Self-performance ratings and comments

The following sections will describe the methods used to collect these performance metrics.

Equipment

Participants drove a 2009 Ford Explorer that was equipped to record the previously mentioned performance metrics (see Figure 2).

Figure 2. Instrumented vehicle used for closed course testing

Driver response times were recorded as the number of seconds it took the driver to press a response button after a green LED light periodically turned on. The light was attached in a fixed location to the top of the dashboard just underneath the driver's eye line such that the light turning on would catch the driver's attention if the driver was focused on the forward roadway (see Figure 3).

Figure 3. Dashboard-mounted light and response button

The light was programmed to begin turning on after a 20-second delay and then would turn on at pseudo-random intervals defined by a normal distribution, with a mean (average) of 45 seconds and a standard deviation of 5 seconds. The light was programmed to remain on for a duration of 15 seconds, unless the driver pressed the response button on the tip of the turn signal rod, which would turn the light off. The program PsychoPy was used to control the light response task, as well as record the response time data at 60 Hz.

The speed and GPS were recorded with a Qstarz BT-Q8181XT GPS receiver that reported the vehicle location at 10 Hz. The GPS receiver is a Wide Area Augmentation System (WAAS), European Geostationary Navigation Overlay Service (EGNOS), and Metropolitan Service Area (MSAS) differential GPS device that uses WGS-84 datum with a position accuracy of 2.5 meters. The receiver was affixed to the passenger side of the front windshield near the rear view mirror. TTI developed the software used to record the incoming GPS data stream into a text file that also allows for single ASCII character keyboard inputs from the researcher in the vehicle to add a flag in the data stream.

The ASCII character input was used to flag the start and end of the text messaging tasks during the study. More specifically, when the participant would pick up the cell phone to begin each task, the experimenter pressed the "S" key to flag the data stream. When the participant put the phone back down, the experimenter pressed the "E" key. This allowed for an easy calculation of the length of time to complete each text messaging task.

The final piece of equipment used in the instrumented vehicle to record a performance metric was the eye-tracking system. The *faceLAB*® eye-tracking system by Seeing Machines, Inc. is primarily driven by software, which is installed on a portable laptop host computer that provides a standard interface (see Figure 4). The *faceLAB*® eye-tracking system is a noninvasive desktop or dashboard-mounted system, which provides much more comfortable and uninhibited use for the participant versus the more traditional head-mounted system. The *faceLAB*® hardware uses a small pod aimed at the subject's face to illuminate the face and eyes with infrared light. The amount of light used is well within the safe limits of exposure and is almost indiscernible. The subject's skin and iris reflect this infrared light. However, the pupil is an opening in the eye, much like a camera's shutter, and does not reflect the infrared light. The result is a sharp contrast between the dark pupil and the surrounding washed-out iris and face. This contrast is significant regardless of the subject's eye color. The image of the subject's face is captured by two small cameras equipped with filters designed to only allow infrared light to pass through. The images from each of these cameras are transmitted to the *faceLAB*® software for processing, where a calibration process allows the software to mathematically map the pupil's location and unique facial features to determine the subject's point of gaze. Furthermore, the *faceLAB*® software also builds a three-dimensional model that displays the subject's point of gaze vectors.

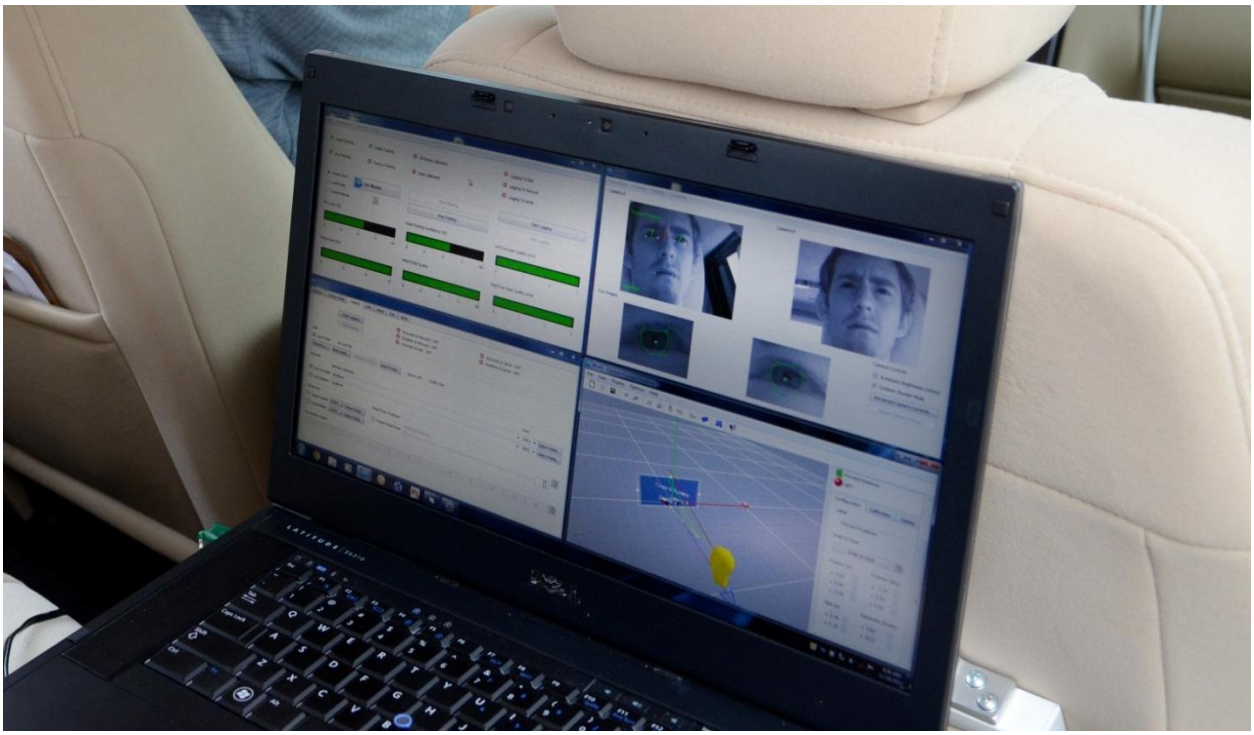

Figure 4. User interface for the eye-tracking system

The project team created a plane in the *faceLAB*® software to represent the forward roadway. This allowed for the data to include a named reference point for when the driver was gazing at the forward roadway. The percent of time that the driver spent looking at the forward roadway was simply the total number of rows in the data stream that denoted that the driver was gazing at the "Forward Roadway" divided by the total number of rows in the data stream.

To allow for future presentations, and to facilitate data reduction by serving as a visual record of each participant's experiment, three different video cameras were used to record the study (see Figure 5). One camera was affixed to the passenger side of the windshield and aimed at the forward roadway to show the driven route and capture how well the driver maintained his/her lane position. A second camera was attached to the passenger side window and captured the driver's profile view. This camera position showed how the driver held the cell phone when texting, as well as a duplicate response light mounted on the center console within view of this camera. This duplicate light was added so that the viewer could observe when the dashboard-mounted light turned on and off in conjunction with what the driver was doing during that time. A third camera was attached to the right air conditioning vent on the vehicle's center stack. This camera was aimed at the driver's face in order to capture where the driver's eyes were gazing.

Figure 5. Camera positions used to record each driving condition

Text Messaging Tasks

For each of the three texting experimental conditions (manual, Siri, and Vlingo), the same text messaging tasks were completed by the driver.

- Task 1: Send Only
- Task 2: Read & Reply
- Task 3: Read & Reply
- Task 4: Read & Reply
- Task 5: Read Only

The first task involved the participant initiating a text message with a contact person. The next three tasks consisted of the subject first reading and then replying to a text message that was received. The fifth and final task was a read-only task, where the driver did not reply.

Because there were two different cell phones used for the driving study, the name of the contact person that the subject was corresponding with depended on which phone the driver was using at the time. For example, if the drivers were using the iPhone to text (either manually or with Siri), then they were corresponding with the pretend contact person named "Sarah," which was, in reality, an experimenter in the vehicle operating the Samsung phone. Oppositely, if the drivers were using the Samsung phone to text (either manually or with Vlingo), then they were corresponding with the pretend contact person named "Alex," who was really an experimenter in the vehicle operating the iPhone. Adequate practice time was given for the participant to become familiar with texting manually, using Siri, and using Vlingo (see Appendix D).

The content of the text messaging tasks was also the same for all three texting conditions. In order to mimic everyday texting, short messages were both sent and received during the experiment. The complete text messaging script is shown in Appendix E. Because the script was the same across all texting conditions, the accuracy of task completion was easily determined. Participants were instructed to send the text message generated by the voice-to-text application, whether it correctly detected their speech or not.

In order to remain consistent across all subjects and experimental conditions, the text messaging tasks were each initiated at the same physical locations along the closed course. Figure 6 shows the location on the closed course route where participants were instructed to initiate each text messaging task. Tasks 1 and 2 were initiated before the driver U-turned, and Tasks 3 through 5 were initiated after U-turning. Because the time to complete each task varied by subject and texting condition, the physical location of the task completion also varied.

Figure 6. Closed course route and texting task initialization locations

As previously mentioned, the start and end of task engagement were flagged in the GPS data stream, where the start of task engagement was declared as the point in time when the driver picked up the cell phone, and the end of task engagement occurred when the driver set the cell phone back down.

Manual-Entry Texting

For the manual-entry text messaging experimental condition, the participants were allowed to choose the cell phone they felt most comfortable using. For example, if a subject's personal cell phone was an iPhone, then that subject could choose to use the study iPhone for the experiment.

Each cell phone had a touchscreen interface, and the keyboard layouts had only minor differences (see Figure 7 and Figure 8).

Figure 7. Keyboard displays on the iPhone

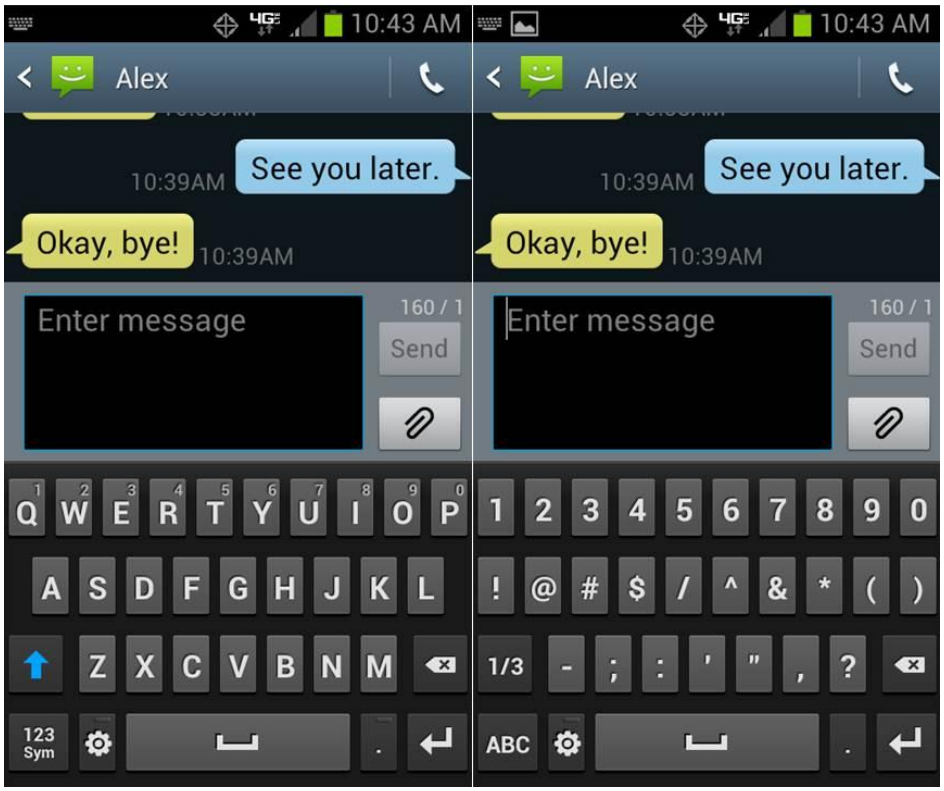

Figure 8. Keyboard displays on the Samsung phone

During the experiment, the T9 and auto-fill features were turned off such that the participants had to manually press/touch each button to produce the text message.

Texting with Siri

Siri is available on iPhone 4S and later models. Siri is a very interactive program, with dialogue exchange back and forth between Siri and the user. In terms of sending and receiving text messages, it is capable of both sending and reading text messages on behalf of the user. Siri does not require that the message recipient be a contact person saved in the phone's address book (i.e., the user could say "Text 555-5555" to send a message to an unnamed contact).

To send a text message using Siri, the user must press and hold the menu button key until the chime sounds, or the prompt "What can I help you with?" appears on the screen (Figure 9).

Figure 9. Input prompt display when Siri is initiated

The user would then say "Text Sarah" (because when the participants used the iPhone, they were corresponding to the experimenter operating the Samsung phone, nicknamed "Sarah"), and Siri would then walk the user through the process of sending a text message. Siri would repeat the input phrase it heard and then prompt the user about the content of the message (see Figure 10).

Figure 10. Display shown when sending a text message using Siri

The participants would then speak the text message they were attempting to send, according to the text messaging script in Appendix E. Siri would not repeat the message that was heard, but would display the content on the screen while asking the users if they were ready to send the message. Recall that the participant was instructed to send the message whether Siri heard the content correctly or not. The participant would then say “Send” or “Yes” and Siri would confirm that the message had been sent (Figure 11).

Figure 11. Display shown to confirm message composition when using Siri

To read a text message using Siri, the user would initiate Siri in the same way as above, but instead of saying "Text Sarah," the user would say "Read message." There was no on-screen visual display to confirm this action, but if Siri heard correctly, the voice would begin the message with, "You have one new text message…[Read the message aloud]." After Siri finished reading the message aloud, Siri would prompt the user as to whether he/she would like to reply or read the message again. In this experiment, the participant was always instructed to say "Reply," except for Task 5, which was a read-only task. For Task 5, once Siri had finished reading the message aloud, the participant returned to the home screen and put the phone back down. For Tasks 2 through 4, after the participant said "Reply," Siri would confirm, both on-screen and audibly, that this response was heard and would prompt the user about the content of the replying message (see Figure 12). The steps that followed were identical to the ones used to send a text message to Sarah.

Figure 12. Display shown when reading and replying to a text message using Siri

If Siri did not understand the participant's verbal command ("Text Sarah," "Reply," "Read Message," etc.), Siri would ask the user to try again. When this event occurred during the experiment, the experimenter instructed the participant to try again until the task had been successfully completed.

Texting with Vlingo

Vlingo is a third-party mobile application that can be installed on Android-based smartphones. It is less interactive than Siri in the sense that it does not read aloud text messages that the user receives. In terms of sending a text message, it is only capable of translating the user's speech to a text message and sending it to a contact person saved in the phone's address book.

To send a text message using Vlingo, the user must press the application icon from the menu screen and then press the "Speak it" button on the Vlingo home screen (Figure 13).

Figure 13. Vlingo application icon and home screen

The screen displays a “Speak now” message when the program is ready to receive the user’s verbal input. Unlike Siri, Vlingo requires the user to say “Text Alex…[desired text message content]” all in one verbal input string. (Recall that when the participants used the Samsung phone, they were corresponding with the experimenter operating the iPhone, nicknamed “Alex.”) The participant would speak the text message according to the script in Appendix E. Once the user finished speaking, the screen would display the message it heard and provide the user the option of editing, sending, or canceling the message. In order to send the message, the participant had to press the “Send” button on the screen. There were occasions during the experiment that the participant would correctly follow these steps, but the message confirmation screen shown in Figure 14 would not be displayed and would instead kick the user back to the Vlingo home screen. When this event occurred, the experimenter instructed the participant to attempt the process again until the message had been sent successfully.

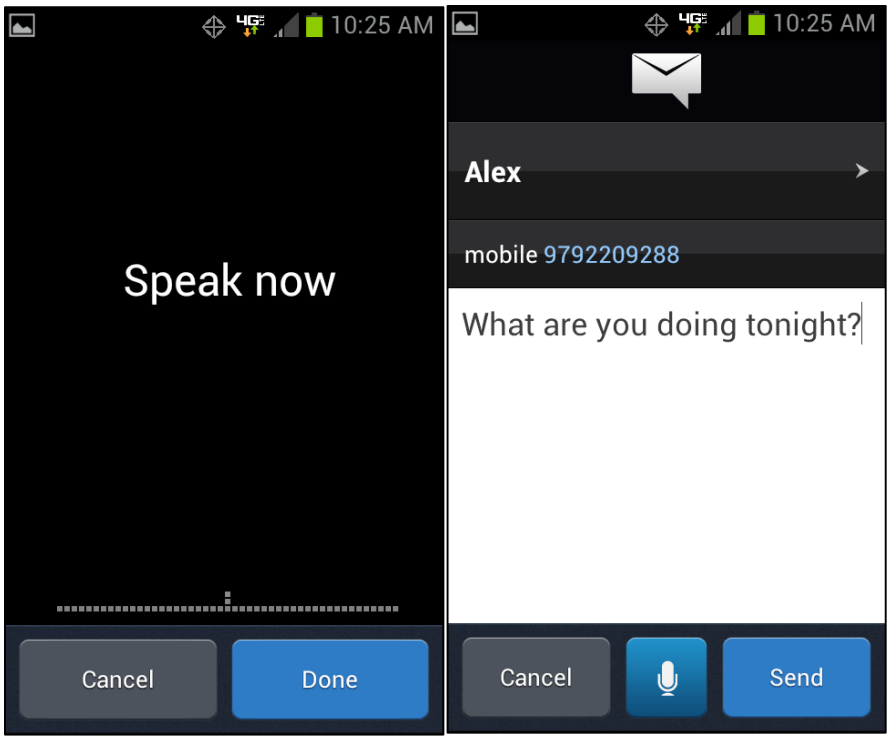

Figure 14. Voice input prompt and message confirmation display when using Vlingo

During the Vlingo-texting condition, the participant would manually read text messages by viewing the Messaging screen. If the task included replying to "Alex," the participant would exit out of the Messaging screen and open the Vlingo application to verbally compose and send the text message (see Figure 15).

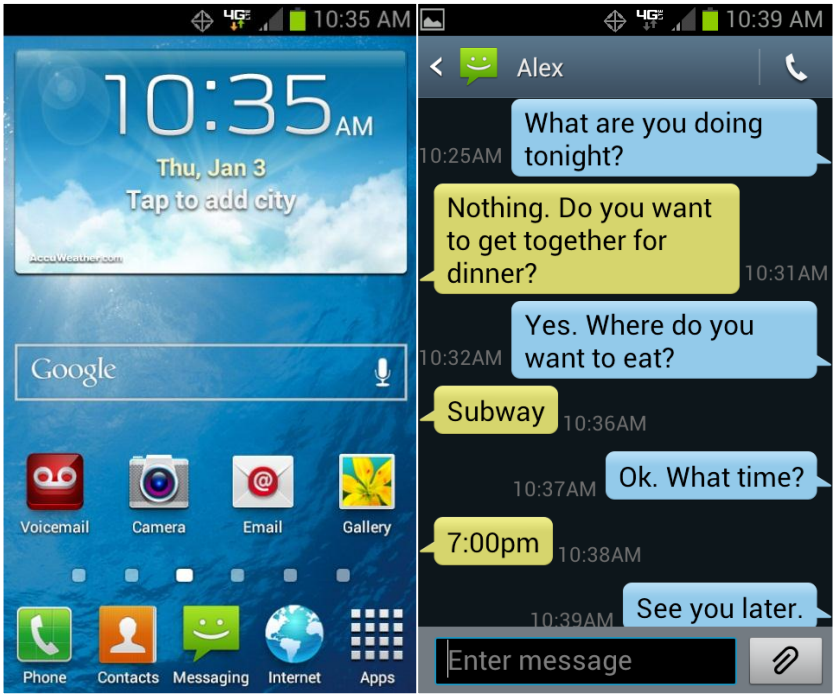

Figure 15. Participants manually read text messages they received when using Vlingo

Demographics

Each participant completed a background survey upon arrival for the study appointment (see Appendix F). The background survey was very similar to the online survey discussed in the previous section. Forty-three participants were recruited in the Bryan/College Station area to complete the driving study. Table 2 shows the age and gender demographics breakdown, where gender was approximately split. Each experiment took no more than two hours to complete, and subjects were each compensated $40 in cash for their participation.

In order to be eligible to participate in the driving study, participants had to verify that they:

- Are 16 years of age or older (if under 18, parental permission was required)
- Have a valid U.S. driver's license
- Are fluent in English
- Are very familiar with sending/receiving text messages on a mobile device, in particular a smartphone

Table 2. Summary of the demographics for closed course participants

	16-17	18-24	25-29	30-39	40-49	50-59	60 or older	TOTAL
Female	1	8	3	1	6	3	1	*23*
Male	1	8	1	2	4	4	0	*20*
TOTAL	*2*	*16*	*4*	*3*	*10*	*7*	*1*	***43***

Of the 43 participants, 42% had an iPhone, 30% had an Android-based smartphone, 2% had a different type of operating system on their smartphone, and 26% did not have a smartphone. Regarding the basic type of interface, 72% of the participants had a touchscreen phone, while the remaining 28% had either a full QWERTY raised keypad phone or a 12-key numerical phone (keys for 0-9, *, #).

Texting Behavior

Participants were asked several questions about their texting behavior. The first question asked participants how many text messages they send/receive on an average day. The answers indicated the following:

- 12% send only 1–5 text messages
- 51% stated they send an average of 6–20 text messages per day
- 35% reported sending 21–99 text messages per day
- 2% said they text 100 or more messages per day
- Zero participants said they do not text every day

When asked the point blank question, "Do you text and drive?" 72% said "Yes" and 28% said "No." Of those participants who answered "No," one person entered a comment that said something to the effect of "only at red lights." If we consider texting while driving to include texting while stopped at a red light, then the percentage of participants who would be classified as "Yes" goes up to 74% and "No" decreases to 26%.

Breaking that down a bit more, the next question asked the participants to select the response that best describes their texting-while-driving behavior. In response, 9% said they "never text while driving," 70% said they "only text at red lights or stop signs when I'm driving," and 21% said they "regularly text and drive (while the vehicle is in motion)." If we again

consider texting at a red light as "texting while driving," then the percentage classified as "Yes" increases to 91% and the "No" group decreases to 9%.

The next two questions asked participants how often they read or write text messages while driving, either while the vehicle is in motion or stopped at a stop sign or red light. Table 3 below summarizes the participant responses.

Table 3. How often participants read or write text messages while driving

	In Motion	**Stopped**
Multiple times a day	16%	29%
Multiple times a week	19%	36%
Multiple times a month	21%	17%
Once a month or less frequently	30%	17%
I never read or write text messages while driving while the vehicle is…	14%	2%

Of all participants, 37% said they have read/written a text message while driving (vehicle in motion and/or stopped at a red light or stop sign) at least once in the past 24 hours; 19% had done so in the past 24–48 hours; 19% had done so in the past week; and 14% had done so in the past 30 days. These results mean that 88% of participants admitted to having read or written a text message while driving in the past 30 days, which is consistent with the "Yes/No" count previously mentioned; however, it is much higher than the results from the AAA survey that was described in the "Introduction" section of this report (2).

Feelings About Texting While Driving

The next section in the background survey asked questions about the participants' feelings and preferences regarding texting while driving. The first two questions asked participants about the level of safety they feel when they read or write text messages while driving. Figure 16 shows the participant responses to those two questions.

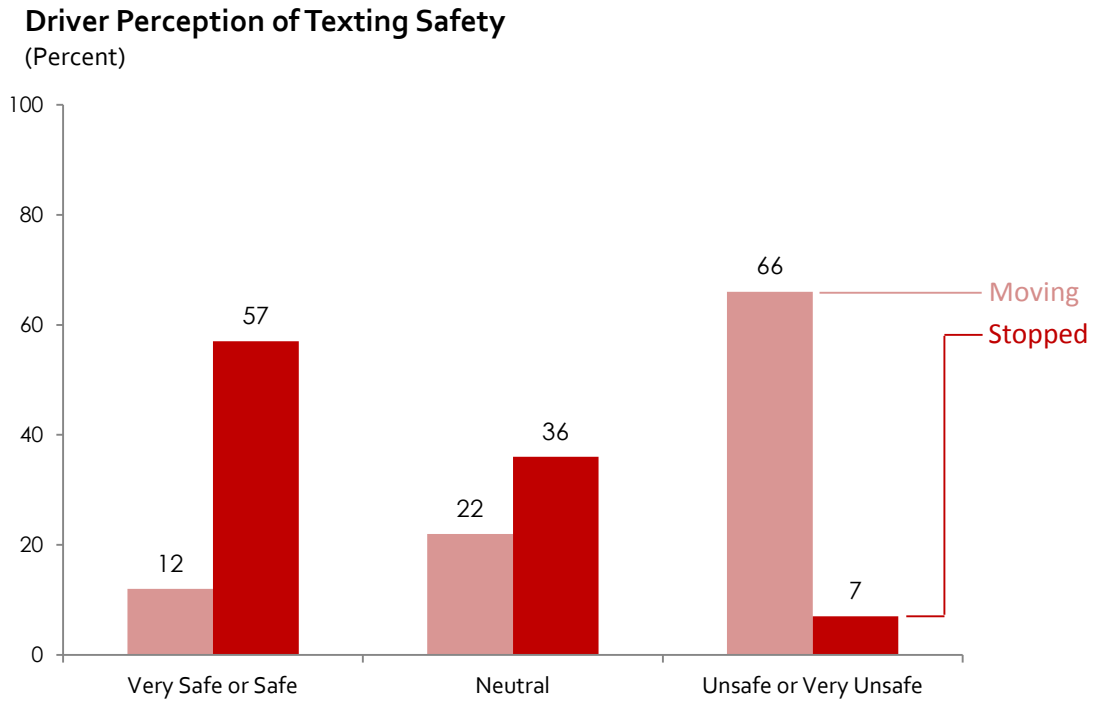

Figure 16. How safe participants feel when reading or writing text messages while driving

Regarding when the vehicle is in motion:

- 66% responded "Unsafe" or "Very Unsafe,"
- 22% were "Neutral," and
- 12% said "Safe" or "Very Safe."

Regarding when the vehicle is stopped at a stop sign or red light, there was almost a mirror image of the "in motion" responses:

- 7% responded "Unsafe" or "Very Unsafe,"
- 36% were "Neutral," and
- 57% said "Safe" or "Very Safe."

These results indicate that participants view sitting in stopped traffic as a safer time to read or write text messages.

The last question of this section asked participants about their preferred method of texting when they are driving. In response, 49% selected their preference to "manually type each letter/number/character"; 23% preferred to "allow T9 or auto-fill to assist while manually

typing"; 12% preferred to use a "voice-to-text recognition app or in-vehicle system (Siri, SYNC, etc.)"; and 16% selected the answer choice that says "I do not text while I'm driving."

Opinions on Texting While Driving

The final two questions sought participant feedback on the safety of texting while driving, both manually and using a voice-to-text feature, and under varying roadway conditions. Recall that the participant answered these questions prior to completing the driving experiment. (A post-experiment questionnaire was given to each subject after finishing the driving study. The results of this questionnaire can be found in the "Findings" section of this report.)

The first question is summarized in Figure 17 below. Results show that participants appeared to agree that texting while driving was very unsafe behavior, but they were less concerned about the danger of texting while stopped at a red light or stop sign.

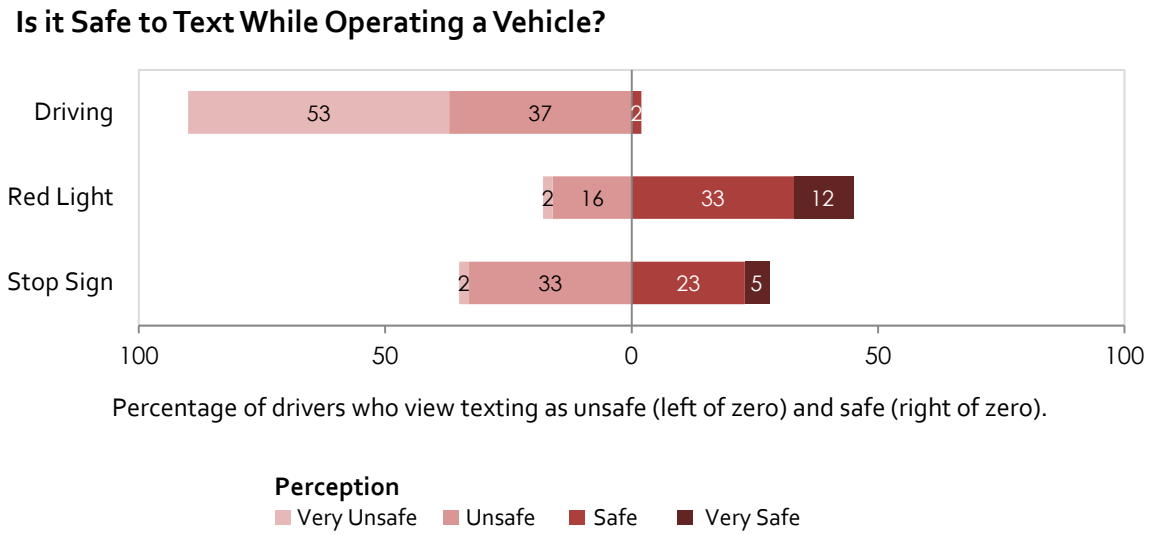

Figure 17. Participant views on the safety of texting while driving

The final question specifically compared manual-entry texting while driving versus voice-to-text applications and the affected change in the ability to drive safely. Answers to this question are summarized in Figure 18.

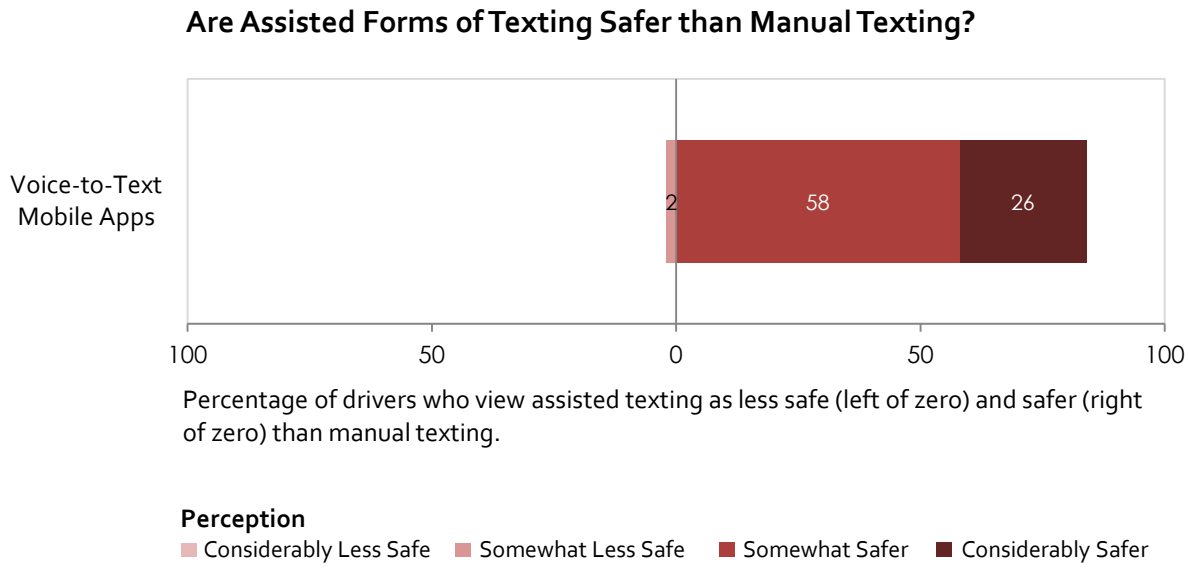

Figure 18. Participant views on the safety of voice-to-text applications versus manual texting

In summary, participants indicated that voice-to-text mobile applications were a safer texting method than manual-entry texting while driving.

Participant Intake, Order of Events, and Verbal Instructions

Upon arrival for the driving study appointment, the participant first consented to participate in the experiment, signed a video release form, and filled out an emergency contact information form. The participant then completed the background survey.

The experimenter provided some initial instructions about the experiment, described how it was structured, and allowed the participant to practice using both study cell phones. The complete set of verbal instructions that the participant was given is shown in Appendix D.

The participant was then escorted to the instrumented vehicle where the experimenter calibrated the eye-tracking system to the individual subject. The participant was allowed to adjust the driver's seat to a comfortable position before calibration. The participant was then given some time to practice responding to the light response task. After completing this step, the participant was directed to the starting point of the closed course and was instructed to drive the entire closed course route as a warm-up/practice lap. This provided an opportunity for the participant to ask questions about the route, where to turn around (U-turn), and where to start and stop.

After the participant completed the warm-up lap, the experimenter asked the participant if he/she was ready to begin the experiment. The participant then drove each of the four recorded laps, with the order of the task depending on the counterbalanced order assigned to that particular subject (see Appendix B). Between each experimental condition, the participant was asked self-performance rating questions and asked for feedback about his/her driving experience (see Appendix C).

Upon completion of the fourth experimental condition, the participant was directed back to the intake office and given a post-experiment questionnaire (see Appendix G) to provide additional feedback about the experiment and mobile device voice-to-text applications he/she used. All of the open-ended responses given in the post-experiment questionnaire are listed in Appendix H. The participant was then given $40 as compensation for his/her time.

FINDINGS

Online Survey Results

The online survey began with several demographic questions, along with questions related to driver and mobile device information (Appendix A).

One survey question asked participants at what age they first acquired a cell phone. Since cellular phones did not become widespread until the 1990s, Table 4 also shows information for younger age demographics. Of those participants 18–24 years of age, the average age they first acquired a cell phone was 14 years old.

Table 4. Average age of first cell phone acquisition

	All Respondents	Respondents Aged 29 and Under	Respondents Aged 18–24
Average Age	26	16	14
Maximum Age	65	21	18
Minimum Age	10	10	10
Median Age	22	16	14
Mode Age	16	16	16

Of all respondents, 49% had an iPhone, 26% had an Android-based smartphone, 9% had a different type of operating system on their smartphone, and 16% did not have a smartphone. Regarding the basic type of interface, 77% of the respondents had a touchscreen phone, while the remaining 23% had either a full QWERTY raised keypad phone or a 12-key numerical phone (keys for 0-9, *, #).

Texting Behavior

Survey participants were asked several questions about their texting behavior. The first question asked respondents how many text messages they send/receive on an average day. Results showed that:

- 30% send only 1–5 text messages
- 40% stated they send an average of 6–20 text messages per day
- 16% reported sending 21–99 text messages per day
- 2% said they text 100 or more messages per day
- 12% said they do not text every day

When asked the point blank question, “Do you text and drive?” 52% said “Yes” and 48% said “No.” Of those who answered “No,” several had comments that said something to the effect of “only at red lights.” If we consider texting while driving to include texting while stopped at a red light, then the percentage of respondents who would be classified as “Yes” goes up to 56% and “No” decreases to 44%.

Breaking that down a bit more, the next question asked the participants to select the response that best describes their texting-while-driving behavior. Of all respondents, 27% said they “never text while driving,” 65% said they “only text at red lights or stop signs when I'm driving,” and 8% said they “regularly text and drive (while the vehicle is in motion).” If we again consider texting at a red light as “texting while driving,” then the percentage classified as “Yes” increases to 73% and the “No” group decreases to 27%. Again, when incorporating participant comments, several who answered “I never text while driving,” admitted to occasionally texting while at a red light. Similarly, several who answered “I only text at red lights or stop signs when I'm driving” admitted to occasionally texting while the vehicle is in motion. That would lead to a final Yes/No split of 74% “Yes” and 26% “No.”

The next two questions asked participants how often they read or write text messages while driving, either while the vehicle is in motion or stopped at a stop sign or red light. Table 5 summarizes the participant responses.

Table 5. How often survey respondents read or write text messages while driving

	In Motion	**Stopped**
Multiple times a day	7%	22%
Multiple times a week	15%	27%
Multiple times a month	15%	20%
Once a month or less frequently	25%	16%
I never read or write text messages while driving while the vehicle is…	38%	15%

Of all respondents, 21% said they have read/written a text message while driving (vehicle in motion and/or stopped at a red light or stop sign) at least once in the past 24 hours; 18% had done so in the past 24–48 hours; 18% had done so in the past week; and 16% had done so in the past 30 days. This breakdown means that 73% of respondents admitted to having read or written a text message while driving in the past 30 days, which is consistent with the "final Yes/No" count previously mentioned; however, it is much higher than the results from the AAA survey that was described in the "Introduction" section of this report (2).

Feelings About Texting While Driving

The next section asked questions about the participants' feelings and preferences regarding texting while driving. The first two questions asked participants about the level of safety they feel when they read or write text messages while driving. Figure 19 shows the results.

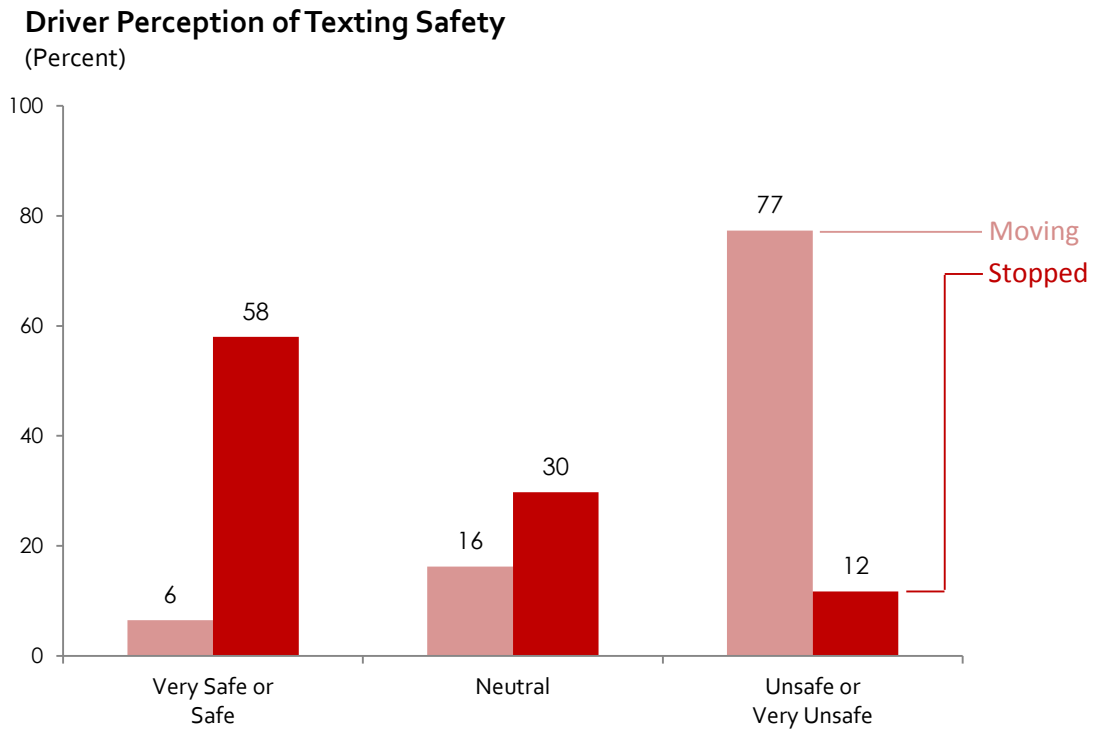

Figure 19. How safe survey respondents feel when reading or writing text messages while driving

Regarding when the vehicle is in motion:

- 77% responded "Unsafe" or "Very Unsafe,"
- 16% were "Neutral," and

- 6% said “Safe” or “Very Safe.”

Regarding when the vehicle is stopped at a stop sign or red light, there was almost a mirror image of the “in motion” responses:

- 12% responded “Unsafe” or “Very Unsafe,”
- 30% were “Neutral,” and
- 58% said “Safe” or “Very Safe.”

These results indicate that respondents view sitting in stopped traffic as a safer time to read or write text messages.

The last question of this section asked participants about their preferred method of texting when they are driving. In response, 25% selected their preference to “manually type each letter/number/character”; 17% preferred to “allow T9 or auto-fill to assist while manually typing”; 19% prefer to use a “voice-to-text recognition app or in-vehicle system (Siri, SYNC, etc.)”; and 39% selected the answer choice that says “I do not text while I’m driving.” A couple of respondents commented that while they are driving, they typically ask a passenger to text on their behalf.

Voice-to-Text Capabilities and Behavior

Of all respondents, 45% had mobile devices capable of voice-to-text applications. Of those whose phones had voice-to-text capabilities, 20% used the voice-to-text feature on a daily or weekly basis, while 17% used it rarely, and 63% say they never used it. Most said the voice-to-text feature on their phone did not work well or they simply forgot to use it. A few said they were unprepared to use it when they needed to, or they found it hard to use.

Of those who did use a voice-to-text application to send/receive text messages, the three most popular applications were Siri, the phone’s OEM voice-to-text feature (commonly found on the keyboard display on touchscreen phones), and Vlingo. Respondents rated the performance of their voice-to-text applications as shown in Table 6.

Table 6. Performance ratings of voice-to-text applications

	Very Poor	Poor	Neutral	Good	Very Good
Usefulness	1%	13%	28%	32%	26%
Effective translation into text	8%	23%	31%	28%	10%
Price	3%	10%	52%	15%	20%
Increasing my safety while texting and driving	4%	11%	42%	31%	12%

Respondents who have voice-to-text capabilities on their cell phones were asked how they feel when using this feature to read or write text messages while driving, both while the vehicle is in motion and while stopped at a red light or stop sign. Regarding when the vehicle is in motion:

- 39% responded "Unsafe" or "Very Unsafe,"
- 43% were "Neutral," and
- 18% said "Safe" or "Very Safe."

Regarding when the vehicle is stopped at a stop sign or red light, there was again an almost mirror image in responses:

- 8% responded "Unsafe" or "Very Unsafe,"
- 28% were "Neutral," and
- 64% said "Safe" or "Very Safe."

Only 4% of all respondents primarily drive a vehicle with voice-to-text capabilities. Of those that do drive a vehicle with voice-to-text capabilities, only two respondents said they use it regularly.

Opinions on Texting While Driving

The final two questions sought participant feedback on the safety of texting while driving, both manually and using a voice-to-text feature, and under varying roadway conditions. The first question asked respondents how safe or unsafe they consider texting while driving, stopped at a red light, and stopped at a stop sign. The results are summarized in Figure 20 below. In other words, respondents appeared to agree that texting while driving was very unsafe

behavior but were less concerned about the danger of texting while stopped at a red light or stop sign.

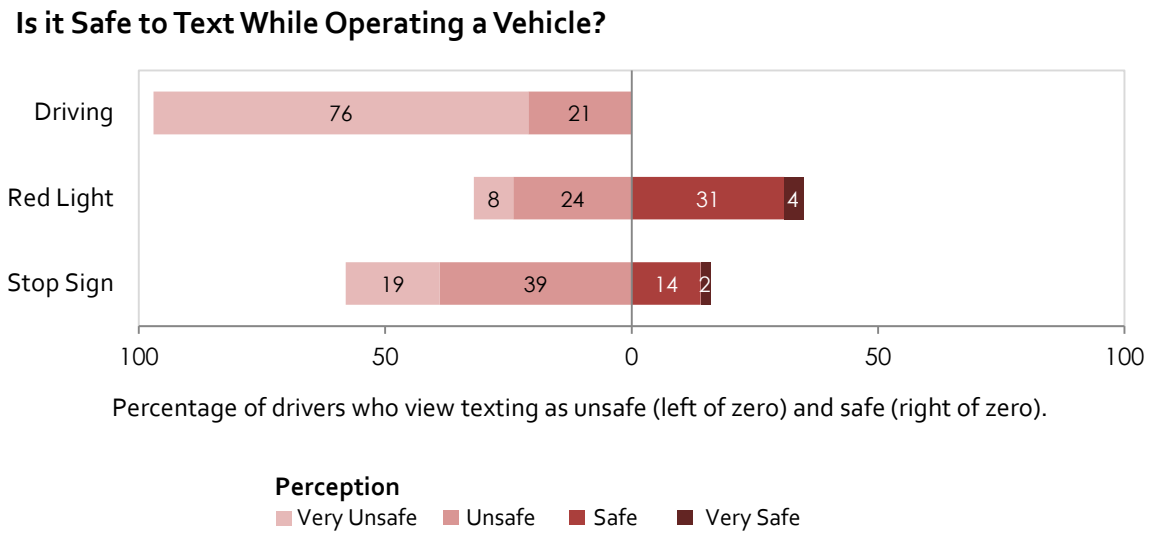

Figure 20. Survey respondent views on the safety of texting while driving

The final question specifically compared manual-entry texting while driving versus voice-to-text programs and the affected change in the ability to drive safely. This question is summarized in Figure 21. The question asked, "Compared to manual texting while driving, what effect do the following technologies have on the ability to drive safely while texting?"

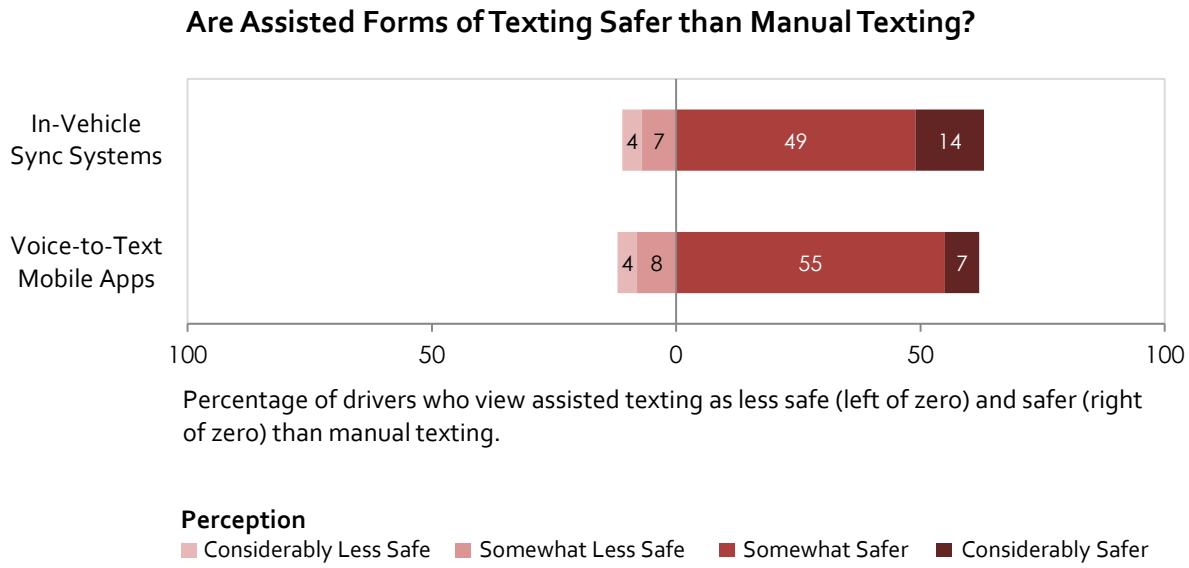

Figure 21. Survey respondent views on the safety of voice-to-text applications versus manual texting

In summary, respondents indicated that either voice-to-text mobile applications or in-vehicle sync systems were a safer texting method than manual-entry texting while driving.

Closed Course Testing Results

The second phase of the project was to select one or more popular voice-to-text technology (based on the results of the online survey) for closed course testing. Since so few survey respondents primarily drove a vehicle with voice-to-text capability, in-vehicle sync systems were not selected for closed course testing. However, as these systems continue to infiltrate the automotive marketplace, future research should be conducted to determine the safety effects of such systems on driver distraction.

Researchers selected two voice-to-text mobile applications for closed course testing: Siri and Vlingo. Each participant drove the closed course four times: a baseline, manual texting, texting with Siri, and texting with Vlingo. The results of the closed course testing are described in the following sections.

All data files were reduced according to the same time periods. In other words, because there were three different data acquisition programs recording the data, each began at slightly different time stamps, so each data set had to be "trimmed" to begin and end at the same time. When trimming the data files, the following assumptions and methods were applied:

- The official "start point" to begin monitoring driving behavior was defined as the time that the driver's speed first reached the instructed speed of 30 mph, or at the onset of the first response light, whichever of these two events occurred first.
- Halfway through the driving course, the driver had to make a U-turn to drive back to the start point in the opposite direction (Figure 1). This U-turn was trimmed out of the data set.
- The beginning of the U-turn was defined as the time that the driver's speed dropped below 30 mph approaching the U-turn location or when the driver completed the second text messaging task (a few participants were unable to complete the task prior to beginning the U-turn), whichever event occurred last.
- The end of the U-turn was defined as the time that the driver's speed reached or exceeded 30 mph after making the U-turn, or when the response light turned on as the driver was nearly (within 5 mph) at 30 mph, whichever event occurred first.
- The "end point" of monitoring driving behavior was defined as the time when the driver's speed dropped below 30 mph approaching the end point location or when the driver completed the final text messaging task, whichever event occurred last.

Data analyses are described and presented visually, including charts, box-and-whisker-plots, and statistical analyses tables. The box-and-whisker-plots presented in this report were generated using the convention that the "box" represents the interquartile range (IQR), or the range between the 25th and 75th percentiles ("middle fifty") of the data set. The central line in the box represents the median data point (see Figure 22). The top part of the box represents the 75th percentile and the bottom represents the 25th percentile. Thus, the relative position of the median score within the 75th and 25th percentiles can give some indication about the skew of the data for each dependent measure. The "whiskers" represent the data that lay outside the interquartile range, where the top point represents the maximum data value, and the bottom point represents the minimum. The mean (average) value is represented using a small black diamond.

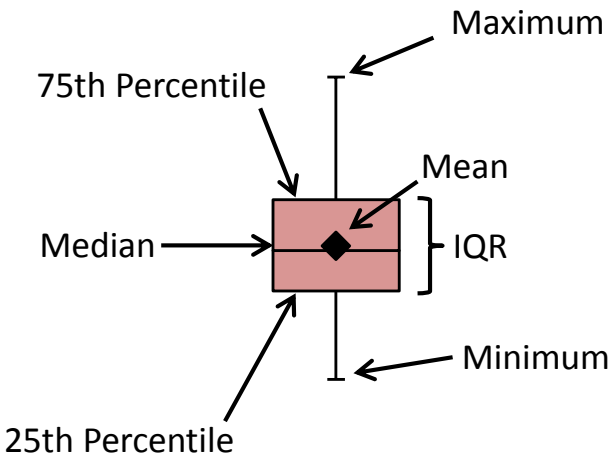

Figure 22. Diagram of box-and-whisker plot

Results were analyzed using SPSS and Excel to perform the analysis of variance. Following each overall F-test, pairwise t-tests were used to compare mean (average) values between each experimental condition using an alpha = 0.05. The resulting p values and summary statistics are reported in data tables in the following sections.

Driver Response Times

It is important to note that due to the programming parameters of the response light task (initial onset delay of 20 seconds, remain on for 15 seconds unless response event received, programmed to turn on at pseudo-random intervals defined by a normal distribution with a mean of 45 seconds and a standard deviation of 5 seconds) and the intermittent nature of the driver's text messaging task engagement (Figure 6), there were times when the driver was responding to the light onset even though they were not engaged in a texting task. In order to not skew the mean response time data, the task engagement events were marked in the data streams, so the times when the light onset occurred during task engagement could be readily identified. Thus, response time events were classified as either engaged in a texting task or not. Since one of the experimental conditions was a baseline, all of the response events from this condition were classified as non-task engagement. For the other three experimental conditions (manual texting or texting via Siri or Vlingo), there were both task engagement and non-task engagement response events, and only task engagement events were analyzed.

Missed response events were *not* included in mean response time calculations, but were counted and analyzed separately as shown in the next section.

Analysis of the light response data for each driving condition indicated that compared to the baseline condition, response times were significantly slower in the manual, Siri, and Vlingo conditions. When texting manually, response times were delayed by a factor of 1.92; when texting using Siri, response times were delayed by a factor of 1.87; and when texting with Vlingo, response times were delayed by a factor of 1.77. Statistical analysis of these results indicated that response times in any of the three texting conditions were significantly different than response times in the baseline condition. However, the response times of each of the three texting conditions were not significantly different from one another. In summary, compared to the baseline condition, response times were significantly delayed no matter which texting method was used, and response times were relatively similar within each texting method.

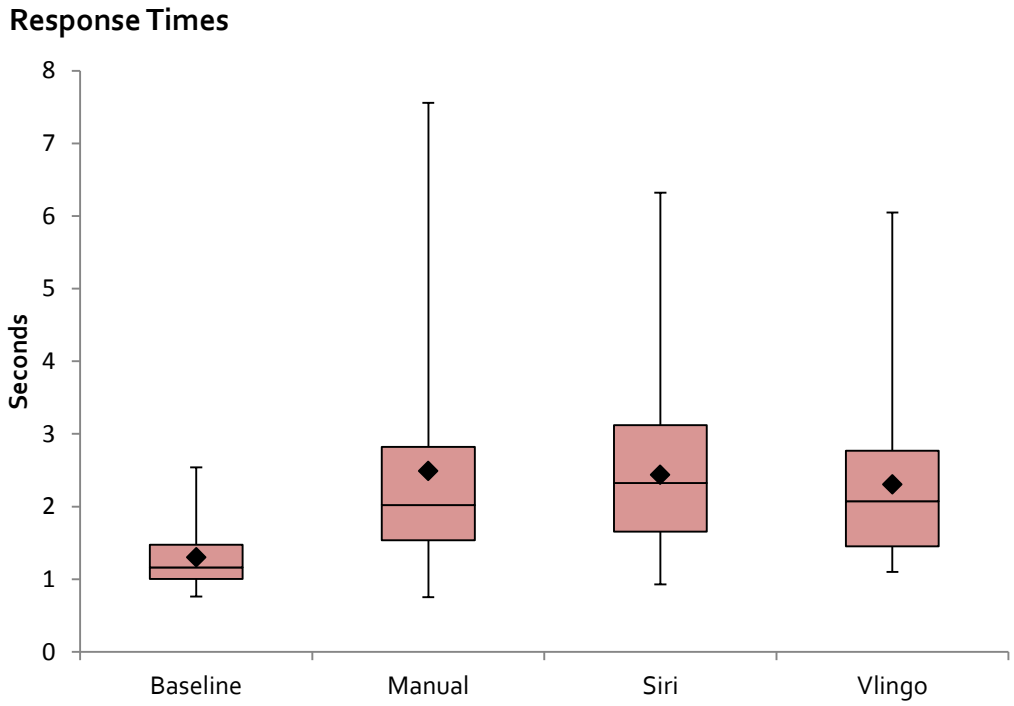

Figure 23. Box-and-whisker plot for driver response times

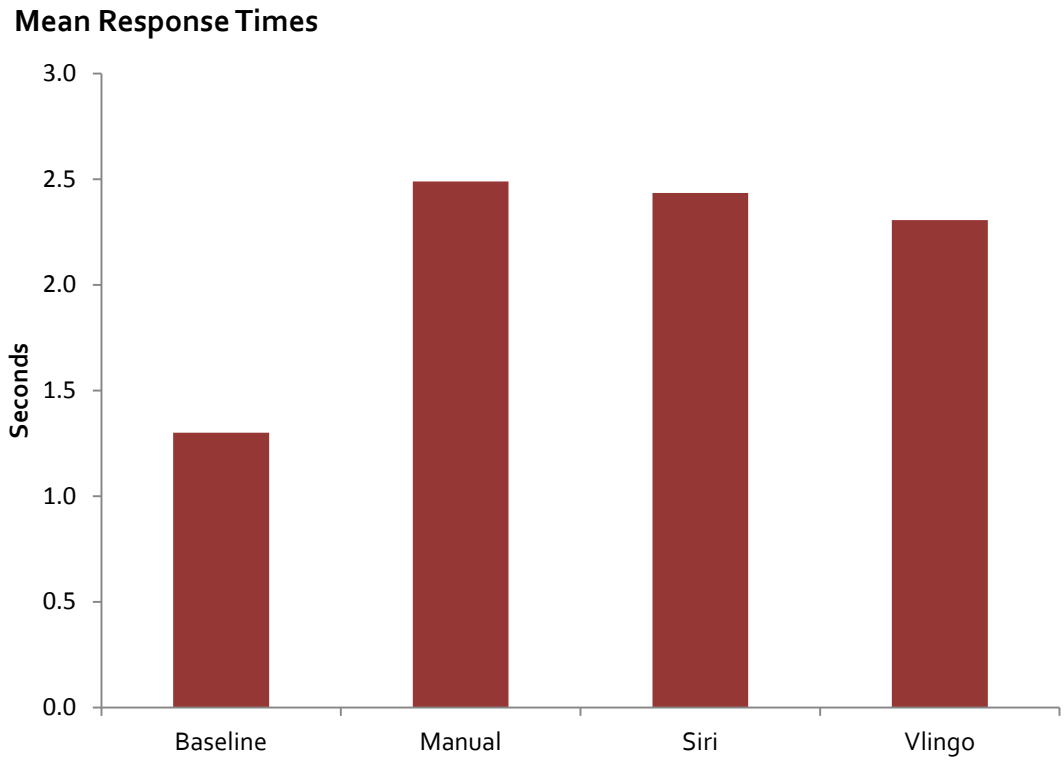

Figure 24. Bar chart for mean driver response times by experimental condition

Table 7. Summary statistics for driver response times

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Baseline	1.300	0.401	0.062
Manual	2.511	1.537	0.237
Siri	2.360	1.199	0.185
Vlingo	2.323	1.141	0.176

Pairwise Comparisons for Texting Conditions

	Baseline	Manual	Siri	Vlingo
Baseline		0.0000	0.0000	0.0000
Manual	0.0000		0.6452	0.4106
Siri	0.0000	0.6452		0.7358
Vlingo	0.0000	0.4106	0.7358	

Missed Response Events

The light response task was programmed such that the light would remain on until the driver pressed the response button or until 15 seconds had elapsed. Therefore, if the driver never noticed that the light was on (or never pressed the response button), this situation was classified as a missed response event.

Across all 43 participants, there were a total of two missed response events in the baseline condition, two in the manual texting condition, one in the Siri condition, and six in the Vlingo condition. Statistical analysis did not reveal significant differences between any of the driving conditions. In each experimental condition, a participant would have approximately ten opportunities to respond to the light, depending on how fast he/she drove.

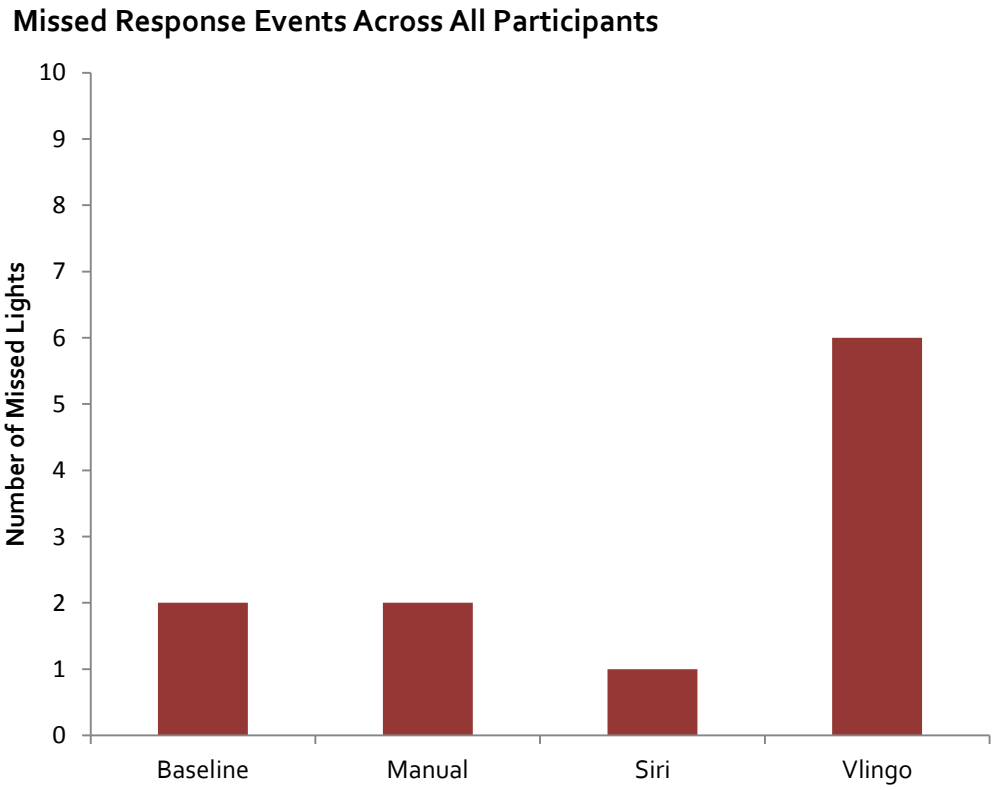

Figure 25. Bar chart for missed response events

Table 8. Summary statistics for missed response events

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Baseline	0.047	0.213	0.032
Manual	0.047	0.213	0.032
Siri	0.023	0.152	0.023
Vlingo	0.140	0.516	0.079

Pairwise Comparisons for Texting Conditions

	Baseline	Manual	Siri	Vlingo
Baseline		1.0000	0.5623	0.2789
Manual	1.0000		0.5623	0.2789
Siri	0.5623	0.5623		0.1624
Vlingo	0.2789	0.2789	0.1624	

Speed

Participants were instructed to maintain a speed of 30 mph during each experimental condition. As previously mentioned with regard to the light response task, there were periods of time during the three texting conditions where the driver was not engaged in a texting task. In order to avoid skewing the speed data toward the baseline condition, only speeds that took place while the driver was engaged in a texting task were analyzed. For the baseline condition (where there were no texting tasks), all speed values were analyzed.

On average, driver speeds slowed during any of the three texting conditions when compared to the baseline. Although these decreases in mean speed values were not statistically significant, the standard deviations in the baseline and manual conditions were significantly different. Of note, the manual texting condition had more speed fluctuations than all other driving conditions.

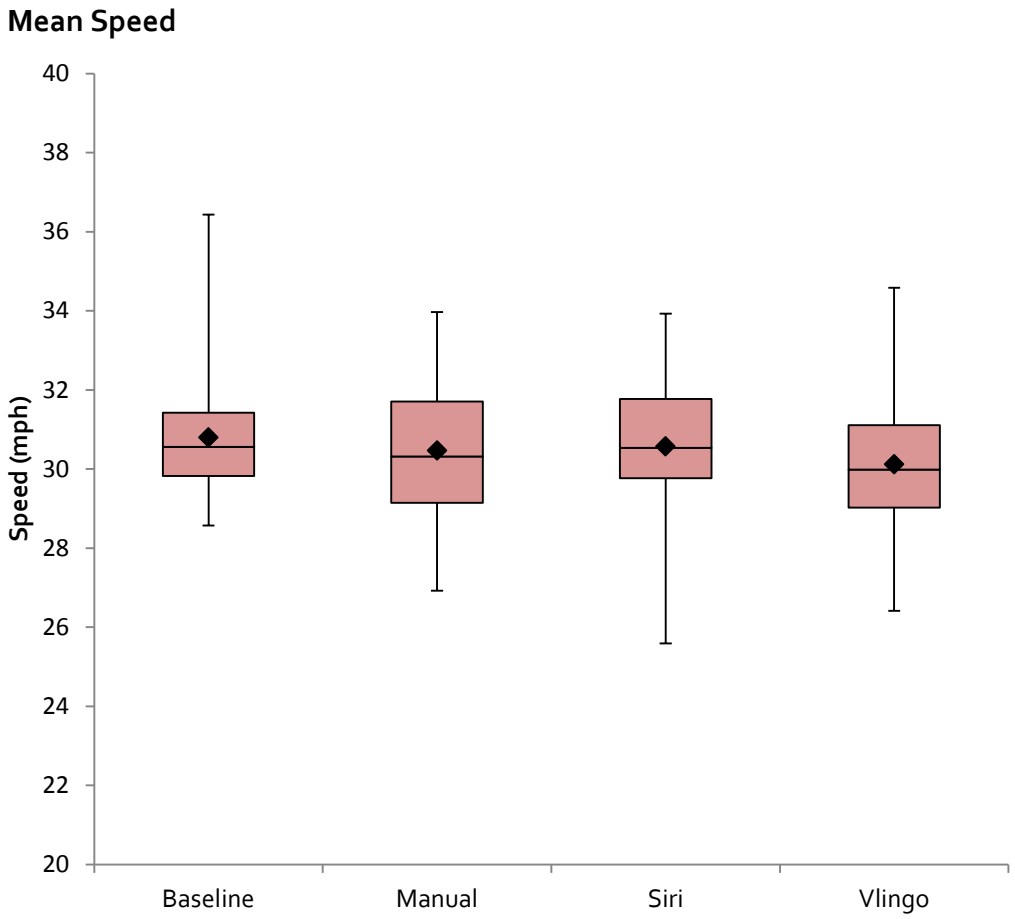

Figure 26. Box-and-whisker plot for mean speed

Table 9. Summary statistics for driver speeds

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Baseline	30.795	1.460	0.223
Manual	30.469	2.010	0.307
Siri	30.572	1.617	0.247
Vlingo	30.117	1.805	0.275

Pairwise Comparisons for Texting Conditions

	Baseline	Manual	Siri	Vlingo
Baseline		0.3916	0.5037	0.0588
Manual	0.3916		0.7935	0.3956
Siri	0.5037	0.7935		0.2216
Vlingo	0.0588	0.3956	0.2216	

Standard Deviation of Lane Position

Participants were instructed to drive straight in their lane. Since the closed course had a few curves, and the "true" lane position while turning is open to much variation, only the lane position values that were recorded on the straight section of the course were analyzed (Figure 1). This section was slightly less than 1 mile long, where participants drove it both before and after making the U-turn. Furthermore, in order to avoid skewing the lane position values in the three texting conditions toward the baseline condition, only lane position values that took place while the driver was engaged in a text messaging task were analyzed.

Statistical analysis revealed no significant differences between any of the experimental conditions. Drivers were typically able to maintain their lane position under any driving condition at an approximate speed of 30 mph.

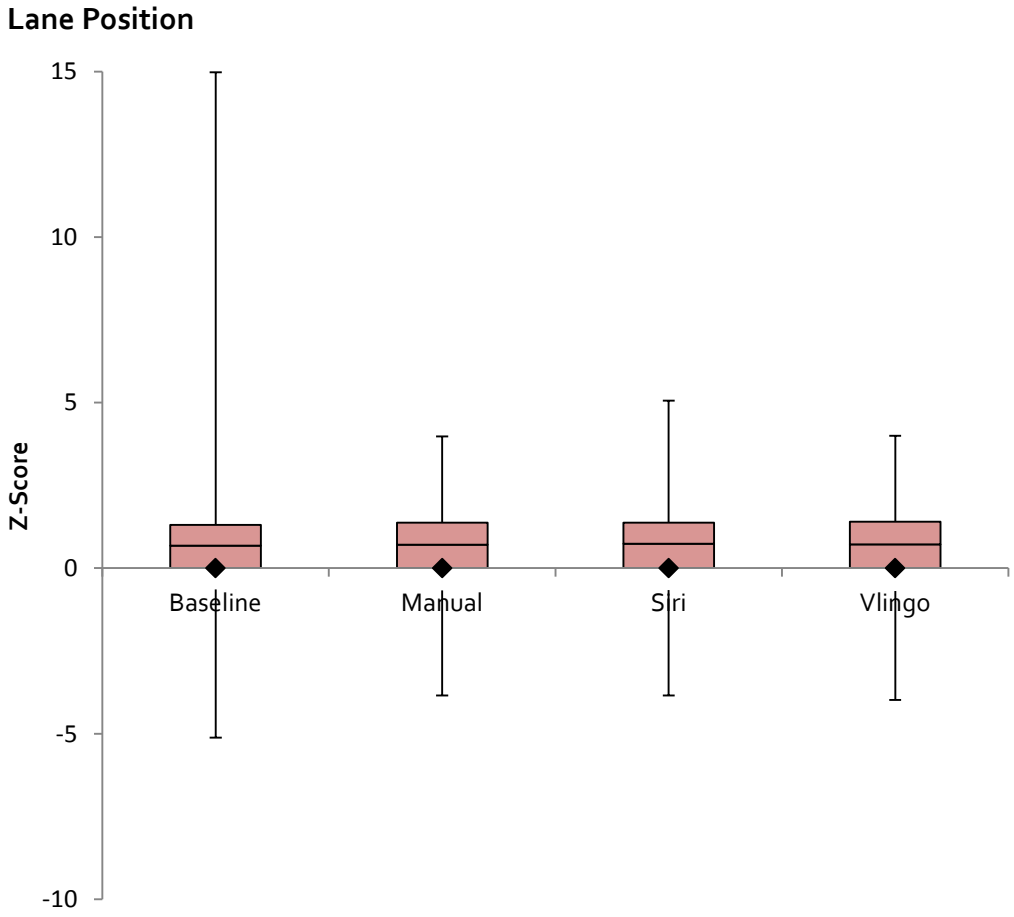

Figure 27. Box-and-whisker plot for the standard deviation of lane position

Table 10. Summary statistics for lane position data

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Baseline	-0.001	0.999	0.004
Manual	0.000	0.999	0.006
Siri	0.000	0.999	0.005
Vlingo	0.000	0.999	0.005

Eye Gazes

Because the project team created a plane in the *faceLAB*® software to represent the forward roadway, whenever the software detected that the driver was gazing at the forward

roadway, it would name the object the driver was viewing as "Forward Roadway." If the software detected that the driver was *not* looking at the forward roadway, the object was named "Nothing." This binary-type approach allows for easy calculation of the percent time looking at the forward roadway, defined simply as the total number of times the data stream denoted that the driver was gazing at the "Forward Roadway" divided by the total number of rows in the data stream.

The percentage of time drivers spent looking at the forward roadway significantly decreased in any of the three texting conditions compared to the baseline. Statistical analysis of these results indicated that the mean percentages of eye gazes to the forward roadway in any of the three texting conditions were significantly different than gazes in the baseline condition. However, the gazes in each of the three texting conditions were not significantly different from one another.

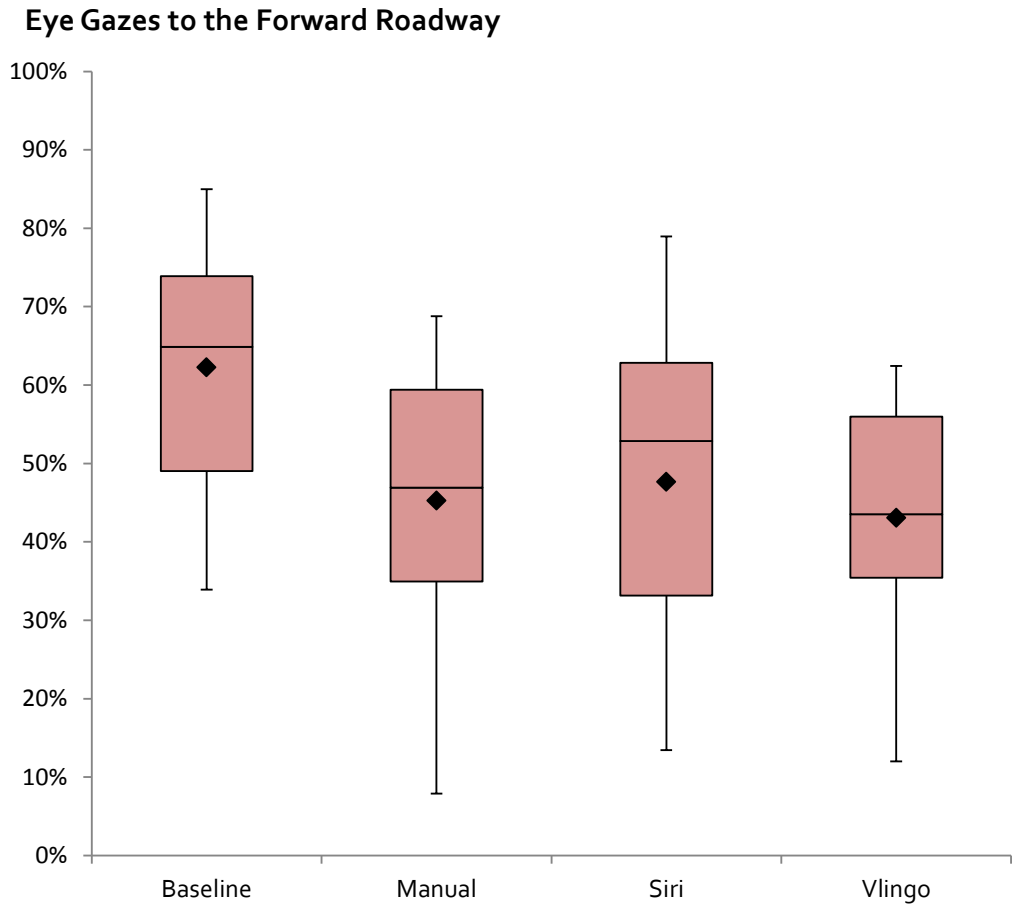

Figure 28. Box-and-whisker plot for the percentage of eye gazes to the forward roadway

Table 11. Summary statistics for percentages of eye gazes to forward roadway

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Baseline	0.622	0.146	0.027
Manual	0.453	0.158	0.029
Siri	0.477	0.190	0.035
Vlingo	0.431	0.150	0.028

Pairwise Comparisons for Texting Conditions

	Baseline	Manual	Siri	Vlingo
Baseline		0.0001	0.0018	0.0000
Manual	0.0001		0.6013	0.5887
Siri	0.0018	0.6013		0.3087
Vlingo	0.0000	0.5887	0.3087	

For every minute of baseline driving time, participants spent an average of 37.3 seconds looking at the forward roadway. When texting manually, participants looked at the roadway for an average of 27.2 seconds for every minute of driving time—10.1 fewer seconds than the baseline condition (see Figure 29). Participants looked at the forward roadway for an average of 28.6 seconds and 25.8 seconds for every minute of driving time—8.7 and 11.5 fewer seconds than the baseline—when texting with Siri or Vlingo, respectively. In summary, compared to the baseline condition, the mean percentage of eye gazes to the forward roadway were significantly fewer no matter which texting method was used. This result implies that using either voice-to-text application did not help the participants keep their eyes on the roadway more frequently than manual texting.

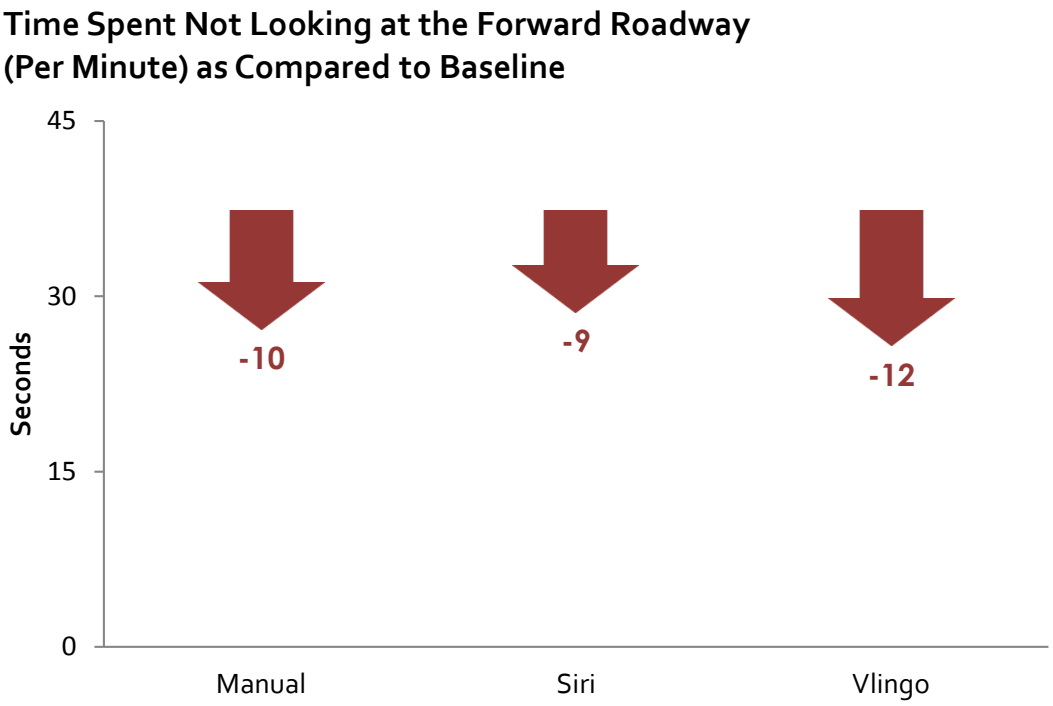

Figure 29. Reduction in forward roadway viewing per minute of driving time compared to baseline

Task Completion

Participants were instructed to complete five different text messaging tasks for each of the texting conditions (manual, Siri, and Vlingo), as discussed previously. During the baseline condition, no texting tasks were given.

Time to Complete Tasks

The experimenter in the vehicle would press the "S" key to flag the data stream at the point in time that the driver picked up the cell phone to begin each text messaging task. The experimenter would press the "E" key to mark the end of the task, which was the time when the driver put the phone back down. This approach allowed for a simple calculation to determine how long it took each subject to complete each texting task, defined as the Time Stamp of "E" minus the Time Stamp of "S." Because each task was independent of the next, the results are discussed individually in the following five sections.

Task 1: Send Only

The first task involved participants sending a text message to the contact person stating, "What are you doing tonight?" There were no statistically significant differences between any of

the texting conditions, indicating that when only sending a message, any method took approximately the same length of time to complete.

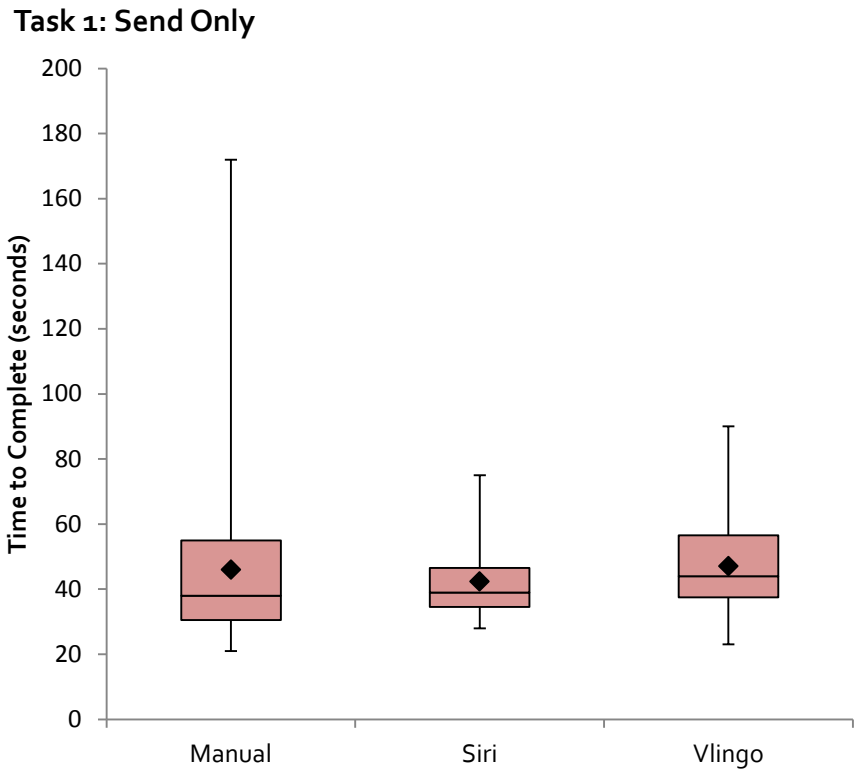

Figure 30. Box-and-whisker plot for Task 1 completion times

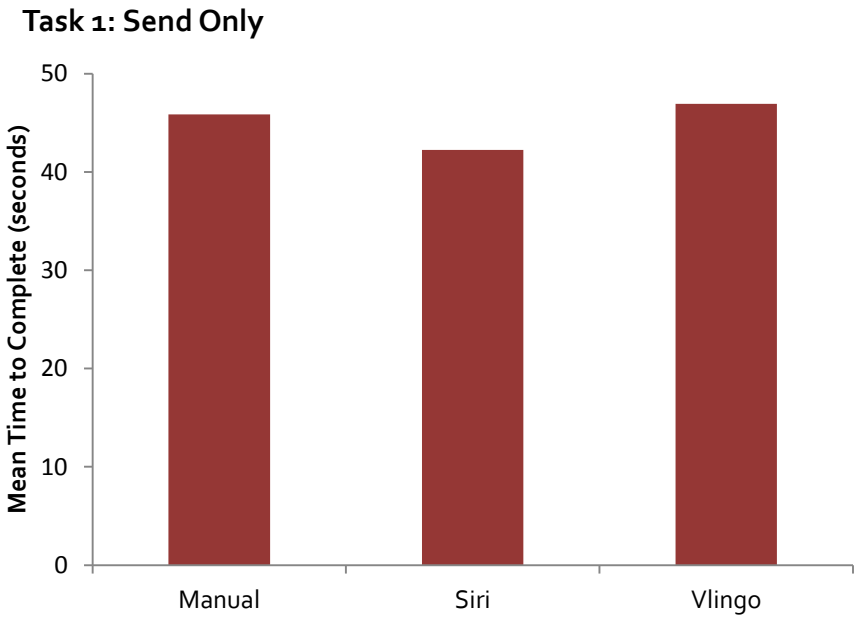

Figure 31. Bar chart for Task 1 mean completion times

Table 12. Summary statistics for Task 1 completion times

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Manual	45.837	26.329	4.015
Siri	42.256	11.840	1.806
Vlingo	46.930	14.950	2.280

Pairwise Comparisons for Texting Conditions

	Manual	Siri	Vlingo
Manual		0.4193	0.8136
Siri	0.4193		0.1117
Vlingo	0.8136	0.1117	

Task 2: Read & Reply

The second task involved the participants reading a message they received ("Nothing. Do you want to get together for dinner?") and then replying with the message, "Yes, where do you want to eat?" Results indicated a statistically significant difference in task completion times

between manual texting and either Siri or Vlingo but not between Siri and Vlingo. When participants used either Siri or Vlingo to complete Task 2, it took much longer than when texting manually.

Figure 32. Box-and-whisker plot for Task 2 completion times

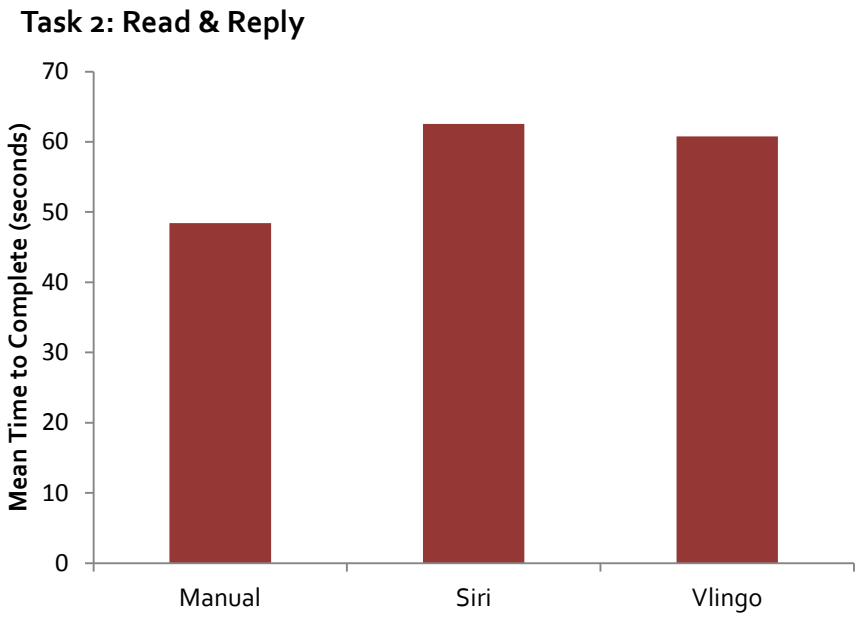

Figure 33. Bar chart for Task 2 mean completion times

Table 13. Summary statistics for Task 2 completion times

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Manual	48.442	24.169	3.686
Siri	62.535	17.038	2.598
Vlingo	60.791	29.089	4.436

Pairwise Comparisons for Texting Conditions

	Manual	Siri	Vlingo
Manual		0.0025	0.0352
Siri	0.0025		0.7355
Vlingo	0.0352	0.7355	

Task 3: Read & Reply

Similar to Task 2, participants first read the message they received ("Subway") and replied with the message, "Okay, what time?" Again, similar to Task 2, results for Task 3 indicated a significant difference between manual and both voice-to-text conditions but not

between Siri and Vlingo. Using either Siri or Vlingo resulted in much longer task completion times than manual texting.

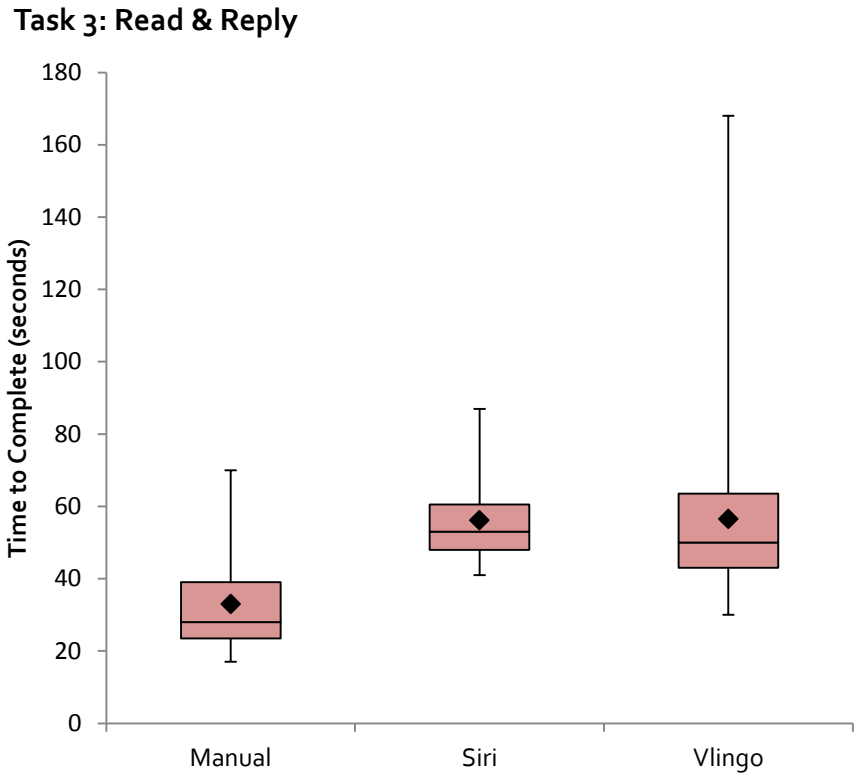

Figure 34. Box-and-whisker plot for Task 3 completion times

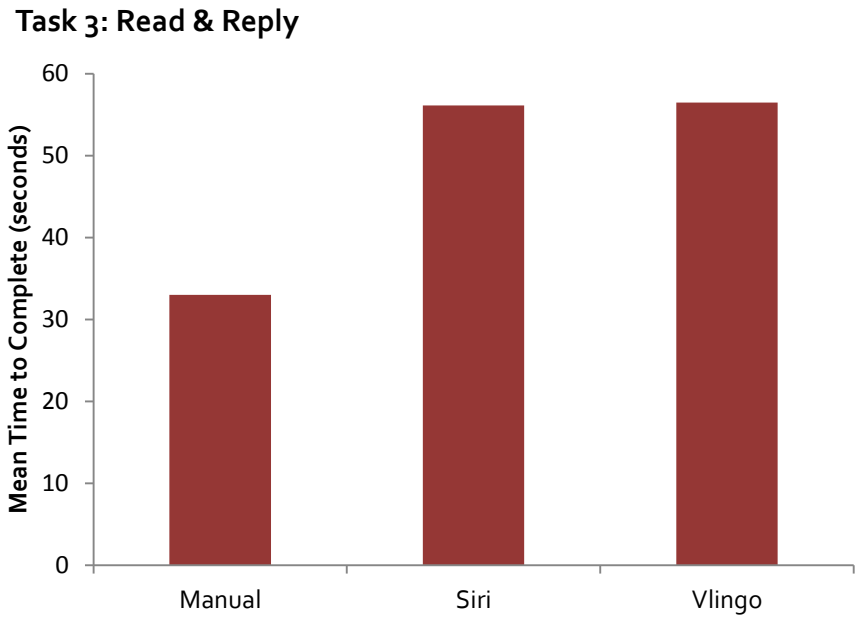

Figure 35. Bar chart for Task 3 mean completion times

Table 14. Summary statistics for Task 3 completion times

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Manual	33.000	12.760	1.946
Siri	56.116	11.264	1.718
Vlingo	56.465	23.432	3.573

Pairwise Comparisons for Texting Conditions

	Manual	Siri	Vlingo
Manual		0.0000	0.0000
Siri	0.0000		0.9302
Vlingo	0.0000	0.9302	

Task 4: Read & Reply

The final "read and reply" task involved participants reading the message "7:00PM" and replying with the message, "See you later." Results indicated a statistically significant difference

in task completion times among all texting conditions, with manual texting having the least and Siri having the greatest task completion times.

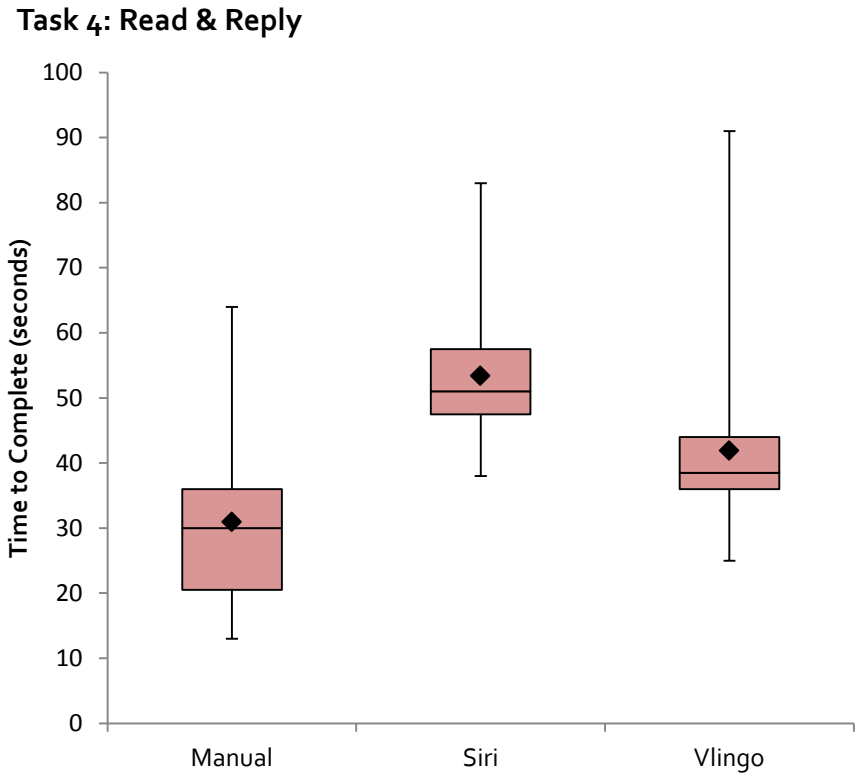

Figure 36. Box-and-whisker plot for Task 4 completion times

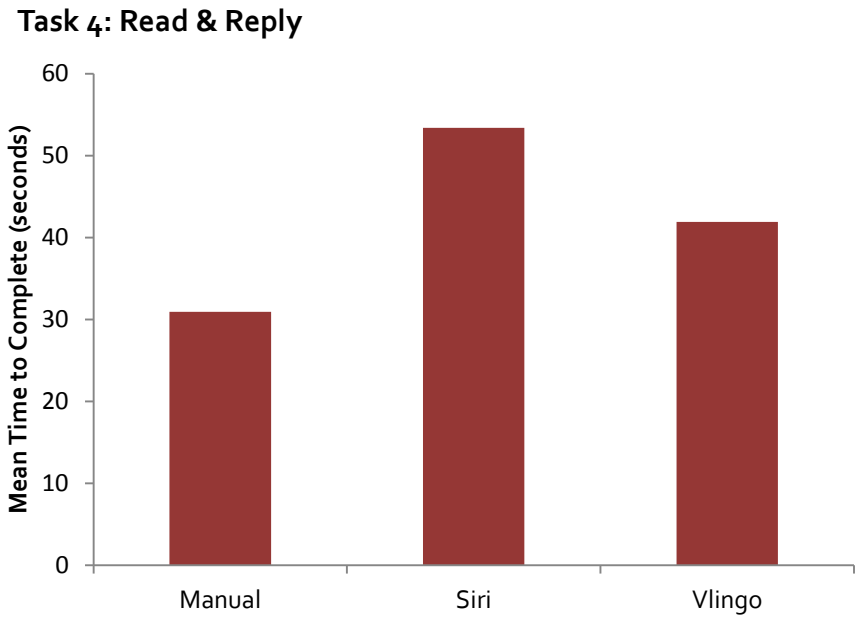

Figure 37. Bar chart for Task 4 mean completion times

Table 15. Summary statistics for Task 4 completion times

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Manual	30.930	12.260	1.870
Siri	53.395	9.353	1.426
Vlingo	41.881	12.615	1.946

Pairwise Comparisons for Texting Conditions

	Manual	Siri	Vlingo
Manual		0.0000	0.0001
Siri	0.0000		0.0000
Vlingo	0.0001	0.0000	

Task 5: Read Only

The final task was a read-only task, such that the participants read the message, "Okay, bye!" and then did not reply. The task completion times for Task 5 were much shorter than all previous tasks, but still showed Siri to have the greatest and manual texting to have the least task

completion times. Results indicated a statistically significant difference in task completion times among all texting conditions.

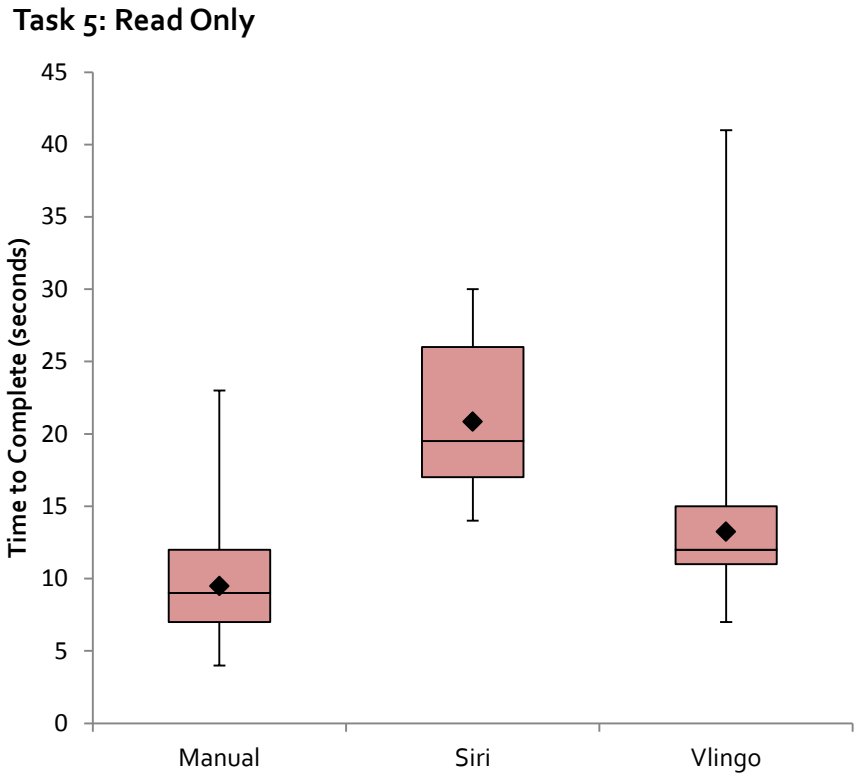

Figure 38. Box-and-whisker plot for Task 5 completion times

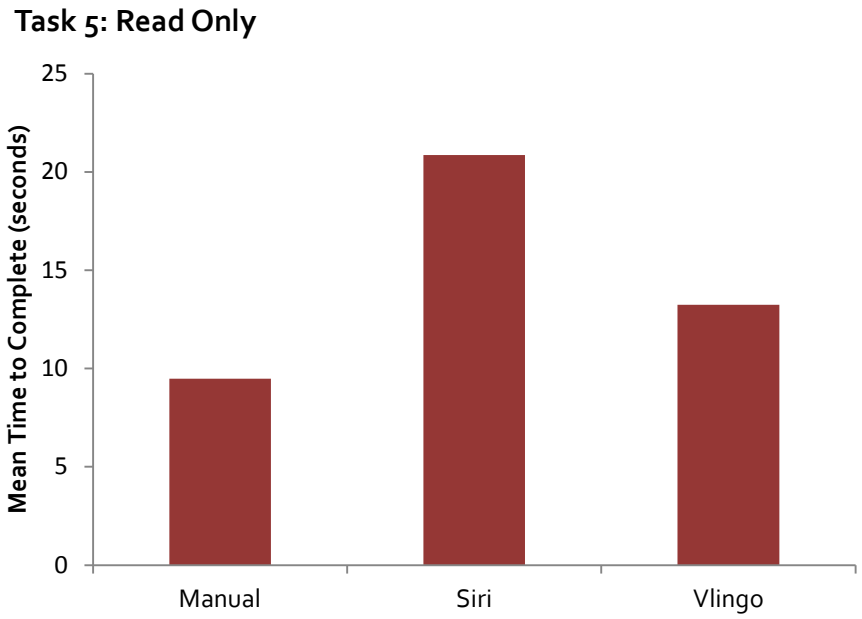

Figure 39. Bar chart for Task 5 mean completion times

Table 16. Summary statistics for Task 5 completion times

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Manual	9.488	3.501	0.547
Siri	20.853	4.755	0.816
Vlingo	13.244	5.426	0.847

Pairwise Comparisons for Texting Conditions

	Manual	Siri	Vlingo
Manual		0.0000	0.0004
Siri	0.0000		0.0000
Vlingo	0.0004	0.0000	

Accuracy of Task Completion

Participants were instructed to send specifically worded text messages either manually, using Siri, or using Vlingo. Taking into account the individual style of texting for each subject (i.e., use of the letter "r" instead of "are" was not counted as erroneous), the accuracy of each

texting task was recorded and analyzed. A single error was counted in the event of an obviously misspelled word, the accidental addition of a word or character, or the omission of a scripted word. The texting script can be found in Appendix E.

Statistical analysis indicated a significant difference in task accuracy between texting tasks completed manually and using Siri, as well as between Siri versus Vlingo. There were no significant differences between texting manually versus using Vlingo. This indicates that Siri was somewhat superior at producing fewer errors compared to both manual texting and Vlingo.

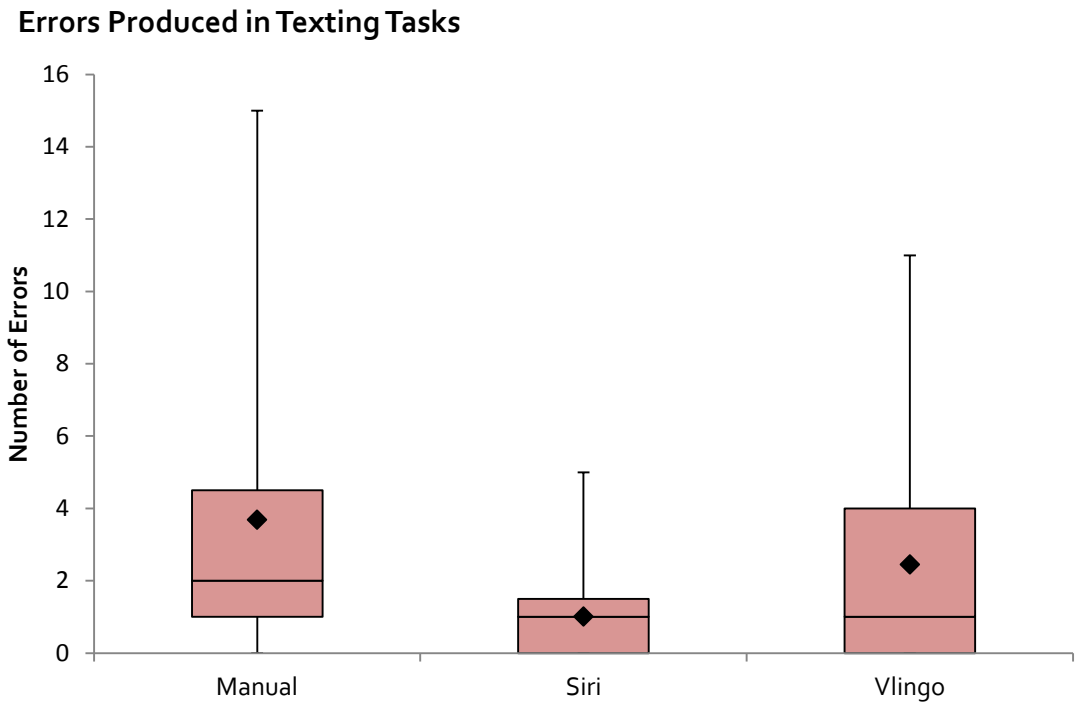

Figure 40. Box-and-whisker plot for task accuracy by texting method

Table 17. Summary statistics for task accuracy by texting method

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Manual	3.674	3.974	0.606
Siri	1.000	1.272	0.194
Vlingo	2.442	2.823	0.430

Pairwise Comparisons for Texting Conditions

	Manual	Siri	Vlingo
Manual		0.0002	0.0836
Siri	0.0002		0.0038
Vlingo	0.0836	0.0038	

Subjective Performance Rating

At the end of each experimental condition, participants were asked to self-assess their driving performance. Following the experiment, participants completed a post-experiment questionnaire that provided further feedback about their experiences. Both self-assessment ratings are summarized in the following sections.

During Experiment

Immediately after completing each experimental condition, participants were asked to self-assess their driving performance using both a 1–100 scale and a multiple-choice format with answers ranging from "Very Unsafe" to "Very Safe." These two questions were analyzed separately.

For the numerical self-assessment question, participants generally felt that texting in any format (voice-to-text or manual) was less safe than not texting. Within the three texting conditions tested, participants felt that Siri was considerably safer than either manual texting or Vlingo and that Vlingo was safer than texting manually. Statistical analyses indicated significant differences between all texting condition self-assessment ratings.

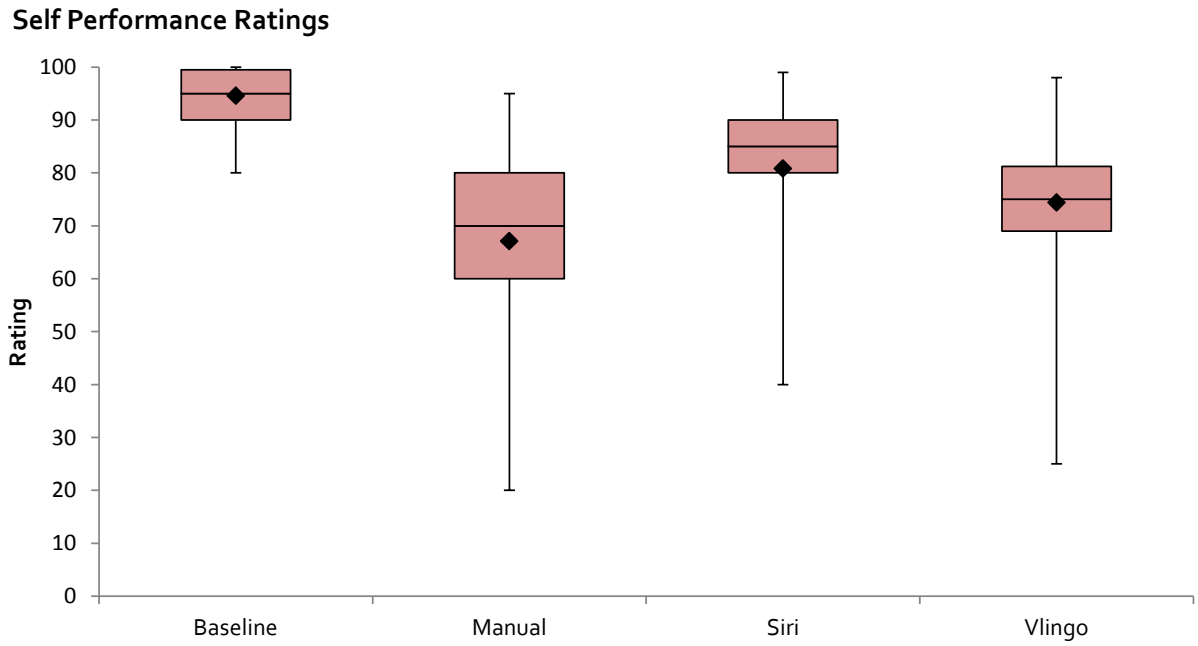

Figure 41. Box-and-whisker plot for numerical self-assessment ratings

Table 18. Summary statistics for numerical self-assessment ratings

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Baseline	94.581	5.288	0.806
Manual	67.116	17.881	2.727
Siri	80.791	12.009	1.831
Vlingo	74.384	14.135	2.156

Pairwise Comparisons for Texting Conditions

	Baseline	Manual	Siri	Vlingo
Baseline		0.0000	0.0000	0.0000
Manual	0.0000		0.0001	0.0396
Siri	0.0000	0.0001		0.0261
Vlingo	0.0000	0.0396	0.0261	

Participants were also asked to rate how safe they felt their driving was after completing each experimental condition. The five answer choices were: Very Unsafe, Unsafe, Neutral, Safe, or Very Safe.

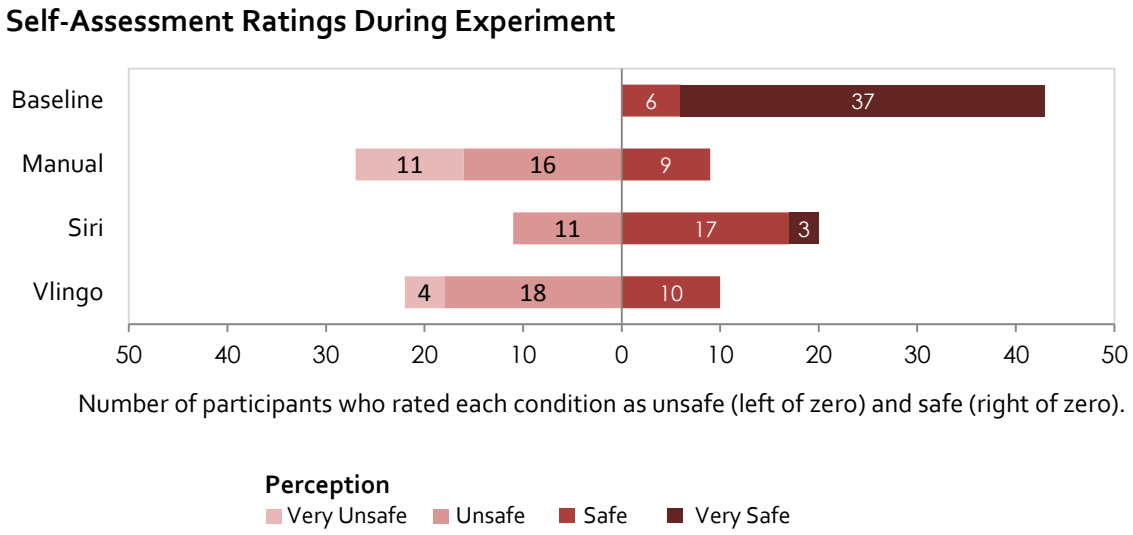

Figure 42. How safe participants felt their driving was by experimental condition

Table 19. Summary statistics for safety choice ratings

Descriptive Statistics

Condition	Mean	Std. Dev.	Std. Error
Baseline	4.860	0.351	0.053
Manual	2.326	1.085	0.165
Siri	3.279	0.934	0.142
Vlingo	2.628	0.952	0.145

Pairwise Comparisons for Texting Conditions

	Baseline	Manual	Siri	Vlingo
Baseline		0.0000	0.0000	0.0000
Manual	0.0000		0.0000	0.1732
Siri	0.0000	0.0000		0.0019
Vlingo	0.0000	0.1732	0.0019	

For the baseline condition, the majority of participants rated their driving as Very Safe and a few rated their driving as Safe. The manual texting condition did not receive any Very Safe ratings but was spread across the remaining choices, where most participants felt their driving was Very Unsafe or Unsafe when texting manually. Participants felt their driving improved when texting with Siri compared to manual texting or using Vlingo and mostly rated their driving as Safe (with several rating it Unsafe or Neutral). There were a few participants who felt their driving was Very Safe when using Siri. Interestingly, Vlingo did not receive any Very Safe ratings but was mostly rated as Unsafe, with several ratings of Neutral and Safe and a few rated as Very Unsafe. Additional analysis indicated a statistically significant difference in self-performance ratings between all experimental conditions except between manual and Vlingo texting. Like the numerical self-assessment question, in general participants felt their driving was less safe in any of the three texting conditions compared to the baseline. Within the three texting conditions, participants generally felt that Siri was the safest, followed by Vlingo, and lastly by texting manually.

Post-Experiment

Upon completing the experiment, participants filled out a post-experiment questionnaire. The first question asked participants to select their favorite method (of the ones they tested during the experiment) for sending and receiving text messages. The results are shown in Figure 43. As we can see, most participants preferred texting with Siri.

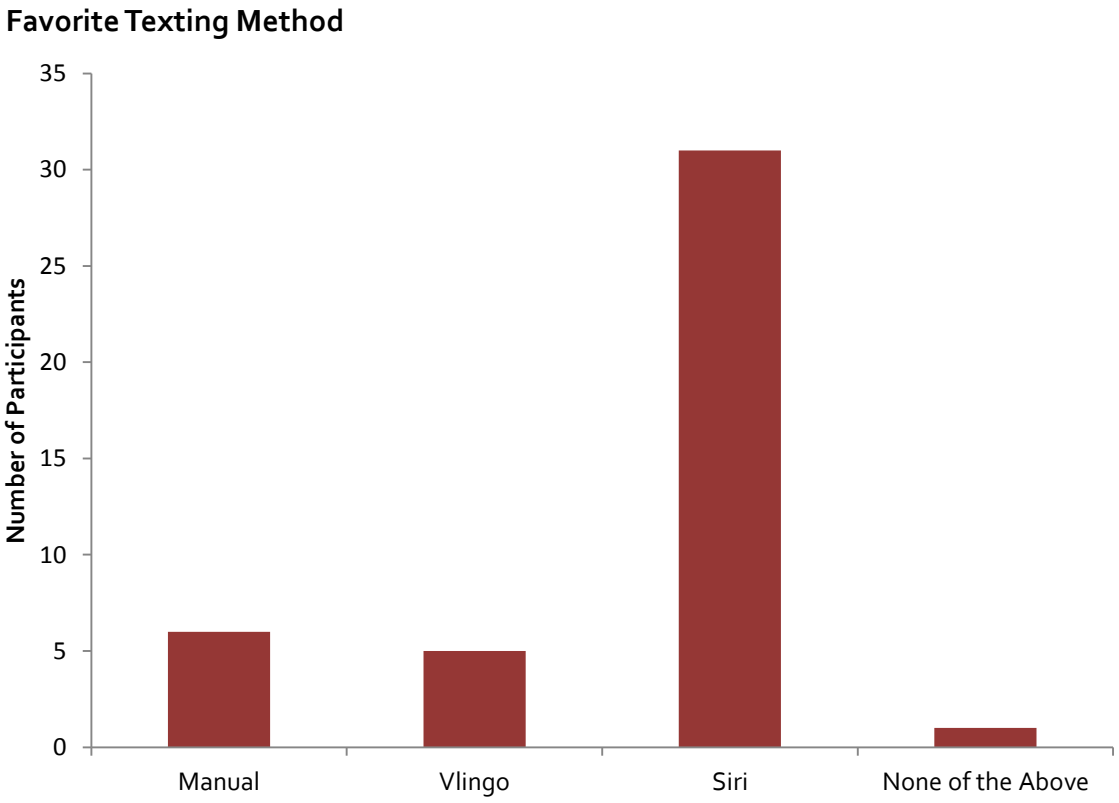

Figure 43. Preferred texting method used in the experiment

The next question asked participants to compare the two voice-to-text applications to manual-entry texting in terms of increasing or decreasing driving safety. As shown in Figure 44, most participants felt that using Siri or Vlingo improved driving safety when compared to manual texting, with Siri receiving many more Considerably Safer ratings than Vlingo.

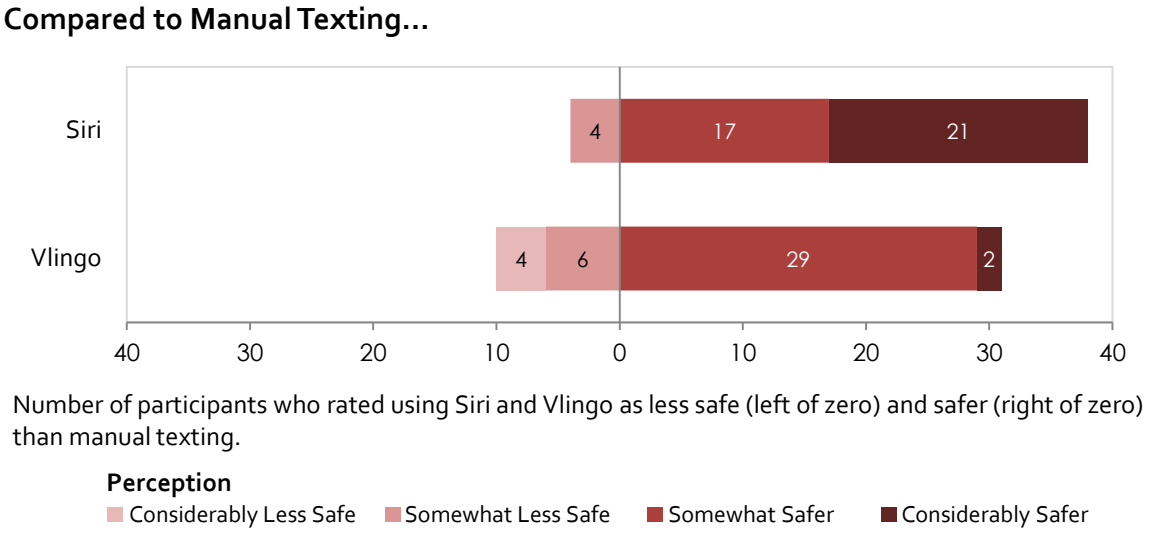

Figure 44. How participants rated Siri and Vlingo compared to manual texting

When asked to specifically compare Siri to Vlingo, participants rated Siri as Somewhat or Considerably Safer than Vlingo, as shown in Figure 45.

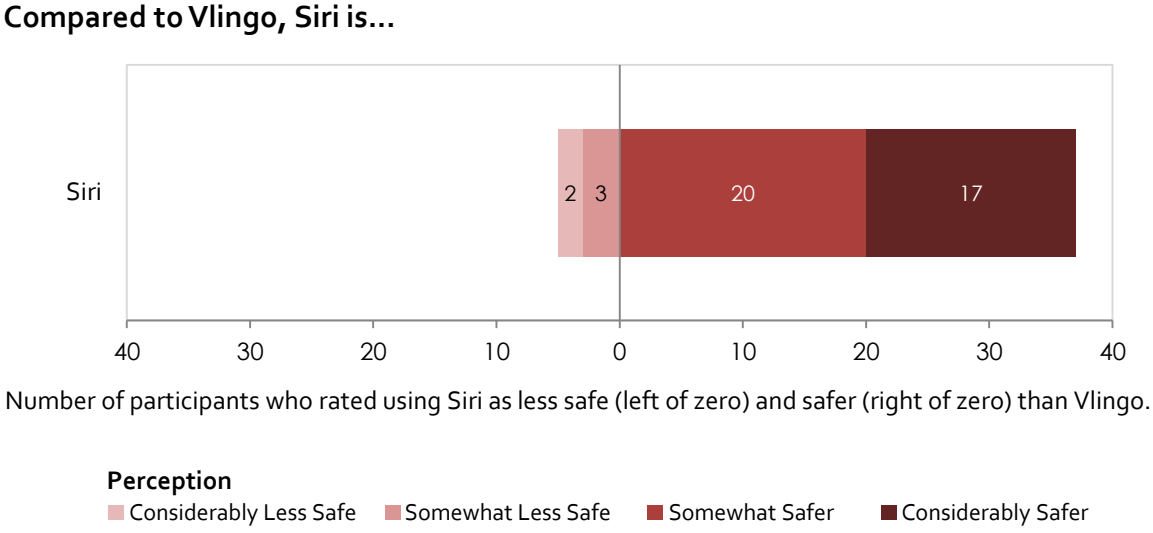

Figure 45. How participants compared Siri to Vlingo

Participants were also asked to rank the three texting methods they used in the experiment, where a rating of 1 equated to the participant's first preference.

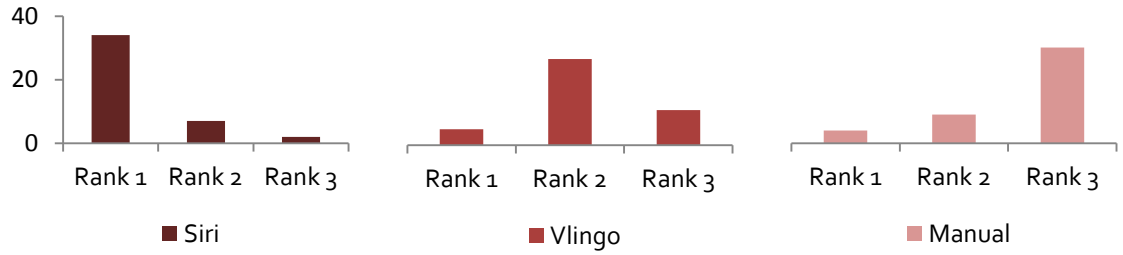

Figure 46. Ranked preferences of texting methods used in the experiment

As shown in Figure 46, most participants ranked Siri as their first preference for texting while driving in the experiment, followed by Vlingo and then manual-entry texting.

SUMMARY AND CONCLUSIONS

The purpose of this research was to evaluate the impacts of using voice-to-text mobile applications to send and receive text messages while driving and was driven by three primary research questions:

1. When texting using a voice-to-text application, does driving impairment improve, remain the same, or increase when compared to manual-entry texting and the baseline?
2. Are there any significant differences in performance between the two types of voice-to-text applications that were tested?
3. How do driver perceptions toward texting while driving compare to their actual performance?

Driver Impairment for Baseline, Manual Texting, and Voice-to-Text Conditions

In response to the first question, driver response times were significantly delayed and eye gaze frequency to the forward roadway significantly decreased no matter which texting method was used when compared to the baseline. To address the question of whether a voice-to-text application is any less impairing than manual-entry texting, no such improvements were found in this research—driver response times and eye gazes to the forward roadway were relatively similar within each texting method. The nature of the light response task is similar to a driver's situational awareness and periodic roadway scanning to detect braking vehicles or roadway hazards. Results indicate that the voice-to-text applications tested in this study did not help keep the driver's eyes on the roadway more frequently than texting manually. For the send-only text messaging task, each texting method took approximately the same amount of time to complete. For all read-and-reply tasks and the read-only task, manual texting took the least amount of time to complete. This result implies that although the drivers were engaged in the texting task for a longer period of time when using either voice-to-text application, their response times were delayed by the same amount as the shorter-duration method, manual texting. Further research is necessary to investigate why this is the case.

Differences Between Siri and Vlingo

Each voice-to-text application that was tested in this research had strengths and limitations. Results indicated that participants produced more accurate text messages (in accordance with the messaging script) when using Siri. But in most cases when participants used Siri, their task completion times were largest compared to Vlingo and manual texting. This was likely due to the back-and-forth, interactive nature of using Siri to read or send a message. Vlingo was incapable of reading a message that the participant received, thereby making it a blended manual-automated condition. Initiating Siri only took one button press, whereas Vlingo required at least three. Although only participants who were very familiar with texting on a smartphone were recruited, not all of the participants were previously familiar with Siri or Vlingo prior to practicing just before the experiment. (Approximately 60% of participants were familiar with using voice-to-text technology, but not necessarily Siri and Vlingo specifically.) This unfamiliarity could have affected the task completion times and task accuracies in the sense that a driver more accustomed to using those applications might have executed the task more efficiently. This, again, is an area requiring further research.

Driver Perceptions vs. Driver Performance

In response to the third question, drivers perceived Siri and Vlingo to be less accurate than manual texting, but results indicated that the opposite was true. The project team decided to have participants send each voice-to-text message—right or wrong—in order to determine how effective each voice-to-text application is at correctly translating the driver's speech. However, many participants commented that they felt compelled to check the accuracy of the message prior to sending, not wanting to send a message riddled with typographical errors. This tendency to look at the message to check for accuracy could explain why eye gazes to the forward roadway were similar to manual texting. Yet, the manual texting condition showed the largest number of errors. Had they been using the voice-to-text application in their everyday driving situation, participants said they would have taken longer to correct any errors produced during the translation. It would be interesting to research how much more distracting that situation would be, and whether any additional driver impairment or time of eyes off the forward roadway would be observed from ensuring accurate text message content. It is also interesting that participants rated Siri so highly above manual texting and Vlingo in terms of their perceived

driving safety, yet the response time and eye gaze data indicate that there were no distinguishable differences, and, in fact, texting manually always resulted in the lowest task completion times, with the exception of the send-only task.

Final Considerations

As with any research, several assumptions and decisions were made regarding the design of this experiment. To ensure participant safety, the instructed speed limit was intentionally kept low. Additionally, only the lane position values from the straight section of the course were analyzed. But qualitatively, the experimenter noted many occasions where the driver began to veer out of the lane when navigating the turns and curves on the course. It would be interesting to analyze the changes in lane position across the entire course in future research. The light response task was also intentionally kept rather intermittent, about 45 seconds apart, so as not to overload the driver. With all of these precautions taken into consideration, the driver response times were still approximately two times slower and eye gazes to the forward roadway significantly decreased compared to the baseline, regardless of the texting method used.

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APPENDIX A: ONLINE SURVEY

Text Messaging User Survey

Introduction and Participant Eligibility

This online survey is part of a research study being conducted by the Texas Transportation Institute for the Southwest Region University Transportation Center (SWUTC). The purpose of the study is to evaluate the effectiveness of newer texting technologies at reducing incidences of distracted driving.

In order to be eligible to participate in this survey, you must:

- Be at least 18 years old
- Be fluent in English
- Have a valid U.S. driver's license
- Have a mobile device capable of sending and receiving text messages

Your participation is voluntary and anonymous – if you decide not to participate, or if you begin the survey and decide not to continue, your relationship with the Texas Transportation Institute will not be hindered. The survey should take no more than 20 minutes to complete. Once you have completed the survey, you will be offered a chance to enter the prize drawing for one of ten $50 Amazon.com gift cards. In order to enter the prize drawing, you must enter a valid email address after completing the survey. Your email address will be kept confidential and will only be used to select and distribute the prize if your entry is selected.

If you have questions, concerns, or complaints about this study, you can contact Christine at 979-845-0866 or by e-mail at studyinfo@ttimail.tamu.edu.

If you have questions, complaints, or concerns about the research or questions about your rights as a research participant and cannot reach the Principal Investigator or want to talk to someone other than the investigator, you may call the Texas A&M Human Subjects Protection Program office at 979-458-4067 or e-mail irb@tamu.edu.

***1. By selecting "Yes" below, you are stating that you are 18 years of age or older, are fluent in English, have a valid U.S. driver's license, have a mobile device capable of sending and receiving text messages, and wish to continue to the survey questions.**

Thank you!

- ○ Yes
- ○ No

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Text Messaging User Survey

Demographic Questions

2. What is your gender?

- Female
- Male

3. Which category below includes your age?

- 18-24
- 25-29
- 30-39
- 40-49
- 50-59
- 60 or older

4. What is the highest level of education you have completed?

- No high school diploma
- High school diploma or equivalent (GED)
- Some college, no degree
- Associate or technical degree
- Bachelor's degree
- Masters degree
- PHD

5. What is your race/ethnic background? (Check all that apply)

- White
- African-American
- Asian or Pacific Islander
- Hispanic
- Other (please specify)

6. What state or U.S. territory are you currently a resident in?

Text Messaging User Survey

Driver and Mobile Device Information

7. Where do you primarily drive?

- Urban area (city, large town, or suburban areas)
- Rural area (smaller town or open country areas)
- Both, urban and rural area

8. At what age did you first acquire a working cellular phone?

Response:

9. What type of operating system does your cell phone have?

- I do not have a smartphone
- Android
- Apple IOS (IPhone)
- Windows
- Blackberry
- Other (please specify)

10. What type of keypad does your cell phone have?

- Touchscreen
- Full QWERTY keypad with raised button-keys
- Numerical keypad (with 12 keys for numbers 0-9,*,#)

11. On a typical day, how many text messages do you send/receive per day on your mobile device?

- I do not text everyday
- 1-5 messages a day
- 6-20 messages a day
- 21-99 messages a day
- 100+ messages a day

Text Messaging User Survey

Texting Behavior

12. Do you text and drive?

- Yes
- No

Comments (Optional)

13. Please choose the option that best describes your texting while driving behavior:

- I never text while driving
- I only text at red lights or stop signs when I'm driving
- I regularly text and drive (while the vehicle is in motion)

Comments (Optional)

14. How often do you read or write text messages while driving while the vehicle is IN MOTION?

- Multiple times a day
- Multiple times a week
- Multiple times a month
- Once a month or less frequently
- I never read or write text messages while driving while the vehicle is in motion

Comments (Optional)

Text Messaging User Survey

15. How often do you read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

- Multiple times a day
- Multiple times a week
- Multiple times a month
- Once a month or less frequently
- I never read or write text messages while driving while the vehicle is stopped

Comments (Optional)

16. I have read and/or written a text message while driving (vehicle in motion and/or stopped at a red light or stop sign) at least once in the past _____ .

- 24 hours
- 24 - 48 hours
- 7 days
- 30 days
- 6 months
- 12 months
- Longer than 12 months
- I have never in my lifetime read or written a text message while driving

Comments (Optional)

Text Messaging User Survey

Your Feelings About Texting While Driving

17. How do you feel when you read or write text messages while driving while the vehicle is IN MOTION?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

18. How do you feel when you read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

19. What is your preferred method of texting when you are driving?

- ○ Manually typing each letter/number/character
- ○ Allowing T9 or autofill to assist me while I manually type
- ○ Voice-to-text recognition app or in-vehicle system (SIRI, SYNC, etc.)
- ○ I do not text while I'm driving
- ○ Other (please specify)

Text Messaging User Survey

Cell Phone Capabilities

20. Does your cell phone have voice-to-text capabilities?

- ○ Yes
- ○ No
- ○ I don't know
- ○ Other (please specify)

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Text Messaging User Survey

Using Voice-to-Text on Your Cell Phone

21. How often do you use the voice-to-text capability on your cell phone to read or write text messages while driving?

- ○ Daily
- ○ Weekly
- ○ Monthly
- ○ Less frequently
- ○ Never

Comments (Optional)

22. Why do you not use your voice-to-text app to send or receive text messages more often? Check all that apply.

- ☐ Hard to use
- ☐ Does not work well
- ☐ I am unprepared to use it when I need to
- ☐ I forget to use it
- ☐ Other (please specify)

Text Messaging User Survey

23. Which voice-to-text app(s) do you use? Choose all that apply.

- Siri
- Vlingo
- ShoutOut
- Jarvis
- On the Move
- Otter
- I don't use any voice-to-text apps on my phone
- Other (please specify)

24. On average, I would rate the performance of these voice-to-text apps in the following categories...

	Very Poor	Poor	Neutral	Good	Very Good	N/A
Usefulness						
Effective translation into text						
Price						
Increasing my safety while texting and driving						

Comments (Optional)

25. How do you feel when you use your voice-to-text mobile app to read or write text messages while driving while the vehicle is IN MOTION?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____						

Comments (Optional)

Text Messaging User Survey

26. How do you feel when you use your voice-to-text mobile app to read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ___	○	○	○	○	○	○

Comments (Optional)

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Text Messaging User Survey

Vehicle Capabilities

27. Does the vehicle that you drive most often have voice-to-text capabilities?

- ○ Yes
- ○ No
- ○ I don't know
- ○ Other (please specify)

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Text Messaging User Survey

Using Voice-to-Text in Your Vehicle

28. How often do you use the voice-to-text capability in your vehicle to read or write text messages while driving?

- ○ Daily
- ○ Weekly
- ○ Monthly
- ○ Less frequently
- ○ Never

Comments (Optional)

29. Why do you not use your vehicle's voice-to-text system to send or receive text messages more often? Check all that apply.

- ☐ Hard to use
- ☐ Does not work well
- ☐ I am unprepared to use it when I need to
- ☐ I forget to use it
- ☐ Other (please specify)

30. Which voice-to-text capable system does your vehicle have?

- ☐ Ford/Lincoln Sync
- ☐ GM/Chevrolet OnStar
- ☐ Kia UVO
- ☐ Toyota Entune
- ☐ BMW Connected Drive
- ☐ Dodge/Chrysler UConnect
- ☐ Other (please specify)

Text Messaging User Survey

31. On average, I would rate the performance of my vehicle's voice-to-text system in the following categories...

	Very Poor	Poor	Neutral	Good	Very Good	N/A
Usefulness	○	○	○	○	○	○
Effective translation into text	○	○	○	○	○	○
Price	○	○	○	○	○	○
Increasing my safety while texting and driving	○	○	○	○	○	○

Comments (Optional)

32. How do you feel when you use your voice-to-text in-vehicle system to read or write text messages while driving while the vehicle is IN MOTION?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

33. How do you feel when you use your voice-to-text in-vehicle system to read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

Text Messaging User Survey

Texting While Driving Is ___?

34. How safe or unsafe do you consider the following activities?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe
Texting while driving is	○	○	○	○	○
Texting at a red light is	○	○	○	○	○
Texting at a stop sign is	○	○	○	○	○

Comments (Optional)

35. Compared to manual texting while driving, what effect do the following technologies have on the ability to drive safely while texting?

	Considerably More Safe	Somewhat More Safe	Neutral	Somewhat Less Safe	Considerably Less Safe
Voice-to-text apps for your cell phone are...	○	○	○	○	○
Voice-to-text systems in your vehicle are...	○	○	○	○	○

Comments (Optional)

Text Messaging User Survey

Thank You!

Thank you for taking time to complete this survey!

If you would like to enter for a chance to win one of ten $50 Amazon.com gift cards, please enter a valid email address below. This is optional. If you do not wish to enter for a chance to win one of the ten prizes, then you may skip this page, and simply click "Done" to submit your survey answers.

If you do choose to enter the prize drawing, please note that if your entry is selected as a winner, but the email address you enter is invalid, your entry will be disqualified, and another winner will be selected in your place. Please double check that the email address you enter below is correct before you hit the "Done" button.

Your email address will be kept confidential and will only be used to notify you about the result of the prize drawing.

36. If you want to enter for a chance to win one of ten $50 Amazon.com gift cards, please enter a valid email address. (This is Optional -- by not entering an email address, you are opting out of the chance to win a prize.)

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APPENDIX B: COUNTERBALANCED ORDER OF LAPS BY SUBJECT

B=Baseline
M=Manual ----> Mi=Manual using iPhone; Ms=Manual using Samsung
S=Siri
V=Vlingo

Subject #	Lap 1	Lap 2	Lap 3	Lap 4
1	B	M	S	V
2	B	M	V	S
3	B	S	M	V
4	B	S	V	M
5	B	V	S	M
6	B	V	M	S
7	M	B	S	V
8	M	B	V	S
9	M	S	B	V
10	M	S	V	B
11	M	V	B	S
12	M	V	S	B
13	S	B	M	V
14	S	B	V	M
15	S	M	B	V
16	S	M	V	B
17	S	V	B	M
18	S	V	M	B
19	V	B	M	S
20	V	B	S	M
21	V	M	B	S
22	V	M	S	B
23	V	S	B	M
24	V	S	M	B
25	B	M	S	V
26	B	M	V	S
27	B	S	M	V
28	B	S	V	M
29	B	V	S	M
30	B	V	M	S
31	M	B	S	V
32	M	B	V	S
33	M	S	B	V
34	M	S	V	B
35	M	V	B	S
36	M	V	S	B
37	S	B	M	V
38	S	B	V	M
39	S	M	B	V
40	S	M	V	B
41	S	V	B	M
42	S	V	M	B
43	V	B	M	S

APPENDIX C: IN-VEHICLE EXPERIMENTER SHEET

Subject # _____ Lap Order (1,2,3,4)_____

Lap B: Baseline

Verbal Instructions: *We are now at the start point of the course. When I ask you to begin, your top priority will be to drive safely, try to stay in your lane, and obey a speed limit of **30 mph**. You will drive the course one full time by beginning here, driving to the end point and making a u-turn, then drive back to this starting point.*

For this segment, you will not be sending or receiving any text messages. Also remember that as soon as you observe the green LED light in front of you, flick the joystick button. *Do you have any questions? Are you ready to begin?*

*****Check to make sure:*****

- **GPS is running and recording (Green Background)**
- **Cameras are angled properly and recording**
- **FaceLAB is tracking AND logging**
- **PsychoPy is running**

**************************************Begin Lap B**************************************

Experimenter Notes:

**************************************End Lap B**************************************

Participant Feedback:

How well do you feel like you were driving on a scale of 1 to 100, rather, what grade would you give yourself?

How safe do you think your driving was? (Circle one)

Very Unsafe Unsafe Neutral Safe Very Safe

Do you have any thoughts or comments about the segment you just completed?

Subject # _____ Lap Order (1,2,3,4)_____

Lap M: Manual-Entry Texting

Verbal Instructions: *We are now at the start point of the course. When I ask you to begin, your top priority will be to drive safely, try to stay in your lane, and obey a speed limit of **30 mph**. You will drive the course one full time by beginning here, driving to the end point and making a u-turn, then drive back to this starting point.*

For this segment, you will compose and read text messages manually. Please only read and write text messages manually for this lap.

Which cell phone did you choose to use in the office when practicing manual-entry texting? (Circle One) iPhone Samsung

Also remember that as soon as you observe the green LED light in front of you, flick the joystick button. *Do you have any questions? Are you ready to begin?*

*****Check to make sure:*****

- **GPS is running and recording (Green Background)**
- **Cameras are angled properly and recording**
- **FaceLAB is tracking AND logging**
- **PsychoPy is running**

**************************************Begin Lap M**************************************

Experimenter Notes:

Press a letter key on the GPS screen every time the driver picks up their cell phone and replaces it, so we know how long it took them to complete each task.

**************************************End Lap M**************************************

Participant Feedback:

How well do you feel like you were driving on a scale of 1 to 100, rather, what grade would you give yourself?

How safe do you think your driving was? (Circle one)

Very Unsafe Unsafe Neutral Safe Very Safe

Do you have any thoughts or comments about the segment you just completed?

Subject # _____ Lap Order (1,2,3,4)_____

Lap V: Using Vlingo to Text

Verbal Instructions: *We are now at the start point of the course. When I ask you to begin, your top priority will be to drive safely, try to stay in your lane, and obey a speed limit of **30 mph**. You will drive the course one full time by beginning here, driving to the end point and making a u-turn, then drive back to this starting point.*

For this segment, you will compose text messages using the Vlingo app on the Samsung phone. Remember that Vlingo can only compose text messages for you, and it cannot read messages you receive. So when I instruct you to take out your phone and read the message you have received, you will have to do so manually. Then when I instruct you to reply to the message, be sure to use Vlingo to compose your reply message, NOT manually replying. This will require you having to exit the Messages screen and re-open the Vlingo app.

Also remember that as soon as you observe the green LED light in front of you, flick the joystick button. *Do you have any questions? Are you ready to begin?*

*****Check to make sure:*****

- **GPS is running and recording (Green Background)**
- **Cameras are angled properly and recording**
- **FaceLAB is tracking AND logging**
- **PsychoPy is running**

**************************************Begin Lap V************************************

Experimenter Notes:

Press a letter key on the GPS screen every time the driver picks up their cell phone and replaces it, so we know how long it took them to complete each task.

**************************************End Lap V*************************************

Participant Feedback:

How well do you feel like you were driving on a scale of 1 to 100, rather, what grade would you give yourself?

How safe do you think your driving was? (Circle one)

Very Unsafe Unsafe Neutral Safe Very Safe

Do you have any thoughts or comments about the segment you just completed?

Subject # _____ Lap Order (1,2,3,4)_____

Lap S: Using Siri to Text

Verbal Instructions: *We are now at the start point of the course. When I ask you to begin, your top priority will be to drive safely, try to stay in your lane, and obey a speed limit of **30 mph**. You will drive the course one full time by beginning here, driving to the end point and making a u-turn, then drive back to this starting point.*

For this segment, you will send and receive text messages using Siri on the iPhone. Remember that Siri can both compose and read text messages for you. To activate Siri, press and hold the menu button.

Also remember that as soon as you observe the green LED light in front of you, flick the joystick button. *Do you have any questions? Are you ready to begin?*

*****Check to make sure:*****

- **GPS is running and recording (Green Background)**
- **Cameras are angled properly and recording**
- **FaceLAB is tracking AND logging**
- **PsychoPy is running**

**************************************Begin Lap S**************************************

Experimenter Notes:

Press a letter key on the GPS screen every time the driver picks up their cell phone and replaces it, so we know how long it took them to complete each task.

**************************************End Lap S**************************************

Participant Feedback:

How well do you feel like you were driving on a scale of 1 to 100, rather, what grade would you give yourself?

How safe do you think your driving was? (Circle one)

Very Unsafe Unsafe Neutral Safe Very Safe

Do you have any thoughts or comments about the segment you just completed?

APPENDIX D: VERBAL INSTRUCTIONS TO PARTICIPANTS

Verbal Instructions at Intake

Thank you for your willingness to participate! This study is about the effectiveness of voice-to-text programs at reducing incidences of distracted driving. Today you will be asked to drive our instrumented vehicle on a closed course. A researcher will be riding with you at all times, giving you directions and additional instructions.

- [***Begin Flip Book***] Because we will be using our eye tracker today, we are asking that you not wear sunglasses if possible in order to allow the cameras to see your eyes.

- [***Show course map***.] This is a map of the course you will drive today. You are here in this building. First you will drive out to the start point of the course, which will allow you several minutes to get used to driving the vehicle.

- Once you are at the start point of the course, the researcher in the vehicle will tell you when to begin. In order to complete <u>one lap</u>, you will begin at START, drive all the way around to the end of the runway, make a u-turn, and drive back to where you started – and that is ONE LAP.

- **You will drive a total of five laps today: one practice lap and four "real" laps**. **The researcher in the vehicle will tell you the order to complete the four "real" laps.** You may complete each lap in a different order than how I will explain it to you, but you will definitely begin with the warm-up/practice lap.
    - **Warm-up/Practice Lap**: No equipment will be recording you or your driving. You will simply be asked to drive one complete lap so that you are familiar with what lane you should be in and where to turn.
    - **No Texting**: You will not be asked to send or receive any text messages. Your only responsibility is to maintain a speed of 30 mph (slowing down for turns and curves as needed of course!), drive straight in your lane, and respond to a light that will turn on periodically – I'll explain more about this in a moment.
    - **Manual Texting**: For this lap, in addition to driving at 30 mph, staying straight in your lane, and responding to the light, you will also be asked to manually text and drive.

- **Using Siri to Text**: For this lap, in addition to driving at 30 mph, staying straight in your lane, and responding to the light, you will also be asked to use the iPhone's Siri voice-to-text program to text and drive.
- **Using Vlingo to Text**: For this lap, in addition to driving at 30 mph, staying straight in your lane, and responding to the light, you will also be asked to use the Samsung's Vlingo voice-to-text program to text and drive.

- [***Show picture of LED light and response joystick***.] As I previously mentioned, during each of the four "real" laps you are driving, you will be asked to respond quickly to a **green LED light** that is on the dashboard in front of you. **As soon as you observe that the light is on, respond as quickly as possible by flicking the response joystick**.

After completing each lap, you will be asked a couple of **follow-up questions** and you will have a chance to provide your thoughts/feedback on your experience during that segment.

In general, **your top priority is to drive safely, try to stay in your lane, and obey the speed limit of 30 mph**. We want you and your passenger to come back safely!

Do you have any questions?

----------Begin Texting Warm-ups----------

Practice Texting (Intake Office)

[*Each participant will practice texting 1) manually, 2) using Vlingo, and 3) using Siri*.]

I want you to practice texting using three different methods: 1) manually, 2) using Vlingo, and 3) using Siri. Whichever method I ask you to use, you should only use that method, as opposed to switching from using Siri to compose a message and then manually read a message.

First, I want you to practice sending and receiving text messages <u>manually</u>. We have two study cell phones, an iPhone and a Samsung. Which cell phone are you most comfortable texting manually with today?

[*Write their cell phone choice on the "Lap M" experimenter sheet for that subject*.]

Remember that even though this cell phone you have chosen is capable of receiving voice-to-text commands, please only read and write texts manually for this section.

[*Guide them through the texting conversation at the end, replying as instructed.*]

Second, I want you to practice sending and receiving text messages <u>using Vlingo on the Samsung phone</u>.

Vlingo is capable of composing a text message for you as you speak the message. It is not capable of reading messages you receive, so for this section, when you receive a message, you will have to read it manually, and then you will have to exit the Messages screen and re-open Vlingo in order to reply using Vlingo. Please be sure to use Vlingo for all of your replies, as opposed to typing any text messages manually.

To open Vlingo, press the menu button and locate the Vlingo app. When you're ready to compose a message, press the "Speak It" button. You will have to say both who you are texting and what the text message says, all in one string. For example, you would say, "Text Sarah Hey, what's up?"

Vlingo then shows you on the screen what it thinks it heard you say. You will have to press the send button to officially send the message.

[*Guide them through the texting conversation at the end, replying as instructed.*]

Lastly, I want you to practice sending and receiving text messages <u>using Siri on the iPhone</u>.

Siri is capable of both composing and reading text messages for you as you speak the commands. To open Siri, press and hold the menu button until you see the voice prompt. You can say, for example, "Text Sarah" and then Siri will respond to you if it heard you correctly. Siri guides you through the process of sending a text message.

To read a message you have received using Siri, again press and hold the menu button until you see the voice prompt. Then you can say, for example, "Read message" and Siri will walk you through how to read the message.

[*Guide them through the texting conversation at the end, replying as instructed.*]

[*Below is the texting conversation to practice for all three methods (they will repeat this conversation a total of three times).*]

1. **Initiate Text**: Take out your phone and text [Name] the message "Hey, where are you?"

   [*Reply to their text*.] "Library, studying."

2. **Read & Reply**: Take out your phone and read the message you have received out loud.
   a. Now reply to [Name] with the message "Are you ready for the exam tomorrow?"

   [*Reply to their text*.] "I think so. You?"

3. **Read & Reply**: Take out your phone and read the message you have received out loud.
    a. Now reply to [Name] with the message "Hopefully, I'm almost done studying."

    [*Reply to their text*.] "Good luck tomorrow!"

4. **Read & Reply**: Take out your phone and read the message you have received out loud.
    a. Now reply to [Name] with the message "Thanks, you too."

    [*Reply to their text*.] "Thanks!"

5. **Read Only**: Take out your phone and read the message you have received out loud.

----------End Texting Warm-ups----------

Do you need to use the restroom or get a drink of water?

APPENDIX E: TEXT MESSAGING SCRIPT

1. **Just entering the curve**: Take out your phone and text [Name] the message "What are you doing tonight?"
2. **Just entering the next curve**: Take out your phone and read the message you have received out loud. "Nothing. Do you want to get together for dinner?"
    a. Now reply to [Name] with the message "Yes, where do you want to eat?"
3. **As the pasture fence begins on the left**: Take out your phone and read the message you have received out loud. "Subway."
    a. Now reply to [Name] with the message "Okay, what time?"
4. **At the intersection**: Take out your phone and read the message you have received out loud. "7:00pm"
    a. Now reply to [Name] with the message "See you later."
5. **At the UXO building**: Take out your phone and read the message you have received out loud. "Okay, bye!"

APPENDIX F: BACKGROUND SURVEY

Voice-to-Text – Closed Course Demographic & Background Survey

Demographic Questions

1. What is your gender?

- ○ Female
- ○ Male

2. Which category below includes your age?

- ○ 16-17
- ○ 18-24
- ○ 25-29
- ○ 30-39
- ○ 40-49
- ○ 50-59
- ○ 60 or older

3. What is the highest level of education you have completed?

- ○ No high school diploma
- ○ High school diploma or equivalent (GED)
- ○ Some college, no degree
- ○ Associate or technical degree
- ○ Bachelor's degree
- ○ Masters degree
- ○ PHD

4. What is your race/ethnic background? (Check all that apply)

- ☐ White
- ☐ African-American
- ☐ Asian or Pacific Islander
- ☐ Hispanic
- ☐ Other (please specify)

5. What state or U.S. territory are you currently a resident in?

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Voice-to-Text – Closed Course Demographic & Background Survey

Driver and Mobile Device Information

6. Where do you primarily drive?

- ○ Urban area (city, large town, or suburban areas)
- ○ Rural area (smaller town or open country areas)
- ○ Both, urban and rural area

7. At what age did you first acquire a working cellular phone?

Response: _____

8. What type of operating system does your cell phone have?

- ○ I do not have a smartphone
- ○ Android
- ○ Apple IOS (IPhone)
- ○ Windows
- ○ Blackberry
- ○ Other (please specify)

_____

9. What type of keypad does your cell phone have?

- ○ Touchscreen
- ○ Full QWERTY keypad with raised button-keys
- ○ Numerical keypad (with 12 keys for numbers 0-9,*,#)

10. On a typical day, how many text messages do you send/receive per day on your mobile device?

- ○ I do not text everyday
- ○ 1-5 messages a day
- ○ 6-20 messages a day
- ○ 21-99 messages a day
- ○ 100+ messages a day

Voice-to-Text – Closed Course Demographic & Background Survey

Texting Behavior

11. Do you text and drive?

- Yes
- No

Comments (Optional)

12. Please choose the option that best describes your texting while driving behavior:

- I never text while driving
- I only text at red lights or stop signs when I'm driving
- I regularly text and drive (while the vehicle is in motion)

Comments (Optional)

13. How often do you read or write text messages while driving while the vehicle is IN MOTION?

- Multiple times a day
- Multiple times a week
- Multiple times a month
- Once a month or less frequently
- I never read or write text messages while driving while the vehicle is in motion

Comments (Optional)

Voice-to-Text – Closed Course Demographic & Background Survey

14. How often do you read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

- Multiple times a day
- Multiple times a week
- Multiple times a month
- Once a month or less frequently
- I never read or write text messages while driving while the vehicle is stopped

Comments (Optional)

15. I have read and/or written a text message while driving (vehicle in motion and/or stopped at a red light or stop sign) at least once in the past _____ .

- 24 hours
- 24 - 48 hours
- 7 days
- 30 days
- 6 months
- 12 months
- Longer than 12 months
- I have never in my lifetime read or written a text message while driving

Comments (Optional)

Voice-to-Text – Closed Course Demographic & Background Survey

Your Feelings About Texting While Driving

16. How do you feel when you read or write text messages while driving while the vehicle is IN MOTION?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

17. How do you feel when you read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

18. What is your preferred method of texting when you are driving?

- ○ Manually typing each letter/number/character
- ○ Allowing T9 or autofill to assist me while I manually type
- ○ Voice-to-text recognition app or in-vehicle system (SIRI, SYNC, etc.)
- ○ I do not text while I'm driving
- ○ Other (please specify)

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Voice-to-Text – Closed Course Demographic & Background Survey

Cell Phone Capabilities

19. Does your cell phone have voice-to-text capabilities?

- ○ Yes
- ○ No
- ○ I don't know
- ○ Other (please specify)

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Voice-to-Text – Closed Course Demographic & Background Survey

Using Voice-to-Text on Your Cell Phone

20. How often do you use the voice-to-text capability on your cell phone to read or write text messages while driving?

- ○ Daily
- ○ Weekly
- ○ Monthly
- ○ Less frequently
- ○ Never

Comments (Optional)

21. Why do you not use your voice-to-text app to send or receive text messages more often? Check all that apply.

- ☐ Hard to use
- ☐ Does not work well
- ☐ I am unprepared to use it when I need to
- ☐ I forget to use it
- ☐ Other (please specify)

Voice-to-Text – Closed Course Demographic & Background Survey

22. Which voice-to-text app(s) do you use? Choose all that apply.

- [ ] Siri
- [ ] Vlingo
- [ ] ShoutOut
- [ ] Jarvis
- [ ] On the Move
- [ ] Otter
- [ ] I don't use any voice-to-text apps on my phone
- [ ] Other (please specify)

23. On average, I would rate the performance of these voice-to-text apps in the following categories...

	Very Poor	Poor	Neutral	Good	Very Good	N/A
Usefulness	○	○	○	○	○	○
Effective translation into text	○	○	○	○	○	○
Price	○	○	○	○	○	○
Increasing my safety while texting and driving	○	○	○	○	○	○

Comments (Optional)

24. How do you feel when you use your voice-to-text mobile app to read or write text messages while driving while the vehicle is IN MOTION?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

Voice-to-Text – Closed Course Demographic & Background Survey

25. How do you feel when you use your voice-to-text mobile app to read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

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Voice-to-Text – Closed Course Demographic & Background Survey

Vehicle Capabilities

26. Does the vehicle that you drive most often have voice-to-text capabilities?

- ○ Yes
- ○ No
- ○ I don't know
- ○ Other (please specify)

Voice-to-Text – Closed Course Demographic & Background Survey

Using Voice-to-Text in Your Vehicle

27. How often do you use the voice-to-text capability in your vehicle to read or write text messages while driving?

- ○ Daily
- ○ Weekly
- ○ Monthly
- ○ Less frequently
- ○ Never

Comments (Optional)

28. Why do you not use your vehicle's voice-to-text system to send or receive text messages more often? Check all that apply.

- ☐ Hard to use
- ☐ Does not work well
- ☐ I am unprepared to use it when I need to
- ☐ I forget to use it
- ☐ Other (please specify)

29. Which voice-to-text capable system does your vehicle have?

- ☐ Ford/Lincoln Sync
- ☐ GM/Chevrolet OnStar
- ☐ Kia UVO
- ☐ Toyota Entune
- ☐ BMW Connected Drive
- ☐ Dodge/Chrysler UConnect
- ☐ Other (please specify)

Voice-to-Text – Closed Course Demographic & Background Survey

30. On average, I would rate the performance of my vehicle's voice-to-text system in the following categories...

	Very Poor	Poor	Neutral	Good	Very Good	N/A
Usefulness	○	○	○	○	○	○
Effective translation into text	○	○	○	○	○	○
Price	○	○	○	○	○	○
Increasing my safety while texting and driving	○	○	○	○	○	○

Comments (Optional)

31. How do you feel when you use your voice-to-text in-vehicle system to read or write text messages while driving while the vehicle is IN MOTION?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

32. How do you feel when you use your voice-to-text in-vehicle system to read or write text messages while driving when the vehicle is STOPPED (at a red light, stop sign, waiting for a train to pass, stuck in traffic, etc.)?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe	N/A
I feel ____	○	○	○	○	○	○

Comments (Optional)

Voice-to-Text – Closed Course Demographic & Background Survey

Texting While Driving Is ___?

33. How safe or unsafe do you consider the following activities?

	Very Safe	Safe	Neutral	Unsafe	Very Unsafe
Texting while driving is	○	○	○	○	○
Texting at a red light is	○	○	○	○	○
Texting at a stop sign is	○	○	○	○	○

Comments (Optional)

34. Compared to manual texting while driving, what effect do the following technologies have on the ability to drive safely while texting?

	Considerably More Safe	Somewhat More Safe	Neutral	Somewhat Less Safe	Considerably Less Safe
Voice-to-text apps for your cell phone are...	○	○	○	○	○
Voice-to-text systems in your vehicle are...	○	○	○	○	○

Comments (Optional)

Voice-to-Text – Closed Course Demographic & Background Survey

Thank You!

Thank you for taking time to complete this survey!

APPENDIX G: POST-EXPERIMENT QUESTIONNAIRE

Subject #: _____

Post Experiment Questions

1. Which method for sending and receiving text messages was your favorite today?
    a. Manual
    b. Vlingo
    c. Siri
    d. None of the above

2. On average, how would you rate the performance of each texting method?

Manual-Entry Texting: (check one per row)

	Very Poor	Poor	Neutral	Good	Very Good
Usefulness					
Effective translation into text					
Increasing my safety while texting and driving					

Vlingo Texting: (check one per row)

	Very Poor	Poor	Neutral	Good	Very Good
Usefulness					
Effective translation into text					
Increasing my safety while texting and driving					

Siri Texting: (check one per row)

	Very Poor	Poor	Neutral	Good	Very Good
Usefulness					
Effective translation into text					
Increasing my safety while texting and driving					

3. Compared to manual-entry texting while driving, what effect do each of the two voice-to-text methods have on the ability to drive safely while texting?

(Check one per row)

	Considerably Less Safe	Somewhat Less Safe	Neutral	Somewhat More Safe	Considerably More Safe
Vlingo					
Siri					

4. Similar to question 3, compare Vlingo and Siri only:

Compared to Vlingo, Siri is _____ in its ability for me to drive safely while texting.

	Considerably Less Safe	Somewhat Less Safe	Neutral	Somewhat More Safe	Considerably More Safe
Siri					

5. If you had to rank the three texting methods, how would you order them?

(Write 1, 2, and 3 below, where 1 = 1st preference and 3 = last preference)

Manual: ____
Vlingo: ____
Siri: ____

6. In your opinion, is the difficulty of texting affected by the mechanism with which you text (manual texting versus voice-to-text programs)? Why or why not?

7. In your own words, how well do you think you did today?

8. What, if anything, did you learn today as a result of this experiment?

9. Do you have any other comments or feedback?

APPENDIX H: OPEN-ENDED RESPONSES

In your opinion, is the difficulty of texting affected by the mechanism with which you text (manual texting versus voice-to-text programs)? Why or why not?

Yes, the amount of time you have to spend looking at the screen and taking your eyes off the road

Yes, because I have big stubby fingers and I have to look at what I'm typing when doing it manually rather than just a glance to hit send

Manual is difficult without T9 because you press different keys; Vlingo is next-have to manually do things but you can speak it to reply

Manual is more difficult while driving-having to look down instead of at road, having to make sure it's typed correctly; voice is distracting also instead of focusing on speed and roadway ahead

Yes, I felt more comfortable with Siri because I had one button to push and then I could set it down and use my hands. The others required too much attention.

Because you have to take eyes off road, so much more distracting. And for me because I had so many typos if I had tried to correct, texting would have taken so much longer.

Yes, you're not paying attention to driving if looking at your phone and typing

Yes, the more a person has to look down at their phone while manually texting, the less they pay attention to their surroundings. Voice to text helps keep your eyes on the road.

Yes, would have to get used to it with the phone first, but you still have to have concentration, to manage the texting.

Yes, I think it is directly effected. The manual texting and Vlingo require more physical input requiring more attention from the user compared to Siri. This attention would otherwise be directed towards driving.

Manual texting-shows what you're sending, voice text needs to read aloud what you texted before sending

Yes, because voice to text program felt more useful than manual texting.

Yes, manual texting requires the driver to take eyes off the road more often

Yes, it's harder to text manually, yours eyes are off the road longer, speaking a text is easier, but then you have to make sure what was put was correct

Yes, Vlingo was because you had to fumble through the phone menus

Yes, with Siri I didn't have to take my eyes off the road except to pick up my phone. Vlingo was effective in that I didn't have to type my messages but I still had to look at my phone often.

Manual texting made me take my eyes off the road almost the whole duration of sending or receiving a text.

Yes, some voice to text programs take longer to access and get used to. Manual texting is straight forward and typically easy to get to on all screens.

Yes, because touchscreen manual texting requires more precision than that of a phone with buttons, additionally the voice-to-text option aided my concentration on the road conditions.

Yes, to accurately text a message you must look at the screen and carefully touch the correct letters and symbols to have the message readable or make sense. There is nothing to "feel" on the flat screen to help.

Yes, voice-to-text programs allow more time to focus on the road

Yes, you have to watch screen more with manual texting.

Voice is easier but to make sure it is getting what you say you have to keep checking.

There was difficulty with all three – they all took your attention off the road – even when speaking – you had to read what the phone heard, but the voice-to-text were better than manual.
Yes, more concentration on pressing QWERTY buttons and not looking at the road and speed.
Yes, familiarity and less hand motions required
Yes, voice to text eliminates a manual step in the process, allowing my eyes to stay on the road.
Yes, I think the voice-to-text programs make it harder because sometimes I have to check to make sure it got it right, and I feel like I check that more often.
Yes, the less I have to look at my phone, the safer I drive
Yes, voice-to-text programs are safer because it takes less time of eyes being off the road.
Yes, because some require more concentration and coordination than others. (Vlingo has a lot more switching of menus than Siri or manual)
Manual much more difficult. Screen too small. Letters too small to choose.
Yes, because with manual texting you have to put a lot more focus on the phone rather than the road, compared to to the voice-to-text which makes it possible to pay more attention to the road.
Voice-to-text is much easier and safer once you get past the "learning curve"
Voice to text is easier than manual because it allows you to keep your eyes on the road more.
Manual texting takes your eyes off the road more and provides more distractions.
Yes, manual texting requires more input and distracts my eyes from the road.
Yes, not sure; just some methods are more difficult
Yes, manual texting was much more difficult to do in comparison to Siri/Vlingo. Eyes were off the road many times.
Yes, eyes diverted more for manual.
Yes with Siri I didn't have to worry about spell check and she read the messages. No with Vlingo, it was confusing going back and forth and was just as distracting as texting.
Yes, not familiar with technology types, affect how comfortable you are with texting
Sending texts with voice-to-text is a considerably safer method since it allows you to keep your eyes on the road longer. However it doesn't always get it right and takes longer to correct.
Manual texting on a touch screen is less safe, but the correctness can be made quicker.
Yes, the more difficult it is the more you take your eyes off the road.

In your own words, how well do you think you did today?
Slightly above average
Pretty good
Pretty good
Okay, manual texting didn't come out well as far as spelling correctly; driving felt okay but probably because at low speed, had I been driving faster, would have felt unsafe
I feel I am a very safe driver. Texting while driving today stressed me a little and impacted my safety. I did not feel I was driving very safe.
Overall, texting portion-not well at all; Siri-better driving
Pretty good
I think I did very well. I stayed in the lines, kept within 5 miles of the speed limit, and noticed the flashing green LED light almost, if not, every time.
Fair
I think I did considerably better using Siri because I was able to focus more attention on driving compared to manual texting and Vlingo. I found Vlingo nearly as distracting as manual texting.

Manual texting-good; Vlingo-was way too many buttons to push to get to the application; Siri-easier, but was never really sure what it was sending
I think I did ok because I never went over the speed limit
I think I was able to maintain safe driving but felt more stressed during the manual texting segment
I think I did alright, obviously if I was in a real road situation I would be more careful and take my time more sending a text but I think although I wouldn't crash, my attention was affected and it was unsafe.
Good
I think I did good with Vlingo and Siri. Manual texting, I did not do very good.
Good, though I did notice myself going over 30 mph when texting and sometimes driving out of my lane.
Apart from manual texting, I did pretty well
Driving…fine. Texting and driving…not fine. Because of unfamiliarity, using the voice texting I was shaky, at best.
Average.
Pretty well on all three
Good, I think I know when to text and when not to text and drive
I think I did well except with manual texting – couldn't maintain speed or lane.
Good
Well, a little lower because of nervousness. I know I am being tested, but I am good at handling my phone, texting, and driving, along with all other distractions I normally have in my car.
Better than anticipated. Although I realize this is a VERY controlled course with virtually no variables to contend with.
Fairly well, there was pressure on my part to do well so I was tense, but I don't think that affected my driving!
I did ok…was glad no one else was on the road!
I did well with all methods, but better using voice-to-text programs.
I think I did ok when I had to do one extra thing on top of concentratin while driving, but when I had to do all 3 things (drive, text, and hit response sensor), it was considerably more difficult.
Very well using Siri. Average with Vlingo. Poor with manual text.
I think I did somewhat alright. It made me realize how bad I am at texting and driving and how unsafe it is.
Good - hardest part for me was maintaining 30 mph; I like Vlingo best
I think I drove badly when it came to manual texting and fairly well with not texting.
Very bad with manual texting. Better with Siri but still distracted.
For not being terribly familiar with the text inputs (I normally use T9) I think I did average.
So-so – I think I'm a good driver, but I am not used to texting while driving or using Siri or Vlingo. So I think I probably did bad with that.
I did well. I tried to make sure my driving was good, before I completed a text. I lowered my speed.
Well, more distracted for Vlingo because I was unfamiliar with it.
I think I was probably right around average. I know that texting and driving is unsafe and distracting and I'm sure I did better without texting.
Much worse with manual texting, but even worse than that due to unfamiliar phone; safer with iPhone that I am familiar with.

I think I did decently well in each task. Though when I had to send a text, all of my concentration went to the text and that probably influenced greatly my ability to drive straight and safely.
Did well at the test but really really bad at the texting.

What, if anything, did you learn today as a result of this experiment?
I don't drive as well as I thought I did while texting
I'd never used Siri before, but I'd used the text to speech. So this confirmed that manual is worse than that.
Not to manually text in heavy traffic, but at stop light or pulled over is probably ok. Siri isn't as difficult as I thought it was.
New talk to text programs-texting is more distracting than people think, even using voice to text just because you're talking doesn't mean it's safer
Siri is the safest for any kind of transportation texting
Not to text and drive; if you have to do something like that, go with voice to text (Siri)-effortless to use
Confirmed I should not text and drive unless I get Siri, though I have no idea what I sent
The more interactive the program is, the more a person stays focused and attentive to the road, rather than constantly looking down.
That texting is difficult, doesn't matter what kind of phone you have
The benefit of using voice to text applications
I really need to try to utilize Siri more!
I learned that texting while driving is still unsafe
I learned that voice to text enabled me to keep my eyes on the road. But anything distracts my eyes from the road is potentially dangerous.
I learned there are more safer methods to texting and driving and it's not as safe as you may feel.
I don't think I learned anything
I learned that I should stop texting unless I am stopped, or I should purchase a voice to text app.
Driving while texting is not as safe as I thought using voice to text programs.
Don't text and drive!
Don't text and drive with a "smart" phone…without Siri!
The lack of safety when texting manually and driving
I don't like Vlingo!
Don't text on a curve.
Never text and drive!
Prefer not to text whether voice to text or manual text. Prefer to use cell phone to make calls while driving
I should use Siri more.
That "hands-free" texting is a better option when I thought they would be equally distracting.
I don't respond as quick as I think I do, and I'm actually checking more things at a time than I think I realize while driving normally.
It'd be nice to have some type of program (like Siri) if I wanted to text and drive.
Although voice-to-text apps may be made with good intentions, I think some (Vlingo) can actually hinder driving performance even more than manual texting.
Using Siri has possibilities to use in open-road little traffic, stop signs.
How unsafe it is to text and drive because of how much it limits your ability to pay attention to the road.

I'd rather not text anything other than yes/no/ok while driving – rather just call them! (or wait until I stop)
Don't text and drive.
Voice texting seems to be a safer choice if you have to text and drive.
Usefulness of voice to text software
Confirmed what I thought, texting while driving is very unsafe. Also, learned using the other methods is still somewhat unsafe.
That texting/driving is not safe.
That voice texting is a safer alternative to manual texting if texting is necessary
Nothing
Don't use any technology that takes your eyes off the road
That I'm not as good at texting and driving as I thought. Also, I learned that voice to text is an option I may want to look into.
I suck at texting and driving which means it is very dangerous.

Do you have any other comments or feedback?
Never used Siri before, my Samsung has SVoice, or I use the microphone button
About Siri, I would probably leave it in the cup holder, reach over, and push it to use it so I'd have two hands to drive and she heard me fine
I feel auto correct on the manual texting could help make things a little safer, but I know it would impact the study
Very interesting to see the differences
Really interesting
It was extremely useful to learn what other apps are out there compared to the normal manual texting that I use.
Texting is not for me, or have to take course on it
Vlingo is way too many buttons, I would never use it. This was very interesting.
It was good experience to have this test
I had fun
I think that if I were familiar with the phones and the Vlingo and Siri, I would've done better, it would improve my safety. You just have to get used to the method you use. Still, I try not to text and drive.
Fun and educational survey
I hope my participation was helpful.
Well organized. Maybe encourage more practice with both types of cell-phones before beginning the experiment.
Instinct is to pick up the phone whenever you hear it.
All cars should have voice activated phones.
Great experiment!
Very organized; tried very hard to be clear; interesting survey
I like Vlingo because it requires less steps to text someone, but prefer Siri because it is more accurate translating into text.
I think it's a great study and very important and applicable to our society.
Would like to have button on car steering wheel to activate Siri.
It's a really useful experiment and I'm glad I got to participate.
Enjoyed it – cool "toys" measuring everything, thanks

No, except I think it’s a very interesting experience.
Good study
Great study, I hope it helps save lives.