A Comparison of Drivers' Braking Responses across Ages

by

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As driving is associated with independence, it is important for occupational therapists to understand what skills are required to drive safely and how to assess them in order to keep older drivers driving independently as long as possible. This study examined the reaction times and braking forces of younger and older adults in both simple and complex reaction situations. Results showed that all participants had an increase in reaction time with increased complexity of the situation. Although previous research has shown that reaction times slow with age, our results did not demonstrate statistically significant differences between the braking reactions of younger and older drivers. However, this study's results show that, the time difference between a brake reaction in a simple situation and one in a complex situation increases significantly with age ($z = 2.364$, $p= .024$). Additionally, younger and older drivers were able to consistently demonstrate application of sufficient force (e.g., 30 pounds) to control brake pedals. These findings support the concept that age related changes might influence the ability to process and react to complex stimuli.

A Comparison of Drivers' Braking Responses across Ages

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Introduction

Driving is a key component of independence and mobility within most communities. People rely on their ability to drive to get them everywhere within their communities and to provide a level of independence. Older adults in a 2006 study expressed distress in relation to driving cessation; they described driving as, “a means to maintain control over and spontaneity in daily life and activities” (Rudman, Friedland, Chipman, & Sciartino, 2006). Participants in the study indicated that it is important to continue to drive for as long as possible (Rudman, Friedland, Chipman, & Sciartino, 2006). Donorfino, D’Ambrosio, Coughlin, and Mohyde (2009) examined what driving and self-regulation means to older drivers. The main theme that emerged through the course of the study was an association between driving cessation and increased dependence indicating that older drivers felt that their ability to drive was directly related to their identity and feelings of self-worth (Donorfio, D’Ambrosio, Coughlin, & Mohyde, 2009).

Vrkljan and Polgar’s (2012) work also underscored the connection between driving ability and independence and identity. Participants in the study indicated a feeling of connection between the occupational performance of driving and their occupational identity of independence. Participants associated driving ability with independence, and indicated that driving cessation brought feelings of lack of value and dependence (Vrkljan & Polgar’s, 2012). Both typical drivers and drivers with disabilities find driving to be important. Dickerson, Reistetter, and Gaudy (2012) found that older adults recovering from a recent stroke rated driving as the most important instrumental activity of daily living (IADL) as compared to other IADLs. Those adults who did not rate driving as the most important IADL had either never driven or had ceased driving.

Although driving is a meaningful and integral component of most people’s lives, the processing delays that can accompany aging may inhibit the ability to drive safely (Vance, 2009). Older drivers may self-restrict their driving by decreasing driving frequency or avoiding difficult maneuvers such as left turns across traffic or driving at night. Despite this, drivers over the age of 70 have a drastically higher ratio of involvement in crashes than the middle-aged driver (Stutts, Martell, & Staplin, 2009). Consequently, it is important that drivers' ability to remain safe on the road is assessed. Comprehensive driving evaluations are useful, but they can be costly and the on-road component can be potentially dangerous (Dickerson et al., 2007). Driving simulators may be an alternative to the on- road component of comprehensive driving assessments and could also be utilized as an intervention tool. However, more research and information about driving simulators is needed before they can be established as effective evaluation and/or intervention tools.

During comprehensive driving evaluations, some of the measurable components of driving ability include reaction time and the ability to apply force to a brake (National Highway Safety Administration, 2004). Reaction time is important when perceiving and reacting to risks or unexpected situations when driving. The amount of force used on a brake pedal may be important in differentiating what physical capabilities are needed to use the brake pedal and how the level of force varies with the level of urgency and expectancy.

This study had two independent variables, with one being age (young or old). The other independent variable is test type (complex driving simulator, simple floor model tester, or simple driving simulator test). The dependent variables are 1)` time as measured by seconds and 2) force as measured by pounds. The outcomes of this study explored the relationship between complex reaction time on a driving simulator and simple reaction time for both young and old drivers. Results also provide information about how force varies in a simple or complex situation, and with age.

The study described in this paper will contribute to our knowledge about driving by measuring driving reactions that involve peripheral input and measure the physical pressing of the brake pedal in order to mirror the actions used in real-life driving situations. This study will also contribute information about the relationship between simple reaction time and complex reaction time, as well as the effects of age on these relationships.

Literature Review

Cognitive Ability

Increased age is often related to slowed cognitive abilities, which can impair driving. There are various cognitive skills that relate to the ability to drive; these include processing speed, attention and perception. Ball et al. (2006) found that for drivers aged 55 and older, poor cognitive ability was predictive of future at-fault motor vehicle collisions, indicating that our cognitive abilities are directly related to our driving abilities.

Processing speed is the cognitive ability that is most closely associated with involvement in a motor vehicle collision (Ball et al., 2010); speed of processing slows significantly with age (Vance, 2009). Processing speed has been shown to be a relevant factor impacting other cognitive abilities such as memory, reasoning and psychomotor ability; so as processing speeds slow, so do a variety of other cognitive functions (Vance, 2009). Processing speed can slow everyday functioning, and is particularly necessary for IADLs like driving (Vance, 2009).

Bedard et al. (2006) found that visual attention deteriorates with age and that poor visual attention is related to poorer driving, and increased crash risk. This finding indicates that older drivers' worsening visual attention could lead to unsafe driving. In a 2009 meta-analysis, Mathias and Lucas found that measures of attention and perception were the best types of tests at predicting whether a driver would pass or fail a test of driving ability. Increased age was also found to correlate with whether drivers passed or failed; indicating that age and perception may be the best predictors of unsafe driving (Mathias & Lucas, 2009). Because perception is increasingly impaired with age, and both age and perception are predictive of driving ability, older drivers are at risk for having inadequate or dangerous driving abilities (Mathias & Lucas, 2009; Vance, 2009).

As cognitive and processing delays set in with increased age, drivers can be prone to make car pedal errors, mistaking one pedal for another. A pedal error may result in unintended acceleration, which has been the cause of many fatalities and injuries (Freund, Colgrove, Petrakos, & McLeod, 2008). Freund, Colgrove, Petrakos and McLeod (2008) found that both The Clock Drawing Test (Agrell & Dehlin, 1998) and age are predictive of pedal errors (Freund et al., 2008). Thus, these studies by Vance (2009), Ball et al. (2006), Mathias & Lucas (2009), Bedard et al. (2006), and Freund et al. (2008) provide evidence that as we age our cognitive abilities deteriorate, which can ultimately affect the ability to drive safely.

Reaction Time

A comprehensive driving assessment is a clinical driving evaluation that is performed by a driving specialist, often an occupational therapist, in order to assess a client's driving ability (Dickerson, Reistetter, & Trujillo, 2010). Driving assessments involve assessing several dimensions of driving ability. Reaction time is one of these dimensions and is a key component of driving ability (Dickerson, et al., 2008). In fact, brake reaction time is one of the most commonly used assessments in driving evaluations (Dickerson, Reistetter, & Trujillo, 2010; Dickerson, in press). The common use of reaction time as a component of driving assessments clearly positions reaction time as a widely accepted and key element of driving ability (National Highway Traffic Safety Administration, 2004).

Reaction time is the measurement of a behavioral response, in time units, from the presentation of a given task to its completion (Baayen & Milin, 2010). Simple and complex (or choice reaction times), are two types of reaction times (Baayen & Milin, 2010). Simple reaction times are those where subjects must respond to simple stimuli such as light or sound while complex reaction times are those where subjects have to select a response from a set of possible responses (Baayen & Milin, 2010). A complex stimulus would be a situation that requires a decision to be made in response to multiple stimuli, such as needing to react to a specific stimulus when other visual and auditory input is being given. Simple reaction time gives an indication of the individual's physical ability to react, while complex brake reaction time is a measure of ability that is more applicable to real-life driving situations.

Bilban, Vojvoda and Jerman (2009) found a positive correlation between age and simple reaction time, with response time increasing significantly after 65. The study tested simple reaction time as the amount of time to depress a brake pedal in reaction to a red or green light. However, drivers' braking reactions may differ when reacting to more complex stimuli – such as in a simulated driving situation. Bilban, Vojvoda and Jerman (2009) postulate that the differences in reaction times across ages were due to a decrease in processing ability attributable to age. The study was based in Slovenia, so a clutch was used on the driving simulator in an effort to make the simulator similar to a car that the participants would drive (Bilban, Vojvoda & Jerman, 2009). This change to the simulator could involve physical or cognitive processing times not required with automatic cars, and would not be relevant to all participants in the United States today. Therefore, additional research is required to test simple reaction times' relation to age without the use of a clutch.

Philip et al. (1999) tested simple reaction times as measured by the amount of time it took participants to press a button in response to a visual stimulus. Findings showed a median reaction time of 236 ± 32 milliseconds for individuals under 30 years of age, and a median reaction time of 262 ± 81 milliseconds for individuals between the ages of 30 and 55. These findings indicate a difference between reaction times of young and old drivers, however do not examine the reaction times of drivers above the age of 55. Dickerson et al. (2008) examined a total of 396 drivers ages 15-91 years. Findings of this study showed a significant relationship between age and brake reaction time, with older drivers taking longer to respond (2008).

Marc Green (2000) performed a systematic review of studies involving reaction time. Green’s paper examined studies following one of three paradigms: simulator studies, controlled road studies, or naturalistic observation, that also focused on reaction times. Green’s (2000) review found that older drivers tend to respond 0.1 to 0.3 seconds more slowly than their younger counterparts. Green (2000) also found that brake response times are the shortest when the reaction is expected and certain, with average timing across all ages being 0.70 to 0.75 seconds. When the reaction stimulus was common but not certain, like brake lights, average brake time was about 1.25 seconds; with an unexpected stimulus, like a car moving in front of the driver, average response time increased to about 1.5 seconds. As urgency of the need to break increased, reaction times tended to decrease; meaning that participants were able to respond more quickly to more urgent stimuli.

In testing, drivers’ reaction times increase as driving tasks become more complex (Cantin et al., 2009; Martin et al., 2010). Cantin et al. (2009) measured complex reaction time as a verbal response to an auditory stimulus while driving in a simulator. The researchers compared the results of complex reaction time to a simple reaction time, as measured by a verbal response to an auditory stimulus while not driving. Because of the reduced peripheral input and the use of a verbal response rather than a physical response, the results may not be entirely representative of reaction times in real life driving applications. However, Cantin et al. (2009) found that while simple reaction times were similar for young (ages 20-31) and old (ages 65-75) groups, older drivers had longer reaction times in all situations. All drivers had longer reaction times for more complex driving situations and, older drivers also had a disproportionate increase between simple reaction time and complex reaction time when compared with the younger drivers. Mihal and Barrett (1976) found complex reaction time to be significantly related to accident involvement for all drivers. Together, these findings indicate that older drivers' longer complex reaction times may be related to an increased risk for accident involvement.

Martin et al. (2010) conducted a study involving peripheral input while measuring reaction time. They found that younger drivers braked to avoid an obstacle that appeared in front of them earlier than older drivers; older drivers took more time to react to the obstacle (2010). The response time was even slower for the older participants when the obstacle appeared from the periphery rather than from the front. While age was found to significantly affect reaction time, age was not found to affect accelerator transfer time, movement time, or brake transfer time. This finding suggests that while older adults may require increased initiation time but not increased time for execution of the response, suggesting perceptual slowing but no significant physical slowing with age.

Driving Simulators

Interactive driving simulators consist of technology that mimics real-life driving situations by making a simulated driving situation as similar to a real-life driving situation as possible. This involves having a 'car' to sit in with the pedals and wheel of a real car and screens in front of the car that imitate the vision that is experienced in a real car. Driving simulators are a safe way to measure driving abilities without putting anyone in danger; however, in order to use them as an evaluation tool we still need more information about how they work and what is normal when using them. Shectman, Classen, Awadzi, and Mann (2009) investigated the applicability of performance in driving simulators to performance in on the road driving situations. Results suggested that simulator performance can be generalized to on road driving. Shectman et al. (2009) found that the behavioral responses of drivers using a driving simulator are similar to the behavioral responses of the same drivers while on the road. These findings suggest that a driving simulator can be a valid measure of driving ability. These conclusions are valid but preliminary because Shechtman et al. (2009) only examined driving errors, not any other aspect of simulator or on the road performance.

In another study, Bedard et al. (2010) found a driving simulator to be a valid measure of driving ability in comparison with on-road performance and results of Trail Making test A and B, and the Useful Field of View. Driving simulators were also found to be a valid representation of on-road driving ability by Lee, Cameron, and Lee (2003). However, more information regarding driving simulators is necessary before they can become more widely incorporated as assessment and training tools.

Reaction Force

Reaction force refers to the force with which a participant presses the brake pedal in reaction to a stimulus. Simple reaction force is the amount of force applied to a brake pedal in reaction to just one stimulus. An example of simple reaction force is pressing the brake pedal anytime a beep noise is activated, in which case the participant needs only to press the pedal in reaction to the beep. Complex reaction force is the amount of force applied to a brake pedal in reaction to complex stimuli. An example would be on a driving simulator where a decision of whether to break or not to break must be made. Simple reaction force speaks to the physical ability of the client to press the pedal, while complex reaction force involves multiple stimuli and a decision about braking must be made. Therefore, complex reaction force involves not only physical response but also processing and decision making. Complex reaction force is more closely related to real life driving, but more difficult to measure.

As individuals age, physical changes such as decreased joint flexibility and decreased muscle mass occur (Baldock, 2004). While physical functioning is thought by many to be related to driving ability, research has been unable to confirm this. In fact, only limitations in neck range of motion have been shown to be specifically related to driving performance (Baldock, 2004).

Previous research has shown a great deal of variation in the amount of force used on a brake pedal, ranging from .2 to 2.3 kilo Newtons, with a maximum load of 780 Newtons in emergency situations (Behr et al., 2010). Although these ranges are known, there is a gap in research for a simple brake reaction force measurement that has no other stimuli given to the participant. In fact, Lansdown, Brook-Carter and Kersloot found that individuals use more pressure on the brake pedal as their mental workload increases (2004). Because aging affects our perception and sensory system, driving may represent an increased cognitive workload for older drivers, causing them to react to stimuli with a more immediate need and excess pressure when compared with younger drivers.

Summary

Processing speed and visual attention have been shown to deteriorate with age (Ball et al., 2010; Vance, 2009). Age-related cognitive deficits may be linked with deteriorating driving ability (Vance, 2009; Ball et al., 2006; Mathias & Lucas, 2009; Bedard et al., 2006; Freund et al., 2008). Multiple studies have found that aging can be associated with delayed reaction times, particularly in complex situations (Bilban, Vojvoda, & Jerman, 2009; Philip et al., 1999; Dickerson et al., 2008; Green, 2000; Cantin et al., 2009; Martin et al., 20120). Thus, it would be reasonable to expect that older drivers would have slower reaction times than younger drivers in all situations, and that older adults' reaction times reaction times will increase disproportionately (as compared with younger drivers) with increased complexity of the task. Older driver's reaction times and performance in driving simulators is limited in that there is little research available that provides a comprehensive testing of simple and complex brake reaction times and forces. There is a need for studies that examine reaction time in situations that are more representative of driving- specifically studies that involve peripheral input and measurement of driving reactions rather than verbal reactions. Further limitations exist with research that relates simple reaction time to the complex reaction time elicited by a driving simulator. Because driving simulators may be important tools in the future for both driving evaluation and intervention, it is critical to increase the use of simulation in driving research. Thus, the purpose of this study was to investigate the relationship between driving simulator performance (complex brake reaction time and force) and simple brake reaction time and force as they relate to age. This performance in complex scenarios was measured specifically using brake pedals, multifaceted visual input, and peripheral input to ensure its relevancy to driving.

Methods

Design

This quantitative study examined the relationships between complex brake reaction time, complex brake force, simple brake reaction time, and simple brake force of both young and old adult drivers. In this study, simple brake reaction time is measured as the amount of time, in milliseconds, required for an individual to depress a brake pedal in reaction to a light that turns from green to red. Complex brake reaction time is the time measured from the appearance of a stimulus on the driving simulator screens to the time of depressing the brake pedal. Simple brake force is the power applied to the brake pedal by a participant when a light turns from green to red. Complex brake force will be measured by the power the participant applies to the brake pedal when faced with emergency braking situations on a driving simulator. The specific research questions were as follows:

Reaction Time

- Is there a difference between simple brake reaction times and complex brake reaction times?
- Is there a difference between simple brake reaction time in a simple brake reaction floor tester and a simulator simple brake reaction tester?
- Is there a difference between simple brake reaction times for young and old drivers with a brake reaction free-standing floor tester?
- Is there a difference between the simulator complex brake reaction times of young and older drivers?

- What effect does age have on the relationship between simple brake reaction times and complex brake reaction times?

Reaction Force

- Is there a difference between simple brake reaction force and complex brake reaction force?
- Is there a difference between simple brake reaction force in a simple brake reaction floor tester and a simulator simple brake reaction tester?
- Is there a difference between simple brake reaction forces for young and older drivers with a brake reaction free-standing floor tester?
- Is there a difference between the simulator complex brake reaction forces of young and older drivers?
- What effect does age have on the relationship between simple brake reaction force and complex brake reaction force?

Sample

A total of 71 participants were involved in the study with two age groups: young adult (age range: 19- 38, n=33, mean age=24.88, SD= 3.73) and older adult (age range: 59 to 83, n= 37, mean age= 67.61, SD= 6.78). Demographic and health status information is shown in Table 1. Inclusion criteria required that participants be currently licensed to drive and have driven at least once within the last month. Participants who do not meet this criterion were not included. Participants were asked to complete an open-ended self-report questionnaire asking how they would rank their health on a scale of 1-10 (with 1 being very poor health, and 10 being excellent health), if there are any specific health concerns or problems or medications they felt comfortable sharing, and what medications they use. Participants who reported conditions deemed by researchers to have a high probability of impacting test performance were eliminated. Over half of the participants ranked their health as 9 out of 10 or higher, with younger and older participants each having a mean rank of 8.55. All participants completed the Simulator Sickness Questionnaire (Kennedy et al., 1993). If any participant identified themselves as particularly susceptible to motion sickness, they were eliminated from the study. Participants reported their driving habits and experiences through the Driver Habits Questionnaire (see Table 2).

Participants were recruited by convenience sampling, through flyers posted at community centers in Greenville, NC, via email to East Carolina alumni, via contact with Greenville, NC churches, and via prior acquaintance. The younger adult participants were recruited first by researchers, and completed by December 2011. After these participants had been tested, recruitment of older adult participants proved difficult. Therefore, financial incentive for participation was sought for the remaining participants. Funding for participation incentives was obtained from Advanced Therapy Products. The Institutional Review Board (IRB) provided approval for the reward system and methods. From that point, older adult participants were offered a $50 gas gift card in return for participation. Participants were advised that their receipt of the incentive was in no way dependent on their performance, and participants who were unable to complete the study secondary to motion sickness still received the gift card. All participants signed the Informed Consent to Participate in Research form (as approved by East Carolina University Institutional Review Board) prior to any collection of information. IRB approval was sought and gained during the study to offer incentives to the older adults participants.

Instrumentation

The Driving Habits Questionnaire. The Driving Habits Questionnaire (DHQ), developed by Owsley et al., was used to assess how often and when each participant drives (1999). The DHQ was found to be sufficiently reliable by Owsley, Stalvey, Wells, and Sloane, with a reliability coefficient for each item/question at or above .60 (1999).

The RT-2S Simple Brake Reaction Time/Force Tester. The RT-2S Simple Brake Reaction Time/Force Tester, as produced by Advanced Therapy Products, Inc., was used to measure participants' simple brake reaction times and simple brake force. This tester requires that participants sit in an immobile chair; when a light in front of them turns from green to red the participant must move their foot from the gas pedal onto the brake pedal as quickly as possible. Timing of the red lights was administered randomly by the researcher, with the button to change the lights being out of view of the participant. The machine then records the amount of time it takes the participant to make this change for each individual test. The machine also records the amount of force used on the brake pedal up to a level of 30 lbs., due to this being the maximal amount of pressure a typical car will respond to. The machine was calibrated for force using a multimeter. The RT-2S Simple Brake Reaction Time Tester was found to be a significantly reliable and a valid measure of brake reaction time by Dickerson et al. (2008). A picture of this instrument is available in Figure 1. Throughout the rest of this paper this instrument shall be referred to as a 'floor tester'.

The STISM WT-2000 Driving Simulator. The STISIM driving simulator software (by Systems Technology, Inc.) was used in conjunction with a WT-2000 Driving Simulator (Advance therapy Products) for this study. The WT-2000 is designed to resemble a car with an automatic transmission, it has a brake and gas pedal that are positioned according to the specifications of real cars, and the screen displays revolutions per minute (RPMs) and miles per hour (MPHs). STISIM software is used with three separate computer monitors, with the side monitors placed at approximately 70 degrees away from the participant to represent peripheral input. The brake pedal is equipped to measure the force with which the pedal is pressed. The driving simulator is also equipped to measure the simple and complex reaction times of each participant. A picture of this simulator is available in Figure 2. Bedard et al. (2010) found the STISIM model 400, a similar model, to be a valid and reliable test of an individual's fitness to drive. The simulator is equipped to measure both reaction time and reaction force. The simulator measured brake force up to a level of 30 lbs. due to this being the maximal amount of pressure a typical car will respond to. The machine was also calibrated for force using a multimeter.

KANDY scenario. The KANDY scenario was developed by Cyrus Ridenour, specifically to meet the needs of this study. Reliability and validity measures have not been calculated, however the scenario has face validity. The KANDY scenario is the driving scenario that was used with the STISIM simulator. Participants were first asked to drive through two scenarios on the driving simulator in order to familiarize themselves with the driving simulator. After the participants were familiarized with the simulator, they were asked to drive through one scenario in which their driving and reactions were recorded. The scenario's two critical incidents were unexpected: A stop light turns directly from green to red, and a person steps in front of the car. Each of the critical incidents requires the participant to stop in order to avoid a collision. For each incident, the stimulus that requires the driver to stop is timed to begin when the driver reaches a particular point. The scenario instructs the driver to obey traffic laws and does not require the driver to make any turns while driving. This scenario and the familiarization scenarios are designed to resemble possible situations that drivers may face in real life that would require a reaction. A picture of the simulator screen as seen by participants while using the Kandy scenario can be found in Figure 3.

Testing Environment

All testing was conducted in the dedicated driving lab at East Carolina University in the Occupational Therapy Department. The driving lab has a driving simulator, kitchenette, computers and adequate space for all activities to be performed. The windows are darkened with curtains and blinds and there is no view to the outdoors. The room is generally quiet and all doors to the outside of the lab remained closed throughout the study. The temperature of the room was cool and maintained at a consistent temperature. While each participant was using the driving simulator, three fans were turned on around the simulator in order to blow air onto the participant. Each participant was assessed for any evidence of motion sickness and tiredness after each use of the driving simulator. Crackers, water, and granola bars were available to anyone who wanted them. Participants who did not feel well were given breaks anytime they needed one, and if a participant continued to feel unwell, they were asked to return another day or cease participation. Participants who had been promised compensation were compensated despite early termination of participation.

Procedure

When participants arrived, each participant was welcomed and asked to sit in one of the chairs at a table with a researcher. The researcher explained what the participant would be asked to do and all consent documents were signed. Participants answered demographic and health status questions and completed the DHQ. The Simulator Sickness Susceptibility Questionnaire (Kennedy et al., 1993) was also completed before any testing. The researcher discussed the fact that motion sickness that is sometimes experienced by users of the driving simulator and instructed the participant that they could stop at any time for any reason, including if anything made them feel sick or if they felt uncomfortable for any reason.

Participants were then asked to participate in the two following tasks. The directions for each activity were specific and consistent. The orders of the two tasks (using the driving simulator and the floor tester) were randomized so that participants experienced them in different orders. After each activity, the participant was given a short break.

Task 1. Participants completed five recorded tests on the simple brake reaction floor model tester. For this test, the participant is asked to place their right foot on the accelerator pedal and keep it there until a red light appears in the box, when they are to switch to the brake pedal as quickly as possible. These tests were repeated five times. The light box that displayed red and green lights to cue the participants was placed directly in front of the participants, in the same location for each, so that it was within easy viewing distance. The accelerator/brake pedal was located within easy reaching distance of the chair for each participant, with this distance determined by the preference of the participant. Participants were each asked if they were able to view the lights clearly. There was no incidence in which a participant was unable to properly view the box. Each participant used the same type of chair. Each participant was asked to complete one practice trial, after which five measured brake reaction tests were completed. These five measurements were later averaged together. Each of the five trials' length of time waiting for the green light to turn red was timed randomly to be between three to 15 seconds.

Task 2. Participants completed three scenarios on the driving simulator. Instructions and a review of the rules of driving on the simulator were given before the participant began driving and each participant was asked if they had any additional questions. Each participant drove through a minimum of two familiarization scenarios in order to feel comfortable with the simulator and understand how it operates. Participants were allowed to complete a third familiarization run if they felt it necessary. There was one recorded scenario (KANDY), which requires participants to brake in response to various stimuli. All measurements were recorded on the simulator.

Data Analysis

An excel spreadsheet was used to collect the demographic information, and dependent variables- specifically the average simple brake reaction time and force on the floor tester and simulator, and complex brake forces and reaction times. Data was eliminated for participants if there was a machine malfunction, or in the case of complex brake reactions, if the participants failed to brake or were "riding" the brakes (i.e. always keeping foot on the brake) prior to the critical incident. SPSS (IBM, 2010) was used to calculate the descriptive statistics of the data and box plots and scatter plots were used to visualize the data. In addition, independent and paired two-sample t-tests were used for comparing research questions. When simple reaction time was compared to another type of reaction, the simple reaction time as elicited by a floor tester was utilized because this instrument is currently used to measure reaction times (Dickerson, in press).

Results

Brake Reaction Time

Results for brake reactions of older and younger participants can be found in Table 3. The mean complex brake reaction time for young drivers (n=27) was 1.148, (SD= 0.252), with a range of 0.9 – 1.9 seconds. For older drivers (n=24) it was 1.27 (SD=.397), with a range of 0.3-1.8 seconds. The mean simple brake reaction time as tested by a floor model tester for young drivers (n=32) was 0.628, (SD= .123), with a range of 0.436 to 0.943 seconds. The mean simple brake reaction time as tested by a floor model tester for older drivers (n=36) was 0.624, (SD=.227), with a range of 0.397 to 1.442. The mean simple brake reaction time as tested by a simulator for younger drivers (n=32) was 0.605 (SD=.117), with a range of 0.394 to 0.834 seconds. The mean simple brake reaction time as tested by a simulator for older drivers (n=36) was 0.609, (SD=0.179), with a range of 0.222 to 1.094 seconds.

A paired t-test examined the difference between complex brake reaction time and simple floor timer brake reaction time for all participants was completed (z = -11.093, p= 0.00). This test showed that the difference between complex brake reaction time and simple brake reaction time was statistically significant; the mean reaction time when using the floor tester being .631, and the mean complex reaction time using the simulator being 1.206. A 95% confidence interval of the difference between the complex and simple reaction times has a low point of 0.470 and a high point of 0.678. Figure 4 shows a scatter plot of complex reaction times as they vary by simple reaction times. Figure 5 shows a box plot representation of the difference between complex and simple brake reaction times.

The simple simulator reaction time had a mean of.607, and the simple floor reaction time had a mean of .626. To examine the difference between simple brake reactions as recorded by a driving simulator and by a floor model, a paired t- test (z = -.995, and p = .323) was run. This test showed no significant difference between the results of these two instruments. A 95% confidence interval of the difference between the times recorded by each tool has a low point of -0.056 and a high point of 0.019, Figure 6 displays a scatter plot of simple brake reaction time as tested by a floor model tester and as tested by a simulator. Figure 7 shows a box plot of the difference between simple brake reaction time in a floor tester and in a simulator tester.

An independent t-test (z = .106, p= .916) showed no statistically significant difference between the simple floor tester brake reaction times of younger and older participants. A 95% confidence interval of the difference between the simple floor tester brake reactions of younger and older participants has a low point of -0.083 and a high point of 0.092. This relationship is displayed in Figure 8 with side by side box plots of the simple reaction times of younger and of older participants. When two outliers of this sample (any participant whose time was less than the 1st quartile- 1.5 (IQR) or more than the 3rd quartile + 1.5(IQR)) were removed, an independent samples t-test (z=1.809, p= 0.075) again did not show any statistically significant difference between the groups.

An independent t-test (z = -1.295, p= .203) showed no significant difference between the complex brake reactions of younger and older drivers, however there the older adults have greater spread, or variability. A 95% confidence interval of the difference between complex brake reactions of younger and older drivers has a low point of -0.313 and a high point of 0.069. Figure 9 illustrates this relationship using side by side box plots.

To examine the effect that age has on the difference between simple brake reaction time and complex brake reaction time, an independent t-test ($z = -1.123$, $p = 0.269$) was used, which showed no statistically significant effect. A 95% confidence interval of this difference has a low point of -0.337 and a high point of 0.097. Figure 10 displays a scatter plot of the difference between complex brake reaction time and simple brake reaction time as measured by a floor tester, and how this varies by age. This relationship is also illustrated in Figure 11 using side by side box plots. However, when two outliers of this sample (any participant whose time difference was less than the 1st quartile- 1.5 (IQR) or more than the 3rd quartile + 1.5(IQR)) were removed, an independent t-test ($z = 2.364$, $p= .024$) showed that age had a statistically significant effect on the difference between simple and complex reaction time. These outliers were removed with the assumption that these participants may not have been accurately tested or may have misunderstood the directions of the test because one older adult was unusually fast, and one younger adult was unusually slow. A 95% confidence interval for this difference with the outliers removed has a low point of -0.387 and a high point of -0.029.

Brake Reaction Force

When measuring the simple brake reaction force as tested by a floor model tester, all drivers (n=68) achieved the same amount of reaction force, 30 lbs. of force. Table 4 displays a chart to visualize this finding. The mean simple brake reaction force as tested by a simulator for nearly all drivers (n=68) was 30 lbs., with the exception of seven participants who were unable to achieve 30 lbs. of force. This finding is displayed in Figure 12. The only simple force reactions in the driving simulator that were not 30 lbs. of pressure were identified as outliers (any reaction less than the 1st quartile – 1.5 (IQR) or more than the 3rd quartile + 1.5 (IQR)). Furthermore, upon removal of identified outliers, all reactions as recorded by the driving simulator were the same, equal to 30 lbs. Nearly all participants were able to apply 30 pounds of pressure in the complex force test, there were 3 younger drivers (n= 32) and 5 older drivers (n=33) who did not. This data can be seen in Figure 13.

This data is unable to address the proposed research questions regarding differences between participants or tests, as the tests rarely differentiated between participants. All participants using the simple floor tester were able to apply 30 lbs. of pressure.

Discussion

Brake Reaction Time

In all of the comparisons of simple and complex reactions, the floor tester was used as the measure of simple reaction rather than the simple simulator test, as the floor tester is used as the standard brake reaction time test in comprehensive driving evaluations (Dickerson, in press). Complex brake reaction times of all participants were found to be significantly longer than simple reaction times. For both younger and older adult groups, reaction time increased as complexity of the task increased. This time difference is likely due to the additional sensory input that must be processed and reacted to during complex scenarios, similar to previous studies findings of increased reaction time with increased task complexity (Green, 2000; Cantin et al., 2009; Martin et al., 2010).

The differences between the complex brake reactions of younger and older drivers were not found statistically significant. The differences between the simple brake reactions of younger and older drivers were also not found to be statistically significant indicating that there was likely no major finding of difference between the complex reaction times of younger and older drivers, or of difference between the simple reaction times of younger and older drivers. Despite this indication of our study, previous research has documented that reaction time generally increases with age (Bilban, Vojvoda, & Jerman, 2009; Philip et al., 1999; Dickerson et al., 2008; Green, 2000; and Martin et al., 2010). This discrepancy may be due to this study's limitations; specifically many of the older adult participants in this study were closer to middle age. However, although not statistically significant, this data did demonstrate support for older adult's reactions having more variability. The older drivers had longer mean reaction times than younger drivers in complex situations, and the complex reaction times of older drivers were also more variable than those of younger drivers, having much greater spread in reaction times. The variability of physical condition among different individuals as they age, could contribute to the variability of complex reaction time. While the difference in complex reaction times between young and older drivers was not shown to be statistically significant, it may have clinical significance and may bear further testing.

While simple reaction times are similar for both age groups, the *difference* between simple reaction time and complex reaction time had a statistically significant increase with age. This finding indicates that despite finding little when examining simple or complex reaction times independently, younger and older drivers exhibit a statistically significant difference from one another, in that the difference between participants' simple reaction time and complex reaction time increased disproportionately with age. This was analyzed by comparing the difference in simple reaction time and complex reaction time for young and older groups, and comparing the groups by age. This finding is comparable to the Cantin et al. finding of similar simple reaction times for younger and older drivers, with a disproportionate increase in difference between simple and complex reaction time for older adults when compared with younger adults (2009). The difference between simple and complex reaction times supports the concept that age related changes may result in decreased ability to process and react to complex situations. When viewed functionally, the importance of simple reaction time is limited, as individuals rarely react with certainty to a single stimulus; however complex reaction time, with a reaction to multiple stimuli, is more frequently applied in daily life, and particularly, in driving.

Brake Reaction Force

The findings regarding brake reaction force were limited. The intent of the study in the complex reaction test was to cause participants to brake as forcefully as possible in an effort to avoid a simulated accident. However, many participants did not brake as forcefully during the complex situation as they were able to in a simple situation. This may have been secondary to indecision, distraction, or not taking the simulated situation as seriously as possible. Participants expressed statements that they were not paying enough attention or laughed at inappropriate points, indicating a possible lack of situational gravity.

Simple brake reaction force was measured using either the driving simulator or using the floor tester. The simple floor tester was unable to differentiate between participants, and when outliers were removed, the driving simulator was also unable to differentiate between participants. However, the outliers existing with the driving simulator simple tester may indicate that it is a less than accurate measure of ability to apply force. During testing with the driving simulator, reaction time and force were tested together, which may have created a difficulty for participants to follow all directions. The floor model tester tested brake reaction time and force separately, possibly simplifying the task by allowing participants to focus solely on one instruction at a time.

This study has been unable to conclude that the driving simulator would serve as an accurate measure of simple brake reaction force as compared with the floor model tester. Despite the fact that the measures of force tested were often unable to differentiate between participants, younger and older participants in all simple and complex situations were frequently able to apply at least 30 lbs. of force to the brake pedals. This finding indicates that the younger and older participants were able to apply adequate force to control the brake pedals in driving situations and this is unlikely to be a driving issue for any age, unless there is a specific physical issue with leg strength or mobility.

Limitations

Limitations of the study include the generalizability of the findings to real-life situations. Since both complex reaction time and simple reaction time were measured in a laboratory using simulators, the applicability of the findings to real driving situations may not be absolute. Another limitation of this study is that the driving simulator and simple brake reaction tester used in this study may not be representative of all driving simulators and floor brake reaction testers, therefore the results may not fully represent the results that would be found in other testing labs or application settings.

The sample size was relatively small, with a total of 71 people, and generalizability of the study could be improved with a larger, randomly selected sample. The participants of the older adult participant group were relatively young. Recent terminology has separated older adults into young old (under 75), old (75-85), and old-old (over 85) (Berger, 2002) Participants in the older adult category in this study, tended to be members of the young-old group, being under the age of 75, rather than being members of the old or old-old groups. With processing delays and visual attention deficits increasing with age (Vance, 2009; Bedard et al., 2006)), younger 'older drivers' (like those in their 60's) are likely to have fewer processing delays than older 'older drivers' (like those in their 80's). The entire group of participants also tended to be well educated, healthy, and white; indicating that they may not be fully representative of the greater population of drivers.

The participants of this study were collected using convenience sampling, which could provide a skewed sample that is not representative of the target population. The convenience sample could be unrepresentative for a variety of reasons, possibly including that people who are willing to volunteer may be more confident in their driving abilities and therefore are more likely to be better drivers with normal or fast reaction times. The alternative end of this spectrum is that volunteers may be particularly concerned about their driving ability or reaction times and want to participate in the study to test this. Another possibility is that the convenience sample used would be unrepresentative of the demographics of the target population. The participants sampled are thought to be a relatively representative sample of the population demographics but it is not possible to compensate for the possibility of being skewed. This study also employed a reward system for participation, however only offered gift card incentives to older adult participants. We did not feel that this incentive system effected participant performance during the study.

Complex brake reaction time and force proved particularly difficult to test secondary to a variety of unanticipated participant reactions. The KANDY scenario was designed so that the only safe option for reaction was to brake. If participants swerved instead of braking, they would cause a collision. However, many participants did not brake at all, tried to swerve unsafely, or rode their brakes when approaching any potentially dangerous situation, making it difficult to measure braking reactions. Some participants reported that they rode their brakes because they suspected that they would be required to brake. Other participants laughed or joked after a crash in which they did not utilize their brakes, indicating an inappropriate sense of levity. These reactions, contrary to those we were trying to elicit, complicated the measurement of braking reaction time and force, and ultimately reduced the amount of useable data available. These responses from participants also bring the validity of this data into question, raising the question of whether the KANDY scenario and driving simulator were able to elicit a true complex reaction time.

Implications for Practice

Driving has been clearly positioned as within the scope of occupational therapy practice by the American Occupational Therapy Association (2008) and the *Occupational Therapy Practice Framework: Domain and Practice (*American Occupational Therapy Association, 2002), and should be addressed as such. Therefore, it is imperative to understand the way that driving skills may vary, and to understand the methods of evaluation. Driving simulators may be a useful assessment tool as a part of a comprehensive evaluation or as an intervention tool to practice driving skills in a safe environment (Shectman et al., 2009; Bedard et al., 2010). While a simulator could potentially be useful to measure complex reaction time, complex reaction force, and simple reaction time, it may not be the most accurate measure of simple force, and additional research is needed. A simulator would be a tool in our tool-belt, as the on-road driving evaluation remains the gold standard for evaluating fitness to drive.

During use of the driving simulator, many of the older participants had complaints about the physical construction of the driving simulator, indicating that the features of the simulator were not the same as those in their personal cars (i.e. the gas pedal being too far to the right, the steering wheel being in a different position, etc). In this way, older participants generally showed a preoccupation with the operational features of the car that their younger counterparts did not. This may be a factor bearing consideration with the use of a driving simulator with the older population.

This study supports the idea that a simple reaction time on a floor tester could potentially be used to make an estimate about complex reaction time; however additional inquiry into this possibility is required. Findings also support the use of a driving simulator as an appropriate tool to measure simple reaction time.

Important findings to bear in mind during practice of occupational therapy include that reaction time generally increased with task complexity for all ages, indicating additional required time for processing additional stimuli. The finding that older adults' reaction times increased from simple to complex disproportionately more than those of younger adults is another important point to consider when evaluating driving. Also, these healthy adult participants were nearly all able to apply at least 30 lbs. of pressure. Additional research regarding simple and complex reaction time and reaction force would contribute to the scientific knowledge base available in occupational therapy and would also further the research related to driving simulators and their performance and applicability.

Conclusion

Despite the limitations, the findings of this study provide information as it may relate to driving assessment and intervention. All participants, except for two, had reaction times that increased with task complexity. Older drivers' complex reaction times had greater variability and increased time from their simple reaction times than did those of the younger participants, suggesting an aging effect on processing speed. However whether the driving simulator was able to elicit a valid complex reaction time measure should be questioned. Younger and older participants alike were able to consistently apply enough force (30 lbs.) to effectively control brake pedals.

The findings described throughout this paper contribute to our foundational knowledge of driving and advance the possibility of real-life and therapeutic applications of driving simulators. Ultimately, driving safety is about function, not just age, and driving assessments must examine driving safety with this in mind. Study participants repeatedly demonstrated to researchers that driving was and is very important to them- they consistently wanted to make sure that they were driving well and wanted to know what they could be doing to drive more safely. Participants made it clear that driving is a very highly valued occupation for them. As occupational therapists, it is imperative that we recognize driving as the highly valued occupation that it is (Rudman et al., 2009; Donorfio et al., 2009; Vrkljan & Polgar, 2012; Dickerson, Reistetter, & Gaudy, 2012) and address it accordingly.

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Table 1. *Demographics and Health Status*

VARIABLE		OLDER PARTICIPANTS	YOUNGER PARTICIPANTS
Total Participants	N	42	28
Age	Mean (Standard Deviation)	Mean= 67.61 (SD=6.78)	Mean = 24.88 (SD= 3.73)
Health Rank		Mean = 8.55 (SD= 1.47)	Mean = 8.55 (SD= 0.83)
Gender			
	Male N (%)	16 (42.11%)	7 (21.21%)
	Female N (%)	26 (57.89%)	21 (78.79%)
Highest Level of Education	N (%)		
	Grammar School	2 (5.26%)	0
	High School/ GED	2 (5.26%)	0
	Some College	8 (21.05%)	3 (9.09%)
	College Degree	9 (23.68%)	30 (90.91%)
	Graduate or Professional Level	17 (44.74%)	0
Ethnicity	N (%)		
	Asian/ Pacific Islander	1 (2.63%)	0
	Black/ African American	2 (5.26%)	0
	White/ Caucasian	35 (92.11)	32 (96.97%)
	White/ Caucasian and Latino	0	1 (3.03 %)

Table 2. *Results from Driving Habits Questionnaire**

	OLDER PARTICIPANTS		YOUNG PARTICIPANTS	
Variable	N	%	N	%
Do you wear glasses or contact lenses when you drive?				
Yes	27	71.05	19	57.58
No	10	26.32	14	42.42
Do you wear a seatbelt when you drive?				
Always	36	94.74	31	93.94
Sometimes	2	5.26	2	6.06
Never	0	0	0	0
Which way do you prefer to get around?				
Drive self	34	89.47	31	93.94
Have someone drive you	3	7.89	2	6.06
Use public transportation or taxi	1	2.63	0	0
Has anyone suggested over the past year that you limit your driving or stop driving?				
Yes	0	0	0	0
No	38	100	33	100
How fast do you drive compared to the general flow of traffic?				
Much faster or somewhat faster	4	10.53	13	39.39
About the same	27	71.05	19	57.58
Somewhat slower or much slower	7	18.42	1	3.03

How would you rate the quality of your driving?				
Excellent or good	36	66.87	25	75.76
Average	2	5.26	5	15.15
Fair or poor	0	0	3	9.09
If you had to go somewhere and didn't want to drive yourself what would you do?				
Ask a friend or relative to drive you	29	87.88	29	87.88
Call a taxi or take the bus	0	0	0	0
Drive yourself regardless of how you feel	3	9.09	3	9.09
Cancel or postpone your plans and stay home	1	3.03	1	3.03
Other	0	0	0	0
Please tell me all the places you drive in a typical week.				
0-3 places	12	32.43	9	27.27
4-6 places	16	43.24	18	54.55
7-9 places	7	18.92	2	6.06
10+ places	2	5.41	4	12.12
Total miles driven in a typical week				
0-200 miles	30	78.95	25	75.75
201-400 miles	8	21.05	3	9.09
401-600 miles	0	0	5	15.15
When traveling with others, who usually drives?				

I drive	16	42.11	17	44.74
About half and half	14	36.84	11	33.33
This person drives	5	13.16	5	15.15
Difficulty with driving when it was raining during the past 3 months.				
No difficulty at all to little difficulty	34	91.89	31	93.94
Moderate difficulty	3	8.11	1	3.03
Extreme difficulty	0	0	0	0
Do not do	0	0	1	3.03
Difficulty with driving alone during the past 3 months.				
No difficulty at all	38	100	31	93.94
Little difficulty	0	0	2	6.06
Difficulty with parallel parking during the past 3 months.				
No difficulty at all or little difficulty	23	60.53	22	66.66
Moderate difficulty	1	2.63	2	6.06
Extreme difficulty	0	0	0	0
Do not do	14	36.84	9	27.27
Difficulty with making left-hand turns across oncoming traffic during the past 3 months.				
No difficulty at all or little difficulty	35	92.1	33	100
Moderate difficulty	1	2.63	0	0
Extreme difficulty	0	0	0	0

Do not do	1	2.63	0	0
Difficulty with driving on interstates or expressways during the past 3 months.				
No difficulty at all	33	86.84	28	84.85
Little difficulty	0	0	4	12.12
Do not do	5	13.15	1	3.03
Difficulty with driving on high-traffic roads during the past 3 months.				
No difficulty at all	32	84.21	28	84.85
Little difficulty	3	7.89	2	6.06
Moderate difficulty	2	5.26	3	9.09
Extreme difficulty	0	0	0	0
Do not do	1	2.63	0	0
Difficulty with driving in rush-hour traffic during the past 3 months.				
No difficulty at all to little difficulty	32	84.21	28	84.85
Moderate difficulty	3	7.89	2	6.06
Extreme difficulty	0	0	0	0
Do not do	3	7.89	3	9.09
Difficulty with driving at night during the past 3 months.				
No difficulty at all to little difficulty	33	86.84	31	93.94
Moderate difficulty	4	19.53	1	3.03
Extreme difficulty	0	0	0	0
Do not do	1	2.63	1	3.03

During the past year, have you driven in your immediate neighborhood?				
Yes	38	100	33	100
No	0	0	0	0
During the past year, have you driven to places beyond your immediate neighborhood?				
Yes	38	100	33	100
No	0	0	0	0
During the past year, have you driven to neighboring towns?				
Yes	36	94.74	33	100
No	2	5.26	0	0
During the past year, have you driven to more distant towns?				
Yes	31	81.58	33	100
No	7	18.42	0	0
During the past year, have you driven to places outside the state?				
Yes	23	60.52	25	75.76
No	15	39.47	8	24.24
During the past year, have you driven to places outside the southeast region of the USA?				
Yes	16	42.11	17	51.52
No	22	57.89	16	48.48

	OLDER PARTICIPANTS		YOUNG PARTICIPANTS	
	N	%	n	%
In an average week how many days per week do you normally drive?				
0-2 days	0	0	2	6.06
3-5 days	6	15.78	4	12.12
6-7 days	32	84.21	27	81.82
Total number of friends and/or family members that you regularly travel with in a car over the past year.				
0 -3 people	35	92.11	23	69.69
4-7 people	3	7.56	6	18.18
8-10 people	0	0	4	12.12
How many accidents have you been involved in over the past year when you were the driver?				
0 times	35	92.11	30	90.91
1 time	3	7.89	2	6.06
2 times	0	0	0	0
3 times	0	0	1	3.03
How many accidents have you been involved in over the past year when you were the driver where the police were called to the scene?				
0 times	35	92.11	30	90.91

1 time	3	7.89	2	6.06
2 times	0	0	1	3.03
How many times in the past year have you been pulled over by the police, regardless of whether you received a ticket?				
0 times	35	92.11	22	66.67
1 time	3	7.89	11	33.33
How many times in the past year have you received a traffic ticket (other than a parking ticket) where you were found to be guilty, regardless of whether or not you think you were at fault?				
0 times	37	97.37	25	75.76
1 time	1	2.63	8	24.24

* *(Owsley et al., 1999)*

Table 3. *Brake Reaction Time Data*

Measure	Younger drivers	Older drivers	z	P	Confidence Interval
Complex Brake Reaction Time (driving simulator)	N: 27 Mean: 1.148 SD: 0.252 Range: 0.9-1.9	N: 24 Mean: 1.27 SD: 0.397 Range: 0.3-1.8	-1.295	0.203	(-0.313 - 0.069)
Simple Brake Reaction Time (floor model tester)	N:32 mean: 0.628 SD: 0.123 Range: 0.436–0.943	N: 36 Mean: 0.624 SD: 0.227 Range: 0.397-1.442	0.106	0.916	(-0.083 - 0.092)
Simple Brake Reaction Time (driving simulator)	N: 32 Mean: 0.605 SD: 0.117 Range:0.394-0.834	N: 36 Mean: 0.609 SD: 0.179 Range: 0.222-1.094	-0.130	0.897	(-0.077 – 0.068)

Table 4. *Simple Brake Reaction Forces for Younger and Older Drivers.*

	Younger	Older
Yes	32	36
No	0	0

Note. The chart displays simple brake reaction force for younger drivers(the number of observations that were able to achieve 30lbs of pressure [yes] or not [no]) and simple brake reaction force for older drivers (the number of observations that were able to achieve 30lbs of pressure [yes] or not [no]).

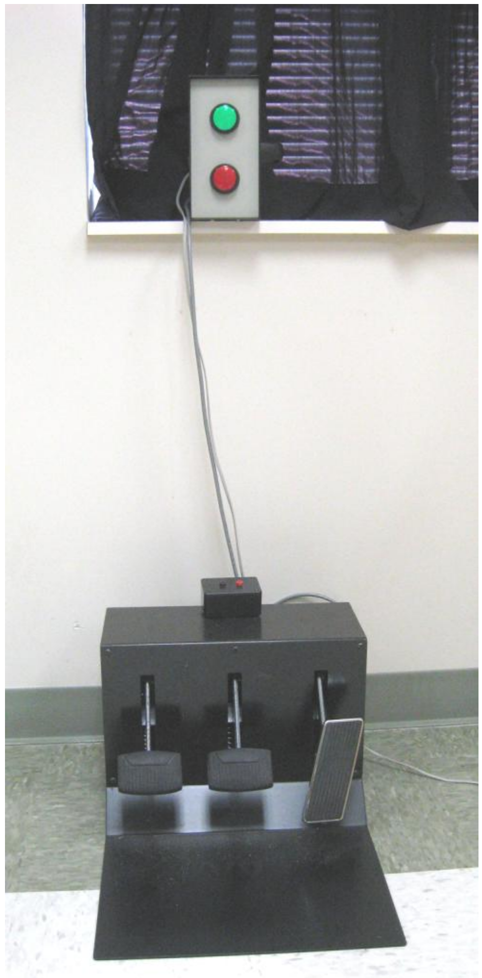

Figure 1. Photograph of the RT-2S simple brake reaction time/ force tester.

Figure 2. Photographs of the STISM simulator.

Figure 3. Photograph of the KANDY scenario in use, as seen by participants.

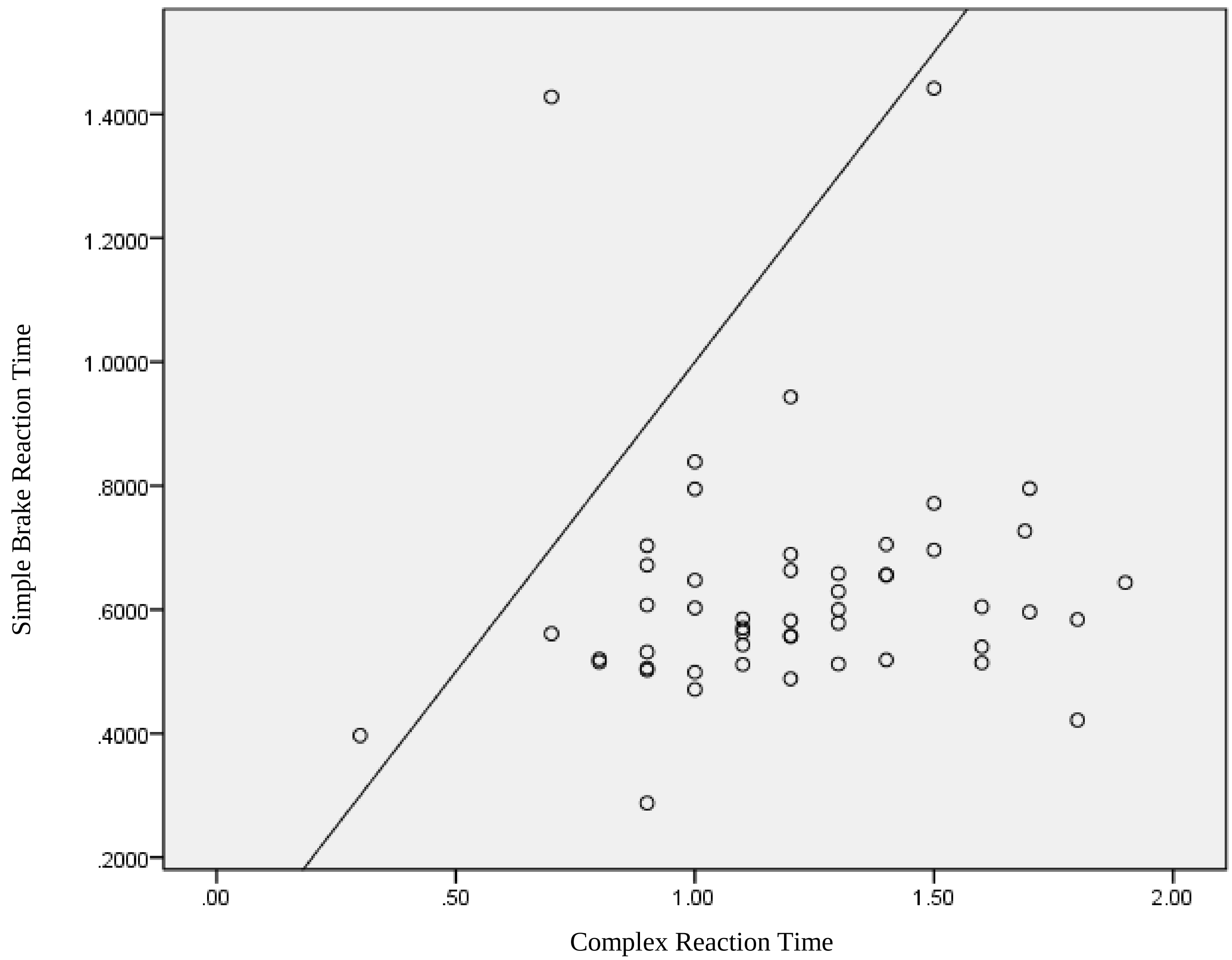

Figure 4. Scatter plot comparing simple and complex brake reaction time. A scatter plot of simple brake reaction times as measured by floor tester (axis y) and complex brake reaction time as measured by driving simulator (axis x). A line representing x=y has been added.

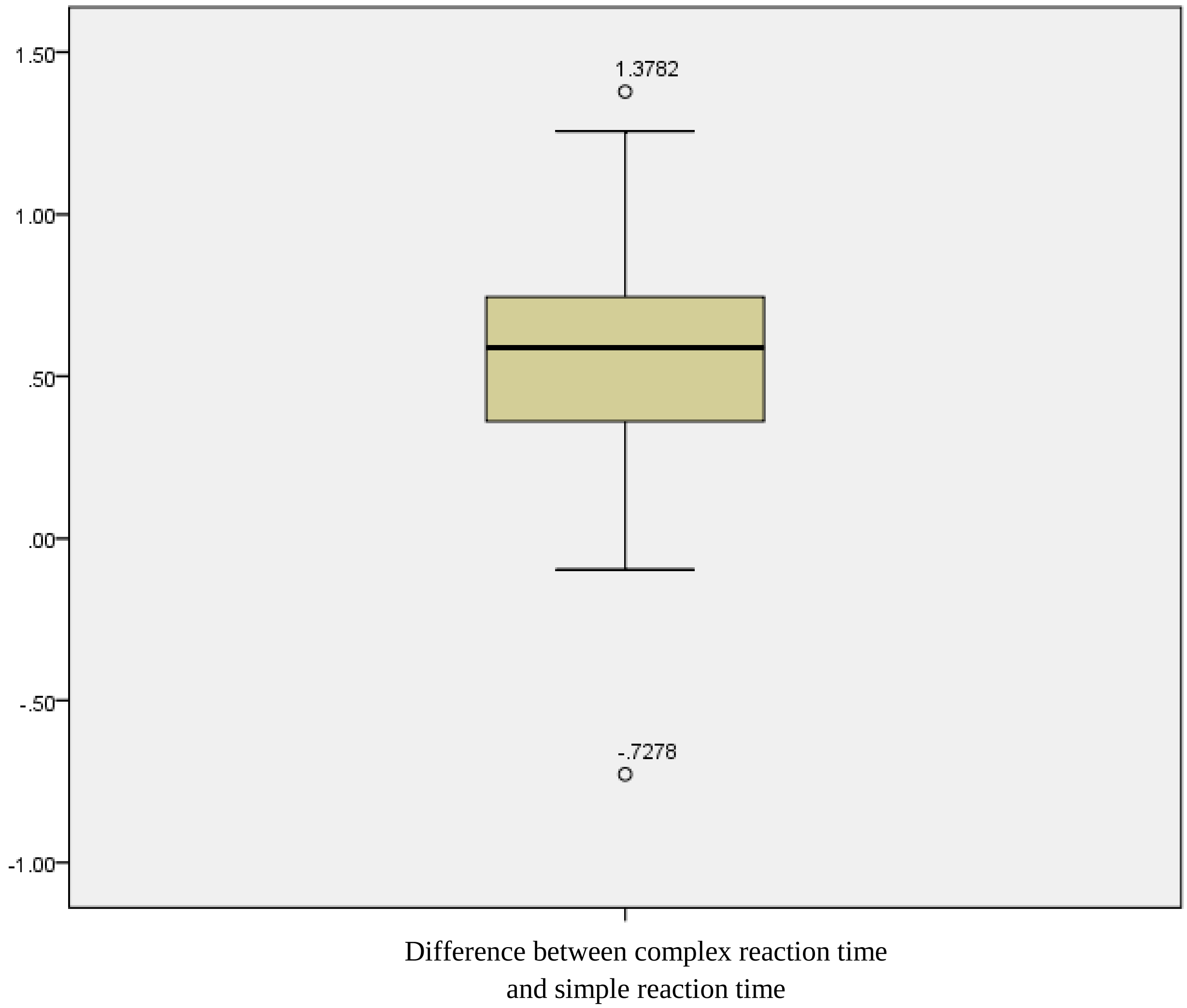

Figure 5. Box plot representing the difference between complex and simple brake reaction times.

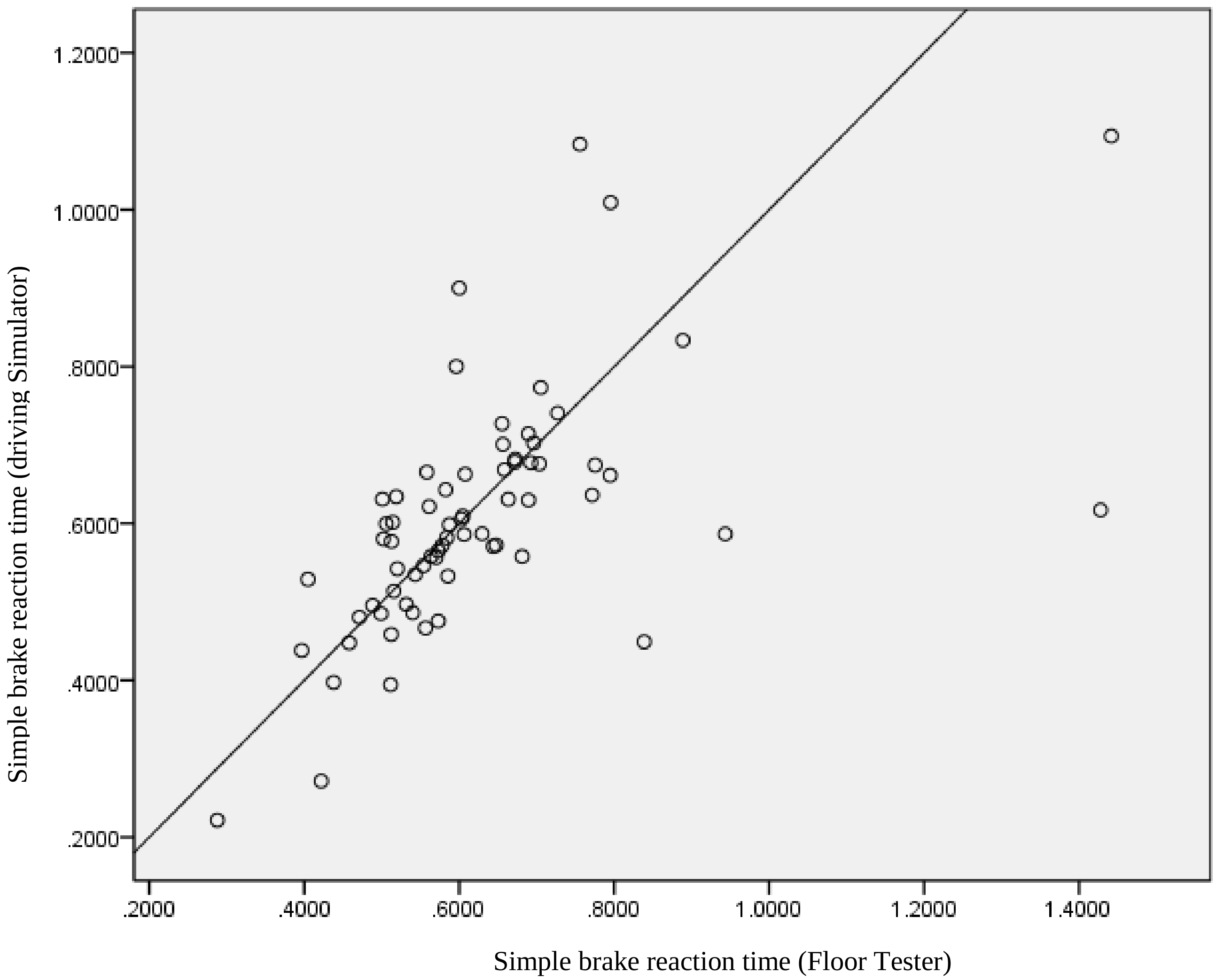

Figure 6. Scatter plot of simple brake reaction time as measured by a floor tester and a driving simulator. A line representing x=y has been added. This graph includes outliers.

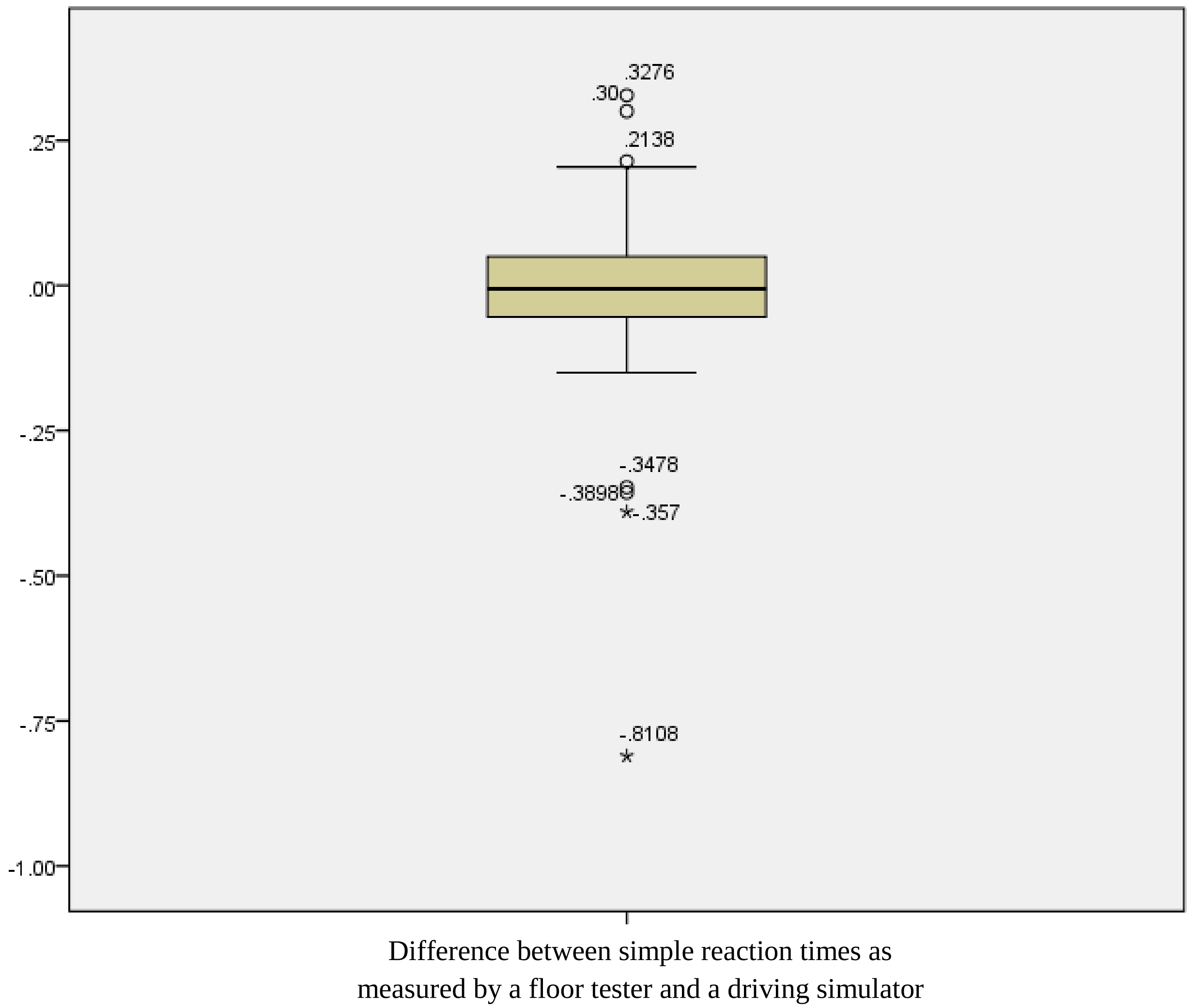

Figure 7. Box plot of the time difference between simple brake reaction time in a floor tester and a simulator.

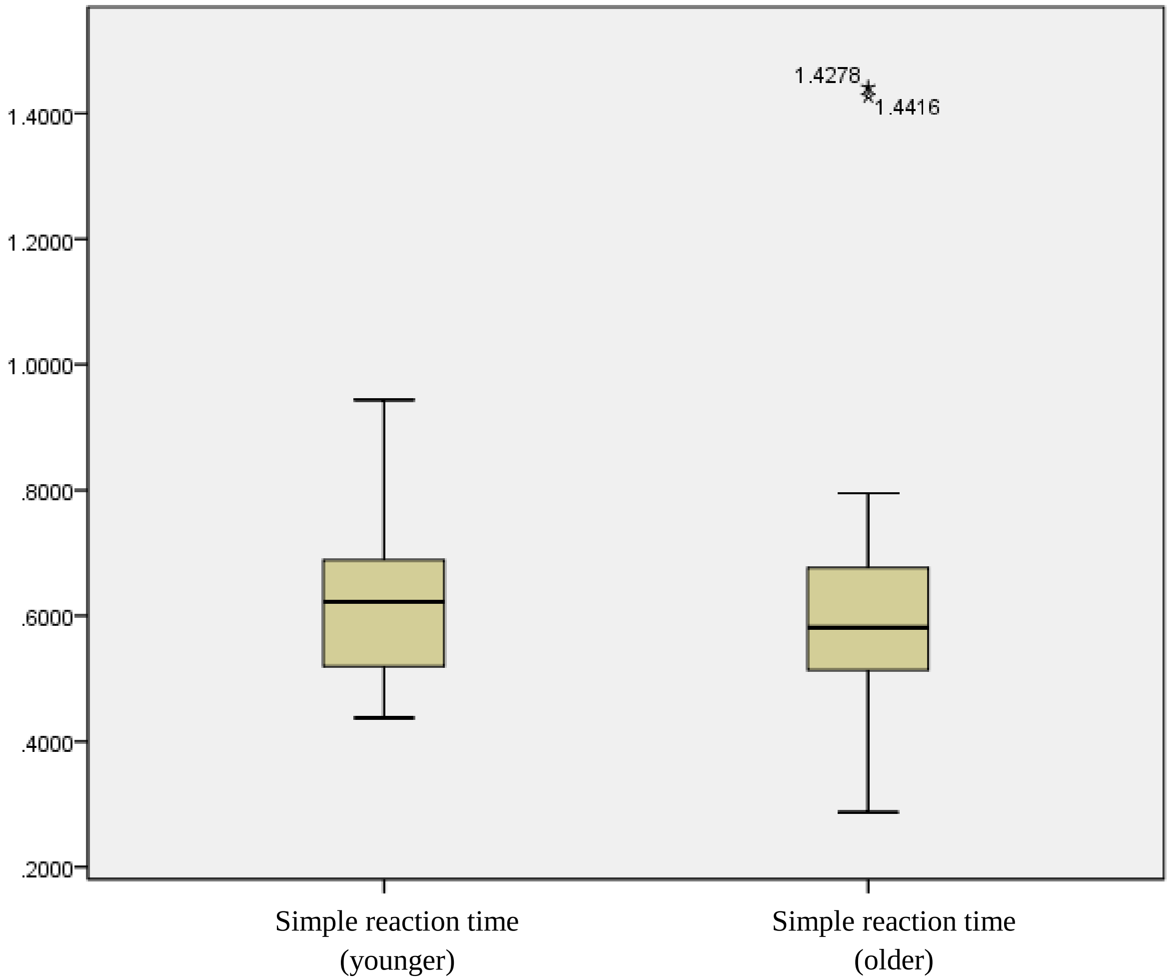

Figure 8. Box plots of simple brake reaction time for younger and older participants.

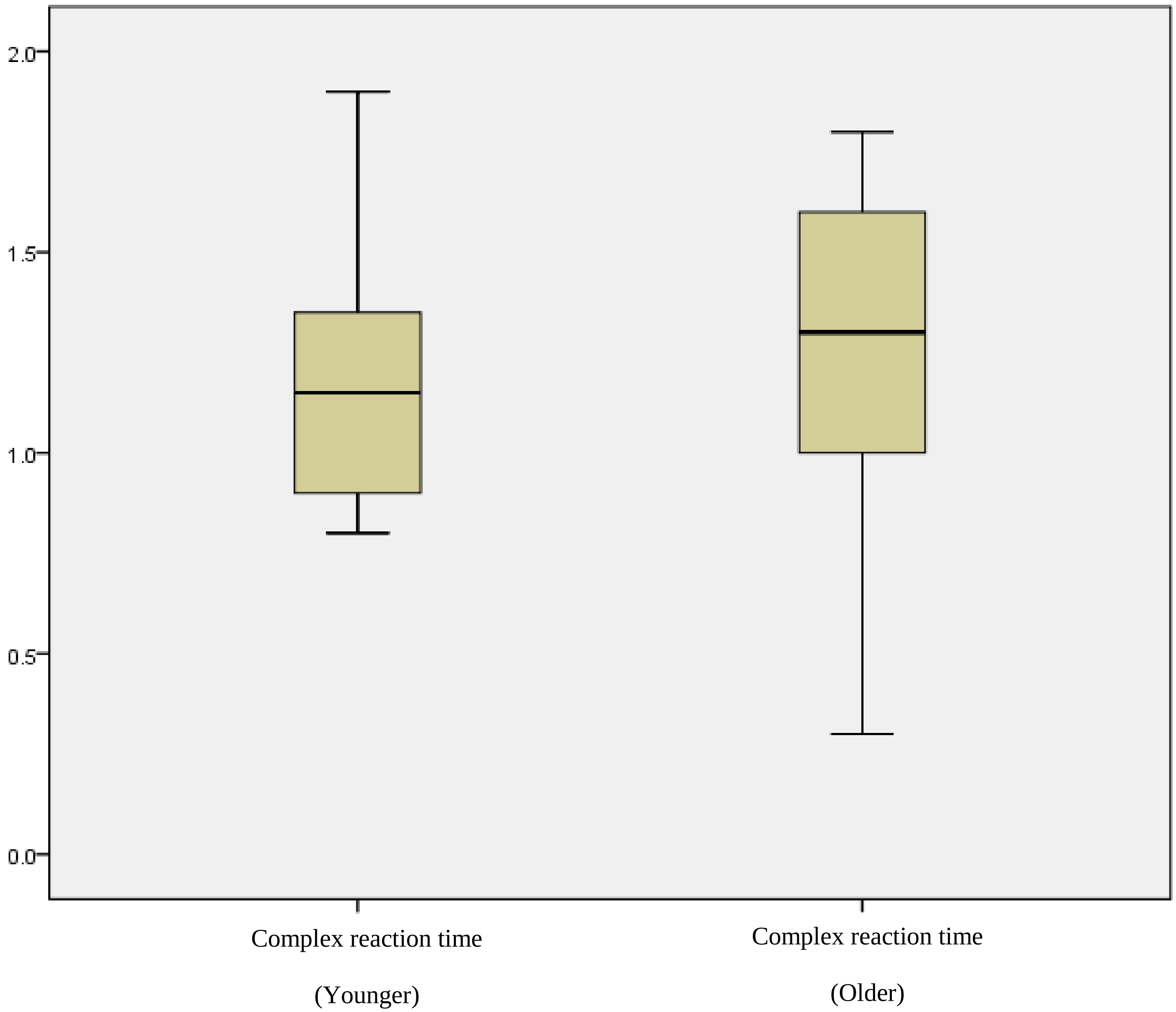

Figure 9. Box plots of the difference between complex brake reaction times of younger and older drivers.

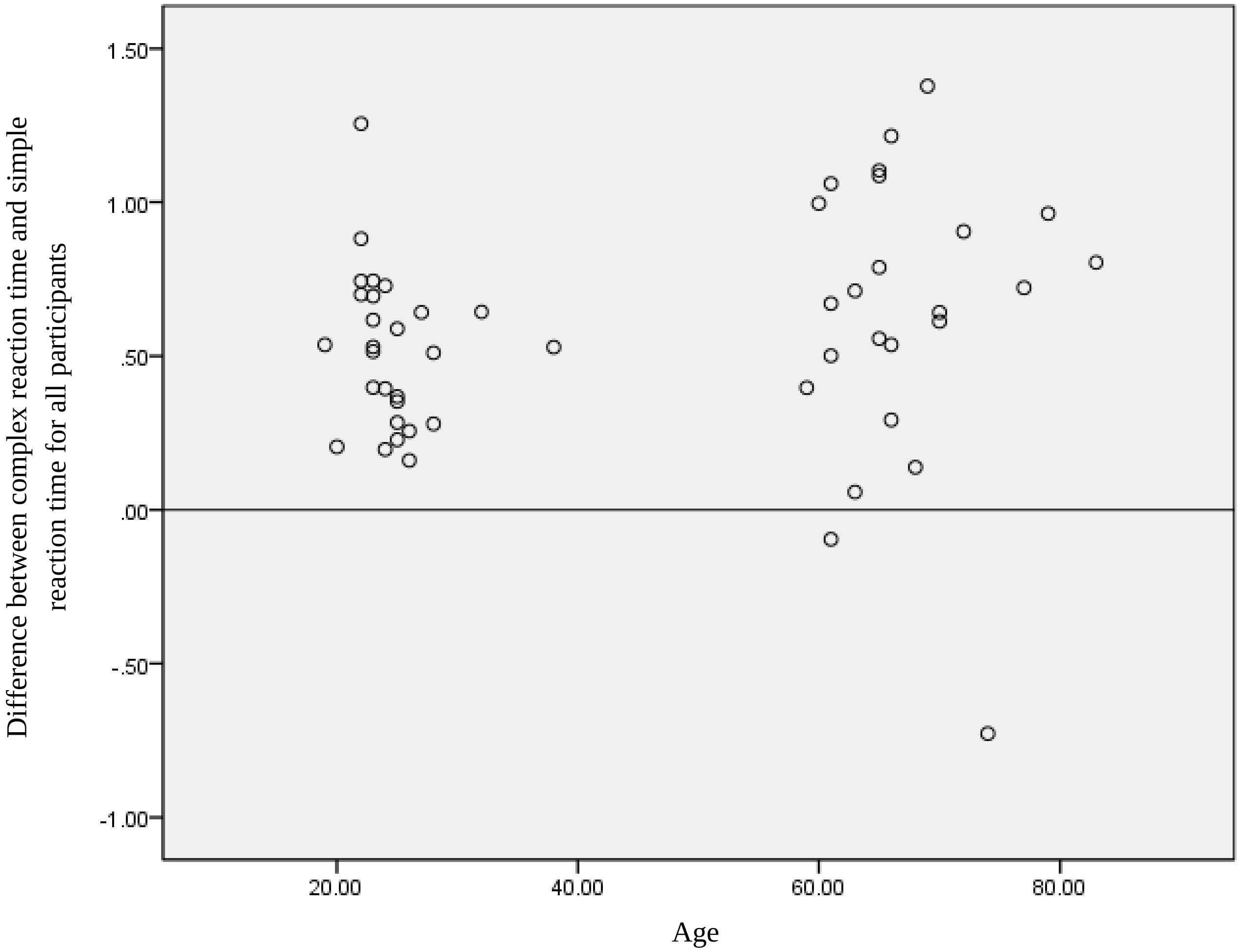

Figure 10 . Scatter plot of the difference between simple and complex brake reaction times for younger and older adults. A reference line is inserted at y=0.0.

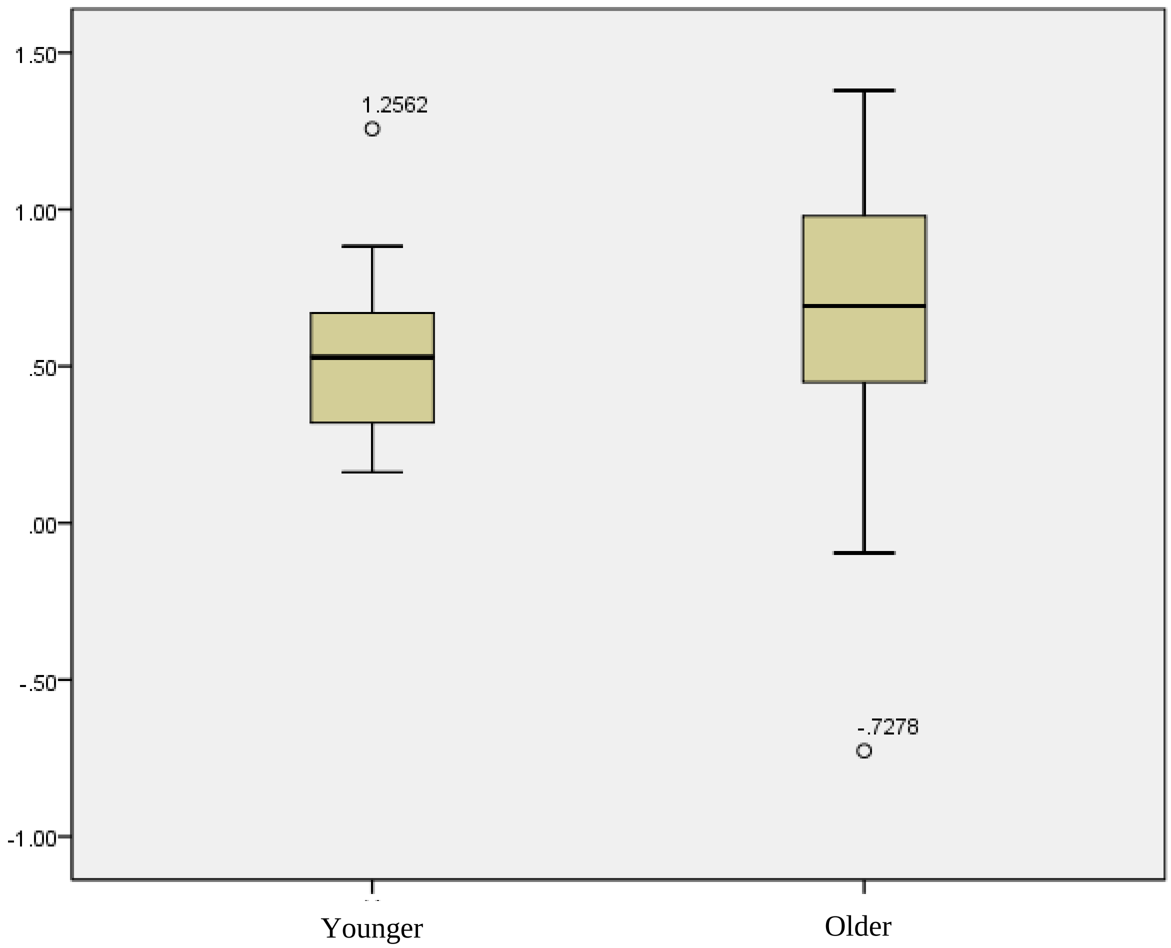

Figure 11.Box plots of the difference between simple and complex brake reaction times for younger and older adults.

Simple Simulator Force		
	Younger	Older
Yes	27	34
No	5	2

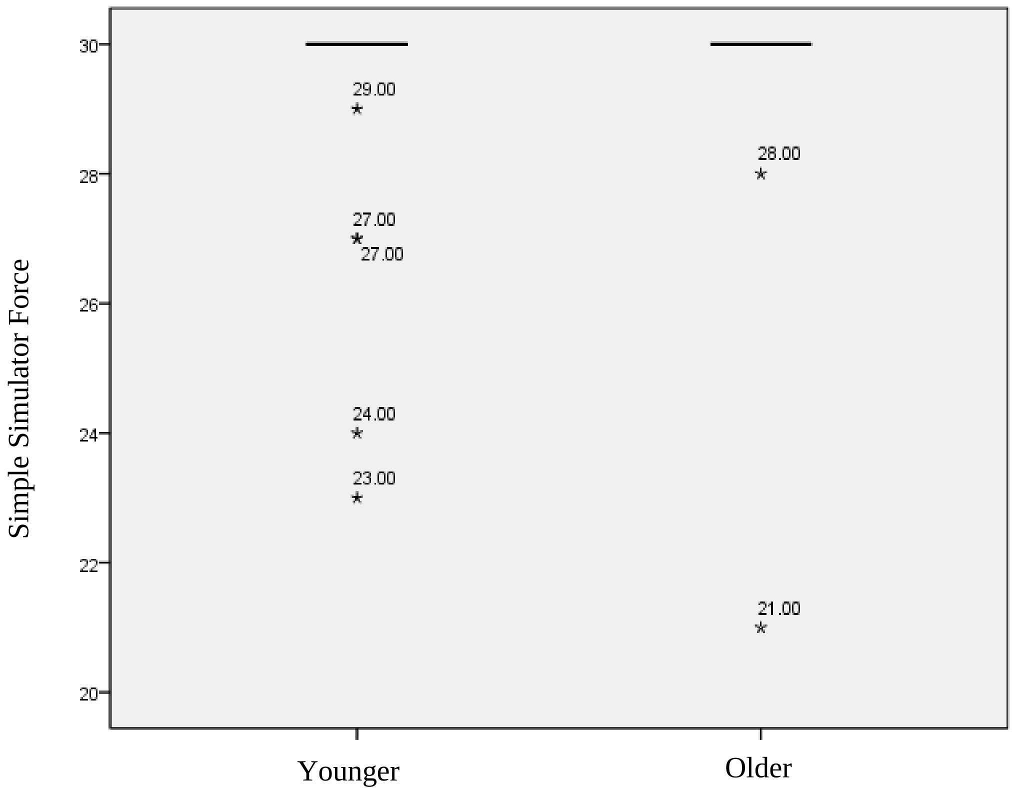

Figure 12. Chart and box plots of simple simulator force for younger and older drivers. A representation of the simple simulator brake reaction force for younger drivers (the number of observations that were able to achieve 30lbs of pressure [yes] or not [no]) and for older drivers (the number of observations that were able to achieve 30lbs of pressure [yes] or not [no]).

Complex Reaction Force		
	Younger	Older
Yes	25	22
No	3	5

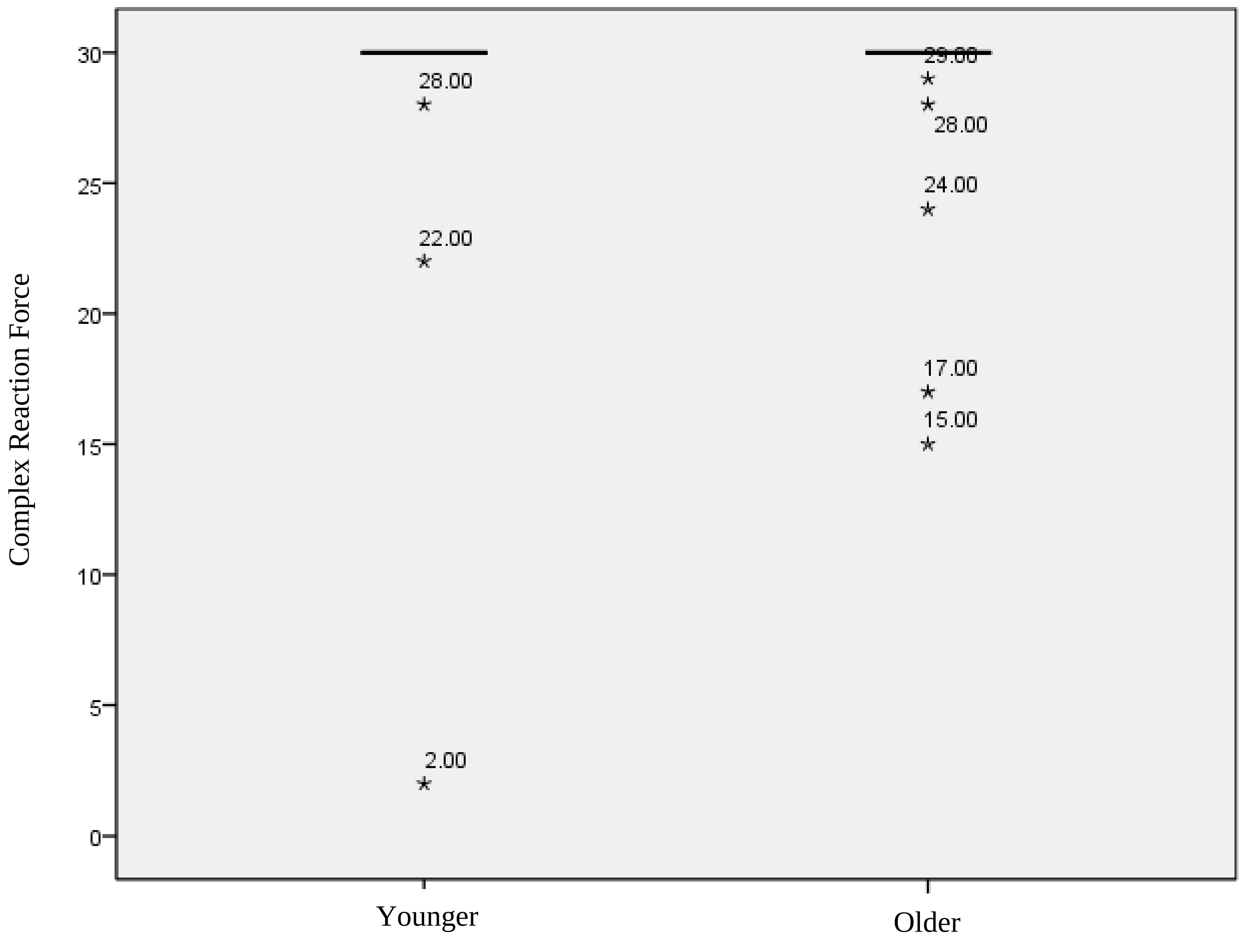

Figure 13. Chart and box plots of complex force for younger and older drivers. A representation of the simulator complex brake reaction force for younger drivers (the number of observations that were able to achieve 30lbs of pressure [yes] or not [no]) and for older drivers (the number of observations that were able to achieve 30lbs of pressure [yes] or not [no]).

Appendix

A Comparison of Drivers' Braking Responses Across Ages

1907-2007
CENTENNIAL
East Carolina University

UNIVERSITY HEALTH SYSTEMS
of Eastern Carolina

Informed Consent to Participate in Research

Information to consider before taking part in research that has no more than minimal risk.

Title of Research Study: A comparison of Drivers' Braking Responses Across Ages

Principal Investigator: Danielle Brown,
Sub-investigators: Kristen Davis and Cyrus Ridenour
Institution/Department or Division: ECU, College of Allied Health Sciences, Department of Occupational Therapy
Address: 3305 Health Sciences Building, Greenville, NC 27858
Telephone #: 252-744-6190

Researchers at East Carolina University (ECU) study problems in society, health problems, environmental problems, behavior problems and the human condition. Our goal is to try to find ways to improve the lives of you and others. To do this, we need the help of volunteers who are willing to take part in research.

Why is this research being done?
The purpose of this research study is to gain normative data on a driving simulator, brake reaction test, Useful Field of View test (UFOV), and Attention Network Test (ANT). The UFOV is a screening tool used to measure how quickly a person can react to stimuli on a computer screen within their direct field of vision (not peripheral areas). A small image will appear on the screen and participants will tap the screen where the object appeared that matches the object in the middle of the screen.
The ANT is a test given on a computer screen in order to measure attention. There is a small cross in the middle of the screen that participants look at and then either on the top or the bottom of the cross there will be an arrow (or other directional object: truck, pointing hand, etc) and the participant presses the keyboard arrows in the way that the arrow was facing (left or right arrows). There will be some distracting similar arrows, but only the ones in the middle are to be paid attention to.
A brake reaction test is an assessment to measure how quickly a participant can move their foot from a mock throttle pedal and press a mock brake pedal in reaction to a stimulus. In this study the stimulus will either be a boxed light that turns from green to red or a need to stop as shown on the screen of a driving simulator (i.e. in order to aviod hitting a person or having a car accident).

We are asking you to take part in this research. However, the decision is yours to make. By doing this research, we hope to learn how to best use a driving simulator, brake reaction timer, Useful Field of View test, and Attention Network Test in the use of driving evaluations.

Why am I being invited to take part in this research?

You are being invited to take part in this research because you are an adult, with a driver's license. If you volunteer to take part in this study, you will be one of about 60 people to do so here at East Carolina University.

UMCIRB Number: 11-0486

Consent Version # or Date:__ 7.22.11____
UMCIRB Version 2010.05.01

UMCIRB
APPROVED
FROM 7·27·11
TO 7·26·12

____
Participant's Initials

Are there reasons I should not take part in this research?

You should not participate if you have experience on driving simulators, brake reaction timers, Useful Field of View test, or Attention Network Test before, get motion sickness easily, do not have a valid drivers license, are under the age of 18, have not driven in the past month, or would not be willing to use a driving simulator which is a motionless device with a steering wheel and three screens which will show a roadway.

What other choices do I have if I do not take part in this research?

You can choose not to participate.

Where is the research going to take place and how long will it last?

The research procedures will be conducted at the Occupational Therapy Department at East Carolina University. You will need to come to the Health Sciences Building, Room 1330 one time for one hour.

What will I be asked to do?

The following procedures will be done strictly for research purposes.
You are being asked to do the following:

- Questionnaire about your health
- Demographics and driving habits
- You will first complete task 1: the order in which you are asked to complete these activities will be randomly assigned:
    - You will be asked to complete a brake reaction/force test
    - You will be asked to complete 3 scenarios on the driving simulator.
- You will next complete task 2: the order in which you are asked to complete these activities will be randomly assigned:
    - You will be asked to complete the UFOV, a cognitive assessment.
    - You will be asked to complete the ANT, a cognitive assessment.

What possible harms or discomforts might I experience if I take part in the research?

There are always risks (the chance of harm) when taking part in research. We know about the following risks or discomforts you may experience if you choose to volunteer for this study. These are called side effects. The following side effects are known to occur in some people:

- Some individuals experience motion sickness on the driving simulator. This is because, although you are using a steering wheel, gas and brake pedals, and see movement, the simulator is not moving so your body does not understand the movement. We use a fan to make sure the room is cool and keep the driving videos short to prevent motion sickness. We will also ask you frequently if you are experiencing any symptoms (like headache, dizziness, feeling warm) and stop the simulator immediately. Sometimes it just takes some time to get use to the simulator.
- We will also start with easy driving videos to get you familiar with the simulator.
- It is important for you to tell us as quickly as possible if you experience a side effect.

What are the possible benefits I may experience from taking part in this research?

During the study, information about this research may become available that would be important to you. This includes information that, once learned, might cause you to change your mind about wanting to be in the study. We will tell you as soon as we can. This might include information about the side effects that are caused by taking part in this study. If that happens, we can tell you about these new side effects and let you decide whether you want to continue to take part in the research.
There may be reasons we will need to take you out of the study, even if you want to stay in. We may find out that it is not safe for you to stay in the study. It may be that the side effects are so severe that we need to stop the study or take you out of the study to reduce your risk of harm. If we find that the research might harm you or that it is not providing enough of a benefit to justify the risks you are taking, we will ask you to stop.

Will I be paid for taking part in this research?

No, you will not be paid for participating in this research.

What will it cost me to take part in this research?
It will not cost you any money to be part of the research.

Who will know that I took part in this research and learn personal information about me?

To do this research, ECU and the people and organizations listed below may know that you took part in this research and may see information about you that is normally kept private. With your permission, these people may use your private information to do this research:

- The research team, including the Principal Investigator and research staff.
- Any agency of the federal, state, or local government that regulates this research including the ECU University & Medical Center Institutional Review Board (UMCIRB).

How will you keep the information you collect about me secure? How long will you keep it?

Information will be kept until the end of the study. It will be kept in a locked file cabinet and the simulator computer file is in a locked laboratory. Except for the consent form, all documentation will be coded. Once the study is complete, all documentation will be destroyed.

What if I decide I do not want to continue in this research?
If you decide you no longer want to be in this research after it has already started, you may stop at any time. You will not be penalized or criticized for stopping. You will not lose any benefits that you should normally receive.

Who should I contact if I have questions?
The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the principal investigator or the sub-investigators.:

- Danielle Brown at (530)651-3501 (weekdays)
- Kristen Davis (317)443-3180 (weekdays)
- Cyrus Ridenour (937)441-4153 (weekdays)

If you have questions about your rights as someone taking part in research, you may call the Office for Human Research Integrity (OHRI) at phone number 252-744-2914 (days, 8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of the OHRI, at 252-744-1971

If you have questions about your rights as someone taking part in research, you may call the ECU Institutional Review Board Office at phone number 252-744-2914 (days). If you would like to report a complaint or concern about this research study, you may call the Director of UMCIRB Office, at 252-744-1971.

Is there anything else I should know?

We will not report your results to the Department of Motor Vehicles. If we believe that you may be at risk for unsafe driving, we will encourage you to contact them, but you will be responsible.
The purpose of the information to be gathered for this research study is to better understand the way that people are able to complete braking reactions and how age may impact braking reactions. The individuals who will use or disclose your identifiable health information for research purposes include only the researchers, Danielle Brown, Kristen Davis, and Cyrus Ridenour. No other individuals will receive your identifiable health information for research purposes. The type of information accessed for this research study includes only information that you provide to us. The information will be used and disclosed in such a way as to protect your identity as much as possible; however, confidentiality cannot be absolutely guaranteed. Someone receiving information collected under this Authorization could potentially re-disclose it, and therefore it would no longer be protected under the HIPAA privacy rules (federal rules that govern the use and disclosure of your health information). There is not an expiration date for this Authorization.

You may not participate in this study if you do not sign this Authorization form. You may revoke (withdraw) this Authorization by submitting a request in writing to any of the researchers: Danielle Brown, Kristen Davis, or Cyrus Ridenour. However, the research team will be able to use any and all of the information collected prior to your request to withdraw your Authorization.

To authorize the use and disclosure of your health information for this study in the way that has been described in this form, please sign below and date when you signed this form. A signed copy of this Authorization will be given to you for your records.

I have decided I want to take part in this research. What should I do now?
The person obtaining informed consent will ask you to read the following and if you agree, you should sign this form:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
- I know that I can stop taking part in this study at any time.
- By signing this informed consent form, I am not giving up any of my rights.
- I have been given a copy of this consent document, and it is mine to keep.

Participant's Name (PRINT) **Signature** **Date**

Participant's Initials

Person Obtaining Informed Consent: I have conducted the initial informed consent process. I have orally reviewed the contents of the consent document with the person who has signed above, and answered all of the person's questions about the research.

____

Person Obtaining Consent (PRINT) **Signature** **Date**