THESIS

SEX DIFFERENCES IN REACTIVE DRIVING WITH AGING

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ABSTRACT

SEX DIFFERENCES IN REACTIVE DRIVING WITH AGING

Driving is a complex task that requires integration of perceptual and motor abilities. Age-related changes in perceptual motor abilities contribute towards driving deficits in older adults. Whether driving deficits in older adults are influenced by sex-differences is unknown. *Purpose:* Therefore, the purpose of this study was 1) to determine sex differences in reactive driving performance with advancing age and 2) to identify the differences in reactive driving strategies between older males and females. We tested reactive driving performance in a simulated environment that focuses on reactive driving. Reactive driving is a key component of car following task and involves responding to an unexpected environmental stimuli with fast and precise movements. *Methods:* Older male (N=12; age= 65.18 ± 7.19 yrs.) and older female (N=12; age= 66.25± 11.96 yrs.) adults performed a reactive driving task. All participants were right limb dominant and performed the simulated driving task with the right leg. We quantified reactive driving performance with the total response time, as the time from the onset of visual stimulus (brake lights of the car ahead) to application of brake force. To determine the contribution of perceptual ability (visual information processing speed), we quantified the pre-motor response time as the time from the onset of the visual stimulus to the activation of tibialis anterior. To determine the contribution of the motor ability (movement preparation and execution speed) to reactive driving performance, we quantified the motor response time as the time from the activation of tibialis anterior to the brake force onset. *Results:* The total response time was not significantly different between older male and older female adults ($|t_{22}| = -.17$; $p > 0.05$). The pre-motor response time was significantly longer in older females as compared with the older males ($|t_{22}| = 2.91$; $p < .01$). In contrast, the motor response time was significantly shorter in older females compared with the older males ($|t_{22}| = -2.52$; $p < .01$). The group differences in premotor and motor response times were not influenced by strength or motor variability. *Conclusion:* Older male and older female adults demonstrate comparable total response time on a reactive driving task. These findings suggest an absence of sex related differences in reactive driving with advancing age. This study provides novel evidence that older male and female adults adopt different strategies for reactive driving. While older males show reduced speed of movement preparation and execution compared with older females, older females show reduced speed of visual information processing relative to older males. Thus, driving rehabilitation must focus on targeting sex specific deficits for enhancing driving function in older adults.

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I would like to thank and dedicate my thesis to my supportive husband Alex, and to my wonderful mother, father and sister.

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I. INTRODUCTION

In the United States the number of older adults aged above 65 years is rapidly growing. Indeed, the older population is expected to grow from 15 percent to 24 percent by 2060.[1,2] With the increase in aging population, the number of older drivers is rising. The ability to drive a car is a significant predictor of the quality of life, and physical and mental health in older adults.

Driving is a complex task that requires integration of visual, cognitive and motor abilities. Visual function plays a key role in driving detection of environmental stimuli (e.g. road sign recognition) that are relevant for safety.[3] Similarly, intact cognitive function is required for integration and processing of environmental demands and making appropriate and timely decisions.[4] Finally, robust motor function enables precise and consistent limb control to operate the vehicle.[5] However, the age-related changes in visual, cognitive and motor function contribute to deterioration in the driving function in older adults.[6]

A key determinant of the risk for car crash is the response time. Longer response times could significantly increase the distance required to bring the car to a complete stop to avoid a car crash. Driving requires fast responses to environmental stimuli[7] and accurate and consistent control of the gas pedal[8] and the brake pedal.[9] Response time has a perceptual and a motor component. The perceptual component of response time involves *visual information processing* and is measured as the time between the onset of the stimulus and activation of a muscle(s).[5,10,11] The perceptual component of response time is commonly described as premotor response time (also known as reaction time).

The motor component of response time involves *movement preparation and execution* and is measured as the time from muscle activation to movement completion in response to the stimulus.[5,10,11] This motor component of response time is commonly described as motor response time.

Among older adults, studies investigating sex differences in total response time suggest that females and males have comparable total response time. Specifically, Botwinick et al. compared total response time, premotor response time and motor response time between females and males aged 68-84 years. The findings suggest no significant sex difference for total response time, premotor response time and motor response of the forearm extensor muscles.[10] Similarly, Hong et al. found no differences in total response time between older females and older males.[11] However, older females had longer motor response time than older males during both ankle dorsiflexion and plantarflexion tasks.[11] Whether sex differences in response time in older adults may contribute to driving deficits is unknown.

Empirical evidence suggests sex differences in premotor response time tasks. For example, Bleecker et al. and Der et al. compared females and males aged 40 to 90 years on simple response time (response to a single stimulus) and choice response time (pre-determined response to multiple stimuli) tasks. Females had longer premotor response times than males on both tasks.[12,13] Further, Der et al. reported that the increase in premotor response time occurs earlier in life in females than males.[13] Sex differences in premotor response time has been largely noted in literature across all ages.[14,15] Yet, evidence regarding sex-differences in motor response time is largely lacking. Therefore, information regarding sex differences in premotor and motor response times and their influence driving performance in older adults is lacking.

The effect of sex differences in functional abilities of older adults is debatable.[16–18] For instance, longer premotor response time is a strong predictor of falls in community-dwelling older adults.[19–21] In a study measuring choice reaction time during a reactive stepping task, older females had longer choice reaction time than older males.[21] The authors suggested that older females had impaired voluntary stepping, which may contribute to more falls in older females. Similarly, Kim et al. reported longer simple reaction time of the hip abductor in response to external audio stimulation in older females than older males. [22] Longer simple reaction time of the hip abductors is related to worse performance in medio-lateral balance,[17] more falls[23] and fall-related injury.[24] Perhaps, longer simple reaction time of the hip abductors might lead to higher risk for falls in older females. Sex differences among older adults have been observed in some functional tasks like dexterity and balance.[16,17] Despite the findings supporting differences in motor functions between older males and females, whether sex differences contribute to towards differential strategies for driving in older adults is not well understood.[25–27]

Reports suggest sex differences in driving behavior in older adults. For example, older females show greater self-regulatory driving behavior such as driving avoidance in rush hour, and making less complex maneuvers such as left-hand turns.[28,29] Interestingly, older males are involved in more car crash fatalities but report fewer driving errors compared to older females.[30] However, the mechanisms underlying sex differences in driving function in older adults are not well understood. Therefore, the purpose of this study was to determine sex differences in driving performance with advancing age. We test driving performance in a simulated environment that focuses on reactive driving. Reactive driving is a key component of car following task and involves responding to an unexpected environmental stimuli with fast and precise movements. We hypothesized that older males and older females will show no difference in total response time during a reactive driving task. Further, older males and older females will show differential decline in perceptual (premotor response time) and motor abilities (motor response time). Previous work has shown that motor variability, but not strength contributed to reactive driving deficits in older adults.[5] Therefore, a secondary goal of our study is to examine the influence of motor variability and strength on reactive driving performance in older male and female adults. We hypothesize that motor variability will influence reactive driving performance in older adults.

II. METHODS

Participants

Twelve older male (age= 65.18 ± 7.19 yr.) and twelve older female (age= 66.25± 11.96 yr.) adults volunteered to participate in this study. The participant characteristics for both groups are presented in Table 1. All participants were current drivers, with normal and/or corrected vision, and reported being healthy without any known musculoskeletal or neurological deficits. Prior to participation, all individuals read and signed a written informed consent and all study procedures were approved by the Institutional Review Board of University of Florida and Colorado State University.

Table 1. Participant characteristics

FAI – Frenchay Activity Index (max score 45); MoCA – Montreal Cognitive Assessment (max score 30); DHQ – Subset of the Driving Habits Questionnaire (max score 15); MVC – Maximal Voluntary Contraction; CV – Coefficient of Variation during the isolated visuomotor tracking task. All scores are mean ± standard deviation

	Males (*N*=12)	**Females (*N*=12)**
Age (years)	65.18 ± 7.19	66.25± 11.96
Height (cm)	177.64 ± 9.15	161.91 ± 5.75
MoCA	26.25 ± 1.87	27.25 ± 2.3
FAI	30.67 ± 3.42	32.25 ± 5.53
DHQ	12.17 ± 4.24	13.08 ± 1.56
MVC (N)		
Dorsiflexion	170.97 ± 74.35	133.45 ± 28.92
Plantarflexion	185.36 ± 56.07	164.56 ± 32.51
CV Isolated Visuomotor Tracking Task (%)	5.84 ± 1.72	8.18 ± 2.45

Experimental Approach

Participants performed four tasks during a 3 hr. experimental session. At the beginning of each task, experimental procedures were explained to the participants. Each participant performed the following tasks within a session: i) cognitive and behavioral assessments ii) maximal voluntary contraction (MVC), iii) visuomotor tracking task with the ankle involving 3 practice and 5 test trials, and iv) reactive driving task involving 3 practice and 10 test trials. All participants were right limb dominant and performed the task with the right leg.

Cognitive and Behavioral Assessments

To evaluate the cognitive status, participants were assessed using the Montreal Cognitive Assessment (MoCA).[31] To evaluate the functional status, participants completed the Frenchay Activity Index (FAI) that assesses involvement in a broad range of activities of daily living.[32] To evaluate current driving behavior, participants completed a subset of the Driving Habits Questionnaire (DHQ) that assesses driving exposure, space, avoidance, and crashes.[33]

Maximal Voluntary Contraction

The MVC task allowed us to measure ankle strength in dorsiflexion and plantarflexion, key tasks required for gas and brake pedal control.

Experimental Set-up: The participants were seated in an upright position. Specific instructions were given to exert maximal force at the ankle without moving the hip, knee, or the trunk while maintaining a stable posture until trial completion. The experimenter monitored the posture of the participant to limit extraneous force production and to ensure compliance with the instructions.

Task: The maximal isometric force was measured during ankle dorsiflexion and plantarflexion. Participants increased force to their maximum as fast as possible and maintained the maximal force for ~3 seconds. Rest period of 60 seconds was provided between successive trials. Participants completed three to five MVC trials, or until two MVC trials within 5% of each other were obtained. We quantified the MVC as the highest MVC among the three trials. The order of the dorsiflexion and plantarflexion MVC was randomized between participants. MVC tasks were repeated at the end of the session to assess whether the experimental task induced muscle fatigue.

Force Measurement: Maximum voluntary force was measured using a force transducer (Model 41BN, Honeywell, Morristown, NJ, USA) located parallel to the force direction on a customized foot device. The force signals were band-pass filtered from 0.03 to 20 Hz, amplified by a gain factor of 50 (Bridge-8 world precision instrument Inc., FL, USA), sampled at 1000 Hz (NI-DAQ card, Model USB6210, National Instruments, Austin, TX, USA), and stored on a research workstation for offline analysis.

Visuomotor Tracking Task

The visuomotor tracking task allowed us to measure ankle motor variability using a standardized protocol that has been extensively studied in our laboratory.[5,34]

Experimental Set-up: Participants were seated in an upright position in front of a 32-inch monitor (Sync Master 320MP-2; Samsung Electronics America; resolution: 1,920×1,080; refresh rate: 60p Hz) that provided the visual feedback of the ankle position produced by the dorsiflexion and plantarflexion. The monitor was located 1.25m away at the eye level. The hip joint was flexed to ~90° with 10° abduction, the knee was flexed to 90°, and the ankle was plantar flexed to ~15°. The participant's foot rested on a customized foot device with an adjustable foot plate and was secure with straps over the metatarsals to ensure position and simultaneous movement between the device and the foot.

Task: The participants tracked a sinusoidal target at a frequency of 0.3 Hz using isolated ankle joint movement. The targeted movement ranged from 5° ankle plantarflexion to 15° ankle dorsiflexion. A custom routine written in Matlab® (Math Works™ Inc., Natick, Massachusetts, USA) controlled the visual presentation of each trial. The participants were instructed to track the sinusoidal target as accurately as possible by moving their foot up and down at the ankle joint. The participants received visual feedback of their performance. Each trial lasted for ~ 35 s., and a rest period of 30 s was provided between consecutive trials to minimize fatigue. A total of 8 trials were performed. The first three trials were familiarization trials and excluded from the data analysis. Each trial lasted for ~35 seconds. We provided a rest period of 90 seconds between consecutive trials to minimize fatigue.

Ankle Position Measurement: The ankle position during the visuomotor tracking task was measured using a low-friction potentiometer (SP22G-5K, Mouser Electronics, Mansfield, TX, USA) located directly lateral to the fibular malleolus. The position signals were sampled at 1000 Hz (NI-DAQ card, Model USB6210, National Instruments, Austin, TX, USA) and saved for offline analysis.

Reactive Driving Task

Reactive driving simulates a car following task in city or highway traffic that involves precise control of the gas and brake pedal to track the leading car with a safe distance.

Experimental Set-up: Participants were seated comfortably in an upright position in front of a 32-in. monitor (Sync Master 320MP-2, Samsung Electronics America, Resolution: 1920 x 1080, Refresh Rate: 60p Hz) located 1.25 m away at eye level. The monitor was used to display visual feedback from: a) ankle dorsiflexion movements on the gas pedal; b) rear-lights of the car ahead. The foot rested on a customized gas pedal (Figure 1A). The hip joint was flexed to ~90° with 10° abduction, the knee was flexed to ~45°, and the ankle was plantarflexed to ~ 15°.

Task: Participants were instructed to track a visual target (leading car) by controlling the gas pedal with right ankle movements. While performing this task, the rear lights of the car in front lighted up (red) at a random time (Figure 1A). Participants reacted to this visual stimulus as fast as possible by moving the foot from the gas pedal to the brake pedal and exerted a control braking force of 40N. Participants performed a total of 13 trials. The first 3 trials were familiarization trials and excluded from the analysis. Each trial lasted 20 s. We provided a rest period of 60 s between consecutive trials to minimize fatigue.

Pedal Position and Force Measurement: The position of the gas pedal was measured using the CSR Elite Pedals (Fanatec, Endor AG, Germany). The force on the brake pedal was measured using a force transducer (Model LAU200, 100 lbF capacity, FUTEK Advanced Sensor Technology, Irvine, CA). The tibialis anterior muscle activity was measured using wireless surface electromyography electrodes (Delsys Trigno; Delsys, Boston, MA).

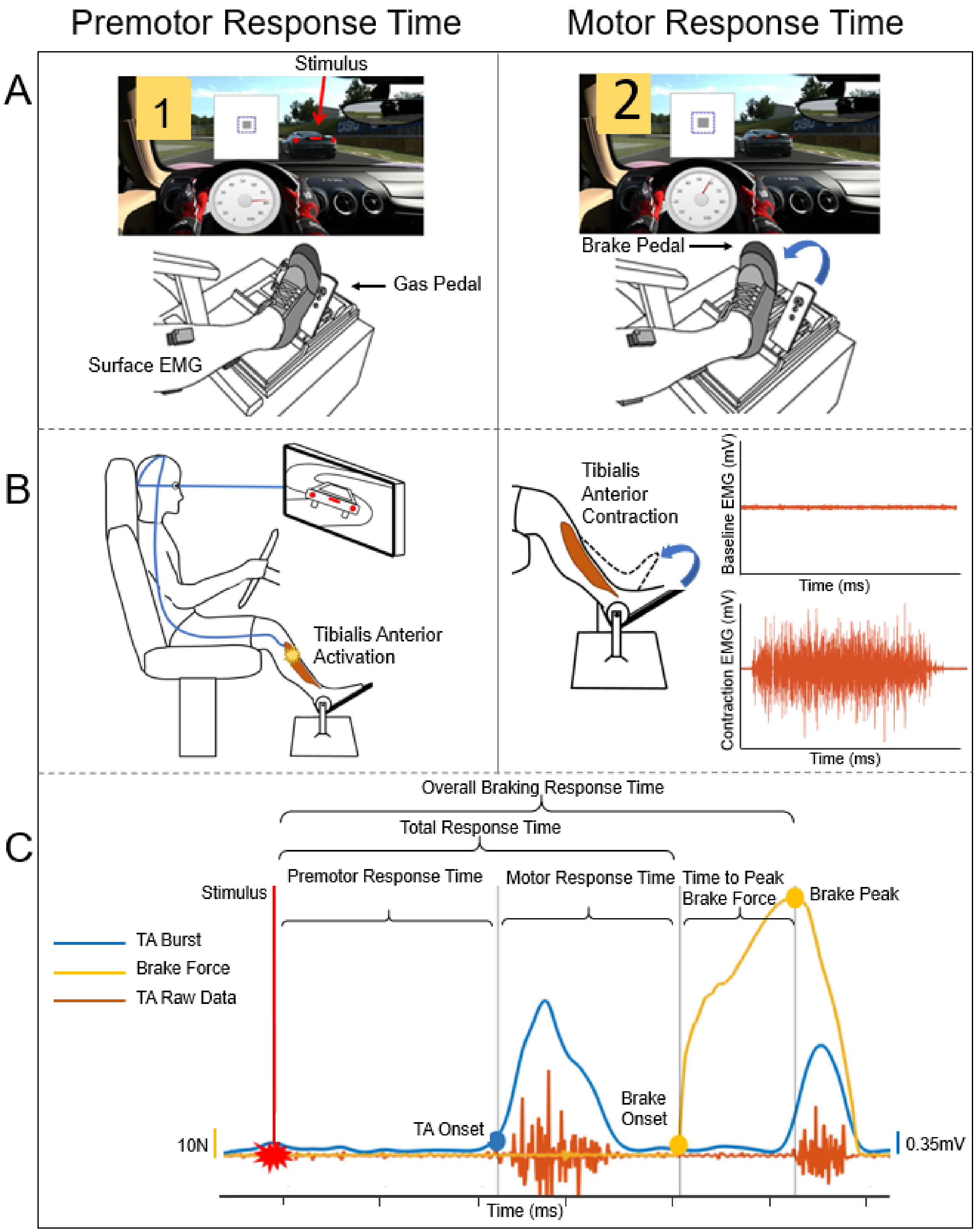

Figure 1: Reactive Driving Task. A) Reactive Driving Task. **Left:** Participants were instructed to drive in the center of the lane. During this task, the rear lights of the car in front lighted up (red) randomly. **Right:** Participants responded to the visual stimulus as fast as possible by moving the foot from the gas pedal to the brake pedal. **B) Mechanism**. **Left:** Visual information processing of the stimulus to activate the tibialis anterior muscle **Right:** Neuromotor control if the tibialis anterior muscle to move to the foot from the gas

pedal to the brake pedal. **C) Outcome Measures.** Visual information processing was quantified as premotor response time. Neuromotor control was quantified as motor response time.

Data Analysis

Motor Variability: We quantified motor variability during the visuomotor tracking task. The force signal was band-pass filtered between 0.4 and 0.6 Hz to remove the task-related frequency. The magnitude of force variability within each trial was quantified as the coefficient of variation of force (coefficient of variation of force = standard deviation of force/mean force output × 100). The first 10 s and final 5 s of position data were eliminated from all analyses to account for initial position adjustments and early movement cessation caused by the anticipation of trial completion.

Reactive Driving Performance**:** The five components of the reactive driving task performance included total response time, premotor response time, motor response time, time to peak brake force, and overall braking response time (Figure 1C). *Total response time (pre-motor +motor response time)* was quantified as the time between the onset of the visual stimulus and the onset of brake force. *Pre-motor response time* was quantified as the time between the onset of the visual stimulus and initial activation of the tibialis anterior muscle. *Motor response time* was quantified as the time between the initial activation of the tibialis anterior muscle and the onset of brake force. *Time to peak brake force* was quantified as the time between the onset of the brake force and peak brake force. *Overall braking response time (premotor response time + motor response time + time to peak)* was quantified as the time between the onset of the visual stimulus and peak brake force.

Statistics

We compared older male and older adults using independent t-test on the following measures: i) strength (MVC dorsiflexion and MVC plantarflexion), ii) motor variability (Coefficient of variation during visuomotor tracking task); and iii) components of reactive driving performance (total response time, premotor response time, motor response time, time to peak, and overall braking response time). To determine the influence of strength and motor variability on reactive driving performance, we conducted Analysis of Covariance (ANCOVA) by covarying the effect of MVC dorsiflexion, MVC plantarflexion and coefficient of variation.

III. RESULTS

Cognitive and Behavioral Assessments

The Montreal Cognitive Assessment score was not significantly different between the older males and the females ($|t_{22}| = 1.17$; $p = 0.26$). Similarly, the behavioral assessments on Frenchay Activity Index ($|t_{22}| = 0.84$; $p = 0.41$) as well as Driving Habits Questionnaire ($|t_{22}| = 0.70$; $p = 0.49$) were not significantly different between the two groups.

Strength and Motor Variability

The strength was not significantly different between the older males and the females for both the dorsiflexion ($|t_{22}| = -1.63$; $p = 0.12$) and plantar flexion ($|t_{22}| = -1.11$; $p = 0.29$) MVC tasks. The motor variability during the isolated visuomotor task was significantly increased for the older females as compared with the older males ($|t_{22}| = 2.70$; $p = 0.01$).

Reactive Driving Performance

We compared older males and older females on the five reactive driving components — total response time, premotor response time, and motor response time, time to peak brake force**,** and overall braking response time. The total response time was not significantly different between the older males and the females (Figure 2; $|t_{22}| = -0.17$; $p = 0.87$). The pre-motor response time was significantly longer in older females as compared with the older males (Figure 3; $|t_{22}| = 2.91$; $p = .01$). In contrast, the motor response time was significantly shorter in older females compared with the older males (Figure 3; $|t_{22}| = -2.52$; $p = .02$). The time to peak brake force was not significantly ($|t_{22}| =$

-0.87; *p* = .39) different between older males (233.85 ± 58.47 ms) and older females (179.73 ± 20.41 ms). The overall braking response time was not significantly ($|t_{22}|$ = -0.78; *p* = .44) different between older females (1097.03 ± 37.49 ms) compared with the older males (1166.31 ± 80.41).

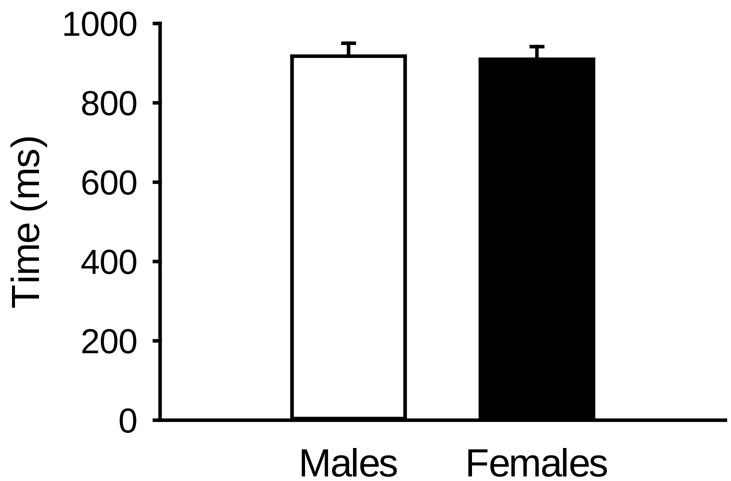

Figure 2. Sex differences in total response time in older adults. The total response time was not significantly different between groups.

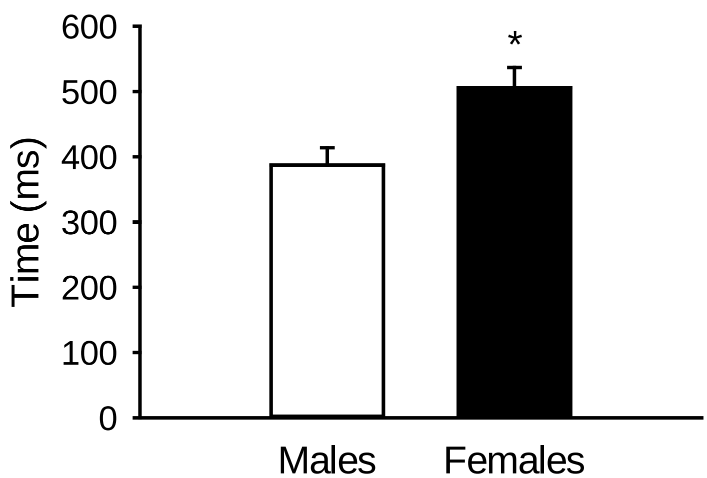

Figure 3. Sex differences in premotor response in older adults. Females had significantly longer premotor response time as compared with the older males. *p-value < .05.

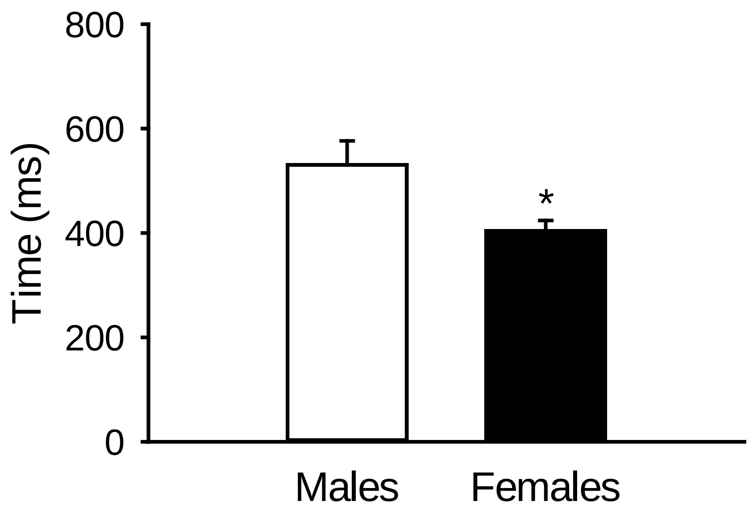

Figure 4. Sex differences in motor response time in older adults. Females had significantly shorter motor response time as compared with the older males. *p-value < .05.

Influence of Strength and Motor Variability on Reactive Driving Performance

We controlled for the effect of strength and motor variability on reactive driving performance by conducting an ANCOVA with dorsiflexion strength, plantarflexion strength and CV as the covariates. MVC dorsiflexion (p = 0.79), MVC plantarflexion (p = 0.78), and motor variability (p = 0.34) did not influence the total response time. MVC dorsiflexion (p = 0.51), MVC plantarflexion (p = 0.40), and motor variability (p = 0.19), did not influence the overall braking response time. Therefore, the sex-differences in reactive driving performance were not influenced by strength or motor variability in older adults.

IV. DISCUSSION

The purpose of this study was to determine sex differences in driving performance with advancing age. Our findings indicate that older males and older females demonstrate comparable total response time on a reactive driving task. These findings suggest an absence of sex related differences in reactive driving with advancing age. Further, older females require longer time for visual information processing but shorter time for movement preparation and execution. In contrast, older males require shorter time for visual information processing but longer time for movement preparation and execution.

Driving is an instrumental activity of daily living (IADL) that is critical for maintaining functional independence in older adults.[35] For this study, we examined a reactive task that is frequently experienced during every day driving. Reactive driving is a key component of car following task and involves responding to environmental unexpected stimuli with fast and precise movements. Aging-related increase in response time[36] can reduce one's ability to produce an accurate response to a given stimuli during driving. Longer response time could significantly increase the distance required to bring the car to a complete stop leading to a collision. Our findings show no sex differences in total response time in older adults during a reactive driving task. Thus, our findings support and extend previous work demonstrating no sex differences in total response time in tasks unrelated to driving [10,11]

Driving involves integration of perceptual and motor abilties.[5,10] One of the most interesting findings in this study is that the older males and older females adopted different strategies during the reactive driving task. Specifically, older female drivers showed a significantly longer time for premotor response (505.94 ± 30.87ms) when compared to the older males (387.27 ± 26.68 ms). Premotor response time represents the time necessary for stimuli perception, integration and decision making in the central nervous system, and sending motor commands to specific muscles. Thus, longer premotor response time suggests that the detrimental effects of aging are found in the central rather than the peripheral neuromuscular system.[37] Age –related changes in the central nervous system include microscopic disruption of myelin or of axons themselves, gross changes in white matter volume,[38] declines of dopaminergic neurotransmission and impairment of corticospinal excitability.[39] Perhaps, the effect of aging in the conduction of nerve impulses in the central nervous system differs between older males and females and requires further investigation.

Another possible explanation to the difference observed in this study with regards to premotor response time may be related to the type of task. Lahtela et al. argued that response time tasks incorporating a strong semantic component (e.g. numbers as stimuli) show female advantage, while tasks dominated by spatial features (e.g. spatial location stimuli) exhibit a male advantage.[40] Driving is a task that requires the integration of spatial relations among objects. It is possible that the shorter premotor response time observed in our study might be associated to greater spatial abilities in older males compared to females.[41] On the contrary, Silverman et al. suggested that shorter premotor response times might be observed in women because women are on average are smaller than men. Thus, the neural impulses have a shorter distance to travel in women than in men. In our study, males' mean height (177.64 ± 2.76) was significantly greater than females' mean height (161.91 1.73±). In our study, height differences between the groups did not contribute to the differences in premotor response times. Therefore, our findings do not support the rationale that height as a variable for influencing the premotor response time.

Studies examining the premotor and motor components of total response time reported contradicting results with regards to motor response time. The early study by Botwinick et al. showed no sex differences for the neuromotor contribution to response time in older adults during a finger extension task.[10] In contrast, Hong's group observed longer motor response time (reported as electromechanical delay) in older females when compared to males for the hip abductors, ankle dorsiflexor, plantarflexor muscles.[11,22] In our study, older females showed motor response time (404.33 ± 19.83 ms) than older males (530.5650 ± 45.99 ms) during a reactive driving task. These findings are in line with a study reporting females have faster foot transfer time from brake to gas pedal.[42]

A possible mechanism that might explain the sex related difference in the motor response time in older adults could be based on sex differences in skeletal muscle fiber-type composition and function. Previous studies have shown sex skeletal muscle differences in specific anatomical locations.[43]The response to the stimulus presented during our reactive driving task requires a fast movement of the foot from the gas pedal to the brake pedal. In a study were reactive balance was evaluated, Miller et al. observed that greater percentage of type II muscle fibers in the knee extensors was associated with faster reactive balance.[44] Perhaps, a greater involvement of type II muscle fibers of the tibialis anterior is required to move the foot to the brake pedal. Structural differences in neuromuscular system might be associated with greater motor execution time in older males compared to older females during reactive driving. Due to the scope of our study, it is difficult to determine if the sex differences observed in motor response time could be related to sex differences in muscle fiber type composition and function in older adults.

Strength, Motor Variability and Reactive Driving

Strength is commonly used as a clinical predictor of functional impairment[45]. Previous studies have shown that advanced age is associated with a decline in strength[46]. Further, some evidence suggests that the decrease in strength is more profound and occurs earlier in females than in males.[16,47] In this study, we found no sex differences in the maximal voluntary contraction (MVC) for ankle dorsiflexors. In addition, total response time in the reactive driving task was not influenced by strength. These findings are in line with a previous study reporting that the decline in strength is not related with impaired reactive driving in older adults.[5]

Sex differences in motor variability have also been reported in older adults.[48] The ability to control and modulate forces is crucial for accurate control of the gas pedal while driving. Increased motor variability in older adults may impair the response time and may be linked to greater chances for driving accidents. In our study, motor variability did not influence the total response time, premotor and motor response time during the reactive driving task. Thus, motor variability does not contribute to sex-differences in reactive driving performance.

Considerations

Our reactive driving task was performed in a simulated driving environment. Future research should examine the contribution sex differences in premotor and motor response time to on-road driving performance in older adults. The understanding of how sex differences in perceptual motor abilities in older adults may direct the development of driving rehabilitation programs. For example, older females show decline in perceptual ability and may benefit from targeted training that enhances perceptual abilities required for driving. Older males show decline in movement preparation and execution and may benefit from targeted training that enhances motor abilities for driving.

In conclusion, this study provides novel evidence that older males and females show comparable performance on a reactive driving task. However, sex differences were noted in differential strategies of reactive driving task. While older males show impaired speed of movement preparation and execution, older females show impaired speed of visual information processing. Thus, driving rehabilitation must focus on targeting sex specific deficits for enhancing driving function in older adults.

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APPENDIX

Participant Information

Date: ______________________ Participant ID: _______________

Date of Birth: _________ Sex: _____________ Height (cm): __________

1. Condition

☐ Healthy

☐ Stroke Date of Stroke: __________Type/Location: _______________

2. Affected Side

☐ Right Arm ☐ Left Arm

☐ Right Leg ☐ Left Leg

3. Leg used for driving

☐ Right Leg ☐ Left Leg

4. Based on question 2 and 3, you drive with your

☐ Affected Leg ☐ Unaffected Leg

5. Dominant Hand

☐ Right Hand ☐ Left Hand

How did you determine it? ________________________

6. Hand used for steering

☐ Right Hand only ☐ Left Hand only ☐ Both

Based on questions 5 and 6, you drive with your

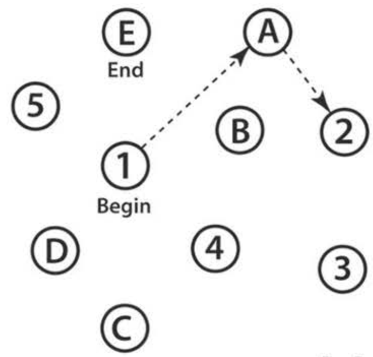
☐ ☐

Montreal Cognitive Assessment

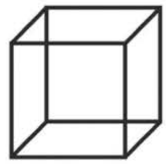
MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME :
Education :   Date of birth :
Sex :   DATE :

	POINTS
VISUOSPATIAL / EXECUTIVE	



[ ]

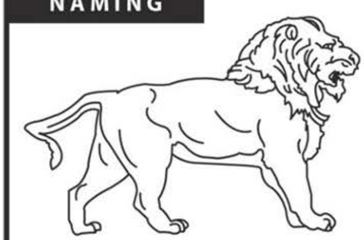


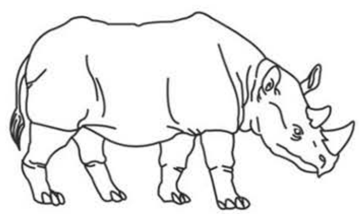
Copy cube [ ]

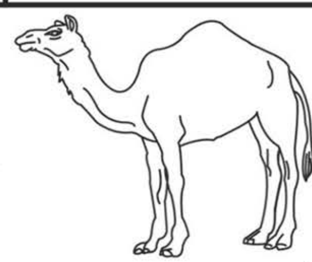
Draw CLOCK (Ten past eleven) (3 points)

[ ] Contour [ ] Numbers [ ] Hands ___/5

NAMING

 [ ]

 [ ]

 [ ]

___/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).
Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2
___/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B
___/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**
___/3

LANGUAGE Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ]
___/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words)
___/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler
___/2

DELAYED RECALL	Has to recall words **WITH NO CUE**	FACE [ ]	VELVET [ ]	CHURCH [ ]	DAISY [ ]	RED [ ]	Points for UNCUED recall only	___/5
Optional	Category cue							
	Multiple choice cue							

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City ___/6

 www.mocatest.org Normal ≥ 26 / 30 TOTAL ___/30
Add 1 point if ≤ 12 yr edu

Administered by: ______________________

Fugl-Meyer Motor Assessment - Lower Extremity

Fugl-Meyer Motor Assessment - Lower Extremity				
TEST	ITEM	SCORE		SCORING CRITERIA
		Pre	Post	
I. Reflex Activity	Achilles			0-No reflex activity can be elicited 2-Reflex activity can be elicited
	Patellar			
II. A. Flexor Synergy (in supine)	Hip flexion			0-Cannot be performed at all 1-Partial motion 2-Full motion
	Knee flexion			
	Ankle dorsiflexion			
II. B. Extensor Synergy (in side lying)	Hip extension			0-Cannot be performed at all 1-Partial motion 2-Full motion
	Adduction			
	Knee extension			
	Ankle plantar flexion			
III. Movement combining synergies (sitting: knees free of chair)	A. Knee flexion beyond 90q			0-No active motion 1-From slightly extended position, knee can be flexed, but not beyond 90q 2- Knee flexion beyond 90q
	B. Ankle dorsiflexion			0-No active flexion 1-Incomplete active flexion 2-Normal dorsiflexion
IV. Movement out of synergy (standing, hip at 0q)	A. Knee flexion			0-Knee cannot flex without hip flexion 1-Knee begins flexion without hip flexion, but does not reach to 90q, or hip flexes during motion 2-Full motion as described
	B. Ankle dorsiflexion			0-No active motion 1-Partial motion 2-Full motion
V. Normal Reflexes (sitting)	Knee flexors Patellar Achilles (This item is only included if the patient achieves a maximum score on all previous items, otherwise score 0)			0-At least 2 of the 3 phasic reflexes are markedly hyperactive 1-One reflex is markedly hyperactive, or at least 2 reflexes are lively 2-No more than one reflex is lively and none are hyperactive
VI. Coordination/speed - Sitting: Heel to opposite knee (5 repetitions in rapid succession)	A. Tremor			0-Marked tremor 1-Slight tremor 2-No tremor
	B. Dysmetria			0-Pronounced or unsystematic dysmetria 1-Slight or systematic dysmetria 2- No dysmetria
	C. Speed			0-Activity is more than 6 seconds longer than unaffected side 1-(2-5.9) seconds longer than unaffected side 2-Less than 2 seconds difference
Lower Extremity Total				Max = 34
Total Motor Score (UE + LE)				Max = 100

Driving Habits Questionnaire

Current Driving **____/2**

1. Do you currently drive? (1) Yes/No
2. Do you wear glasses or contacts when you drive? Yes/No
3. Which way do you prefer to get around?
    a. Drive yourself? (1)
    b. Have someone drive you?

Exposure **___/4**

4. How many days per week do you drive? (0=never; 1=less than 3; 2=more than 3)
5. How many miles per week do you drive? (0-10=0; 10-20=1; 20+=2)

Driving Space **___/4**

During the past year have you driven:

6. In your neighborhood? (1) Yes/No
7. Beyond your neighborhood? (1) Yes/No
8. To neighboring towns? (1) Yes/No
9. Outside of Florida? (1) Yes/No

Avoidance **___/5**

During the past three months have you driven:

10. Driven alone? (1) Yes/No
11. On Interstates or expressways? (1) Yes/No
12. On rush hour traffic? (1) Yes/No
13. When it is raining? (1) Yes/No
14. At Night? (1) Yes/No

Crashes and Citation **___/0**

How many times in the past year:

15. Have you been pulled over by the police and received a ticket? (-1) Yes/No
16. Have you been involved in accident when you were driving? (-1) Yes/No

TOTAL: ___ /15

The Frenchay Activities Index

In the last 3 months how often have you undertaken:

1. Preparing main meals 2. Washing up after meals	0 = Never 1 = Less than once a week 2 = 1-2 times per week 3 = Most days
3. Washing clothes 4. Light housework 5. Heavy housework 6. Local Shopping 7. Social occasions 8. Walking outside for > 15 minutes 9. Actively pursuing hobby 10. Driving car/going on bus	0 = Never 1 = 1-2 times in 3 months 2 = 3-12 times in 6 months 3 = At least weekly

In the last 6 months how often have you undertaken:

11. Travel outing/car ride	0 = Never 1 = 1-2 times in 6 months 2 = 3-12 times in 6 months 3 = At least weekly
12. Gardening 13. Household maintenance	0 = Never 1 = Light 2 = Moderate 3 = Heavy/All necessary
14. Reading books	0 = None 1 = 1 in 6 months 2 = Less than 1 in 2 weeks 3 = More than 1 every 2 weeks
15. Gainful work	0 = None 1 = Up to 10 hours/week 2 = 10-30 hours/week 3 = Over 30 hours/week

Motor Control Testing – Maximal Voluntary Contraction Task

Trial	Grip Strength	Plantar-flexion	Dorsiflexion
L1			
L2			
L3			
L4			
L5			
L6			
R1			
R2			
R3			
R4			
R5			
R6			

- Range of Motion

Plantar Flexion: Left: ____________ Right: _____________

Dorsiflexion: Left: ___________ Right: _____________

Motor Control Testing - Visuomotor Tracking Task

Right Leg		
Practice Tally		Notes:
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		

Left Leg		
Practice Tally		Notes:
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		

Reactive Driving Task

PRACTICE	Following the square	Foot to brake speed	Brake force	Following the square again	Notes:

1					
2					
3					

SIMPLE	**Following the square**	**Foot to brake speed**	**Brake force**	**Following the square again**	**Notes:**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

GO/NOGO	**Red/Blue**	**Following the square**	**Foot to brake speed**	**Brake force**	**Following the square again**	**Notes:**

1						
2						
3						
4						
5						
6						
7						
8						
9						
10						