



Lakehead
UNIVERSITY

School of
Kinesiology



The Effectiveness of a Simulation Driving Protocol with Dual Tasking Scenarios in Differentiating Between Concussed and Non-concussed Individuals

Research Team:

Dennis Dumphy, MSc, School of Kinesiology

Carlos Zerpa, PhD, School of Kinesiology, CRSD

Bruce Weaver, MSc, Northern Ontario School of Medicine, CRSD

Paolo Sanzo, DScPT, School of Kinesiology, Northern Ontario School of Medicine

Michel Bédard, PhD, Faculty of Health and Behavioural Sciences, CRSD



What is a Concussion?

“Concussion is a disturbance in brain function caused by direct or indirect force to the head. It is a functional rather than structural injury that results from shear stress to brain tissue caused by rotational or angular forces. Direct impact to the head is not required.”

(Scorza, Raleigh, & O'Connor, 2012, p. 123)



Signs

Physical	Headache, fatigue, nausea, light and noise sensitivity, balance problems, numbness, dizziness, feeling stunned, visual problems
Cognitive	Mentally foggy, slowed, forgetful, difficulty concentrating/remembering, confusion about recent events, slow response time
Emotional	Irritability, sadness, more emotional, nervousness
Sleep	Drowsiness, sleeping more/less than usual, difficulty falling asleep

(ImPACT, 2015)



Driving and Reaction Time

Three components of reaction time (RT): (Green, 2000)

- Mental processing time
 - Sensation
 - Perception
 - Response selection and programming
- Movement time
- Device response time





Reaction Time

- **Clinical reaction time increased**
(Eckner, Kutcher, & Richardson, 2011)



- **Computer test reaction time increased**
(Eckner et al., 2011)





Impact of Dual Tasking

- **Increased reaction time to brake lights**
(Drews et al., 2009)
- **Increased reaction time with texting present**
(Park et al., 2013)
- **Decreased recognition of relevant stimuli**
(Strayer et al., 2003)





Research Problem

- Most studies on RT and dual tasking in concussed individuals use computer-based testing and subjective rating instruments
- Limited concussion research conducted on a simulated driving environment





Purpose

To compare simple reaction time and reaction time during dual-tasking in simulated driving environments of varying difficulty, in people who have experienced a concussion versus healthy control participants



Participants

- 10 participants with a history of concussion recruited from the Lakehead Concussion Clinic (SCAT3)
- 10 healthy participants via convenience sampling

Inclusion Criteria	Exclusion Criteria
Ages 18 – 45 years of age	Neurological conditions
Valid G-Class License or equivalent	Cardiovascular conditions
Medical clearance by Physician	Physical conditions affecting driving
2 weeks to 1 year post-injury	



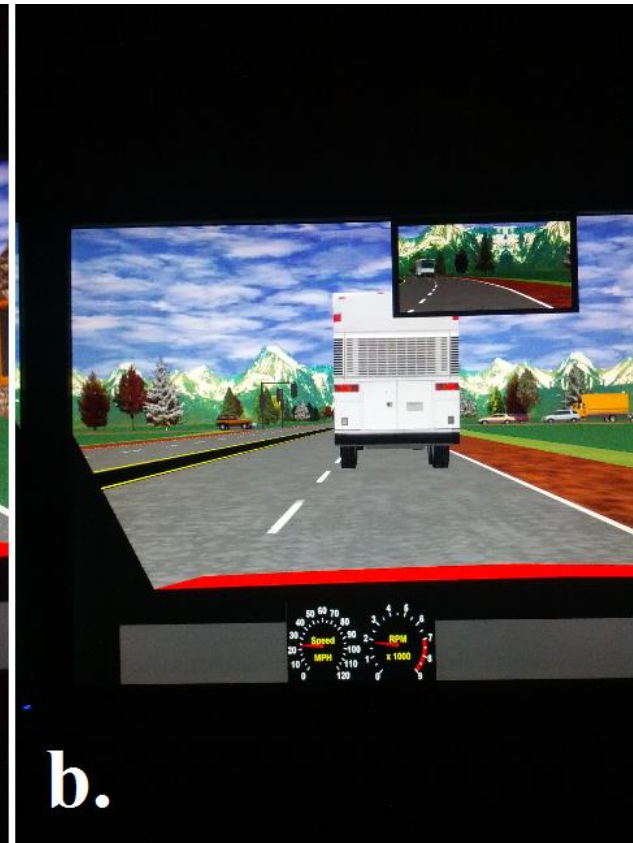
Procedures

- 10 minute orientation drive
 - Adjust to simulator
 - Exposed to dual task markers
- Simulation lasted 20 minutes
- Predetermined RT events
- Reaction time measurement
 - Simple reaction time (6 events)
 - Dual-task reaction time (3 events)





Procedures





Procedures





Data Analysis

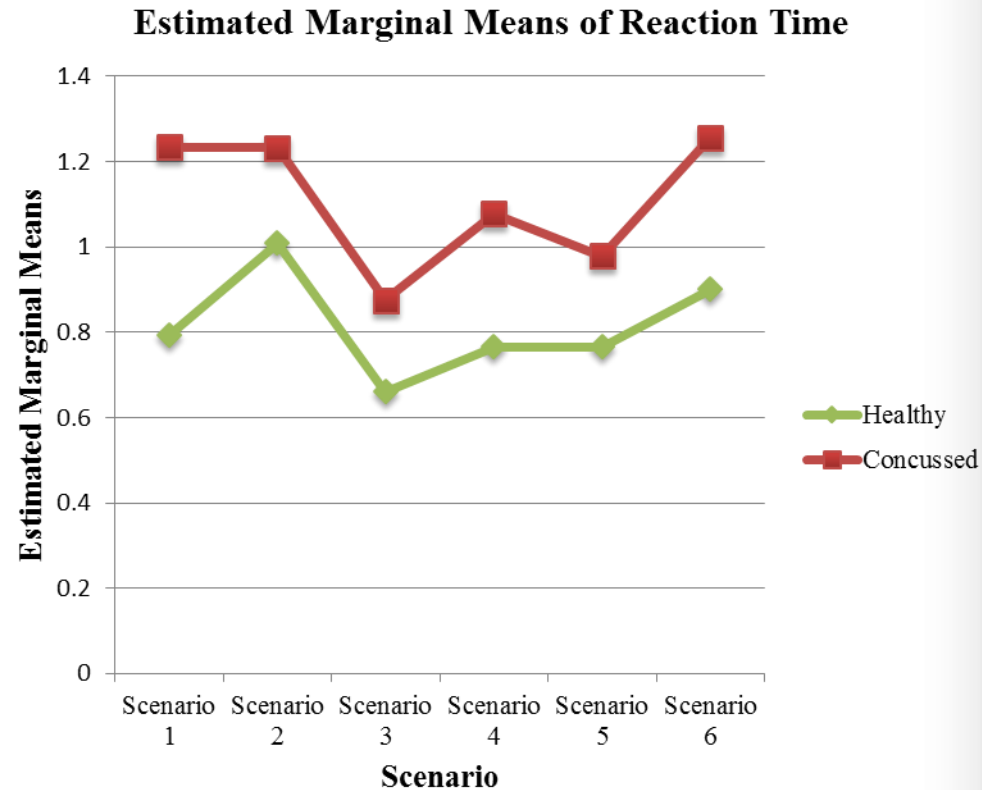
IV	DV	Analysis
1. Group 2. Scenario	Simple Reaction Time	2x6 Factorial ANOVA

IV	DV	Analysis
1. Group 2. Scenario	Dual-Task Reaction Time	2x3 Factorial ANOVA



Simple Reaction Time

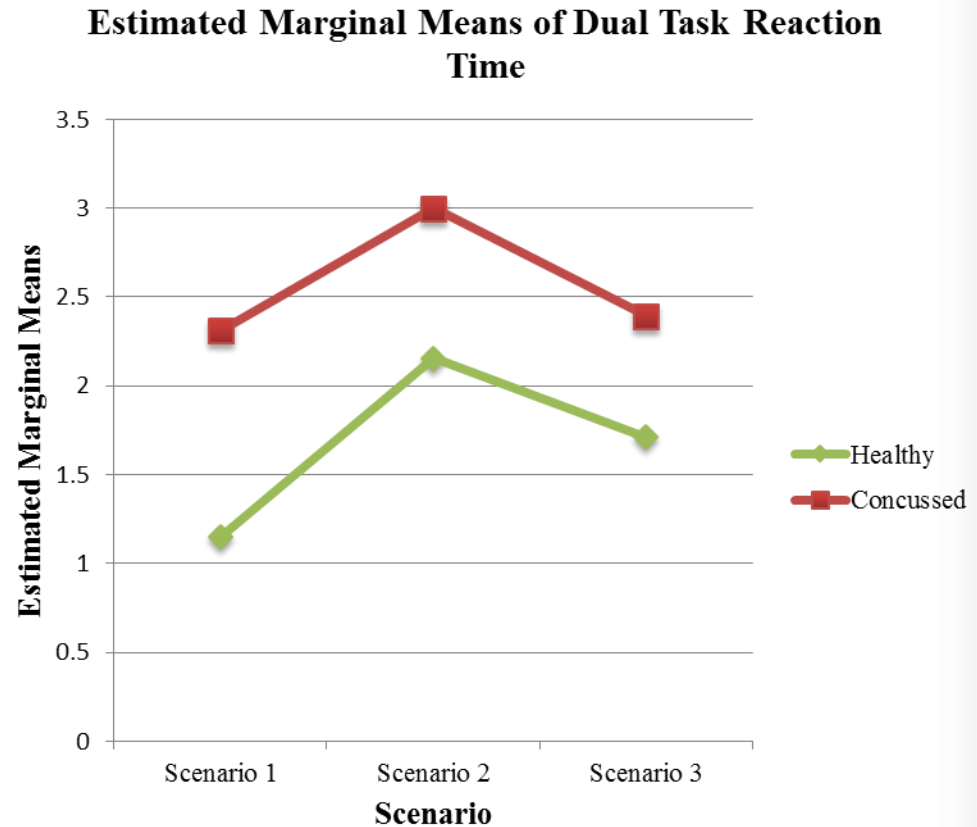
- Interaction effect: $F(3.043, 54.775) = 0.794$, $p = .504$, partial $\eta^2 = .042$
- Main effect of group: $F(1, 18) = 2.072$, $p < .0001$, partial $\eta^2 = .595$
- Main effect of scenario: $F(3.043, 54.775) = 4.082$, $p = .011$, partial $\eta^2 = .185$





Dual-Task Reaction Time

- Interaction effect: $F(2, 36) = 0.750$, $p = .479$, partial $\eta^2 = .040$
- Main effect of group: $F(1, 18) = 23.145$, $p < .0001$, partial $\eta^2 = .563$
- Main effect of scenario: $F(2, 36) = 9.321$, $p = .001$, partial $\eta^2 = .341$





Discussion

- Agrees with previous reaction time research (Fazio et al., 2007)
- Results do not provide details regarding hazard perception, identification, processing and responding
- Provides validation of simulator as a tool to determine the impact of concussion on driving performance



Limitations

- Sample size
- Participant related factors
 - Mood, attentiveness
 - Age and gender
 - Injury severity/timeframe



Thank You!



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Exclusion

Neurological: Seizures, epilepsy, MS, Parkinson's, dementias

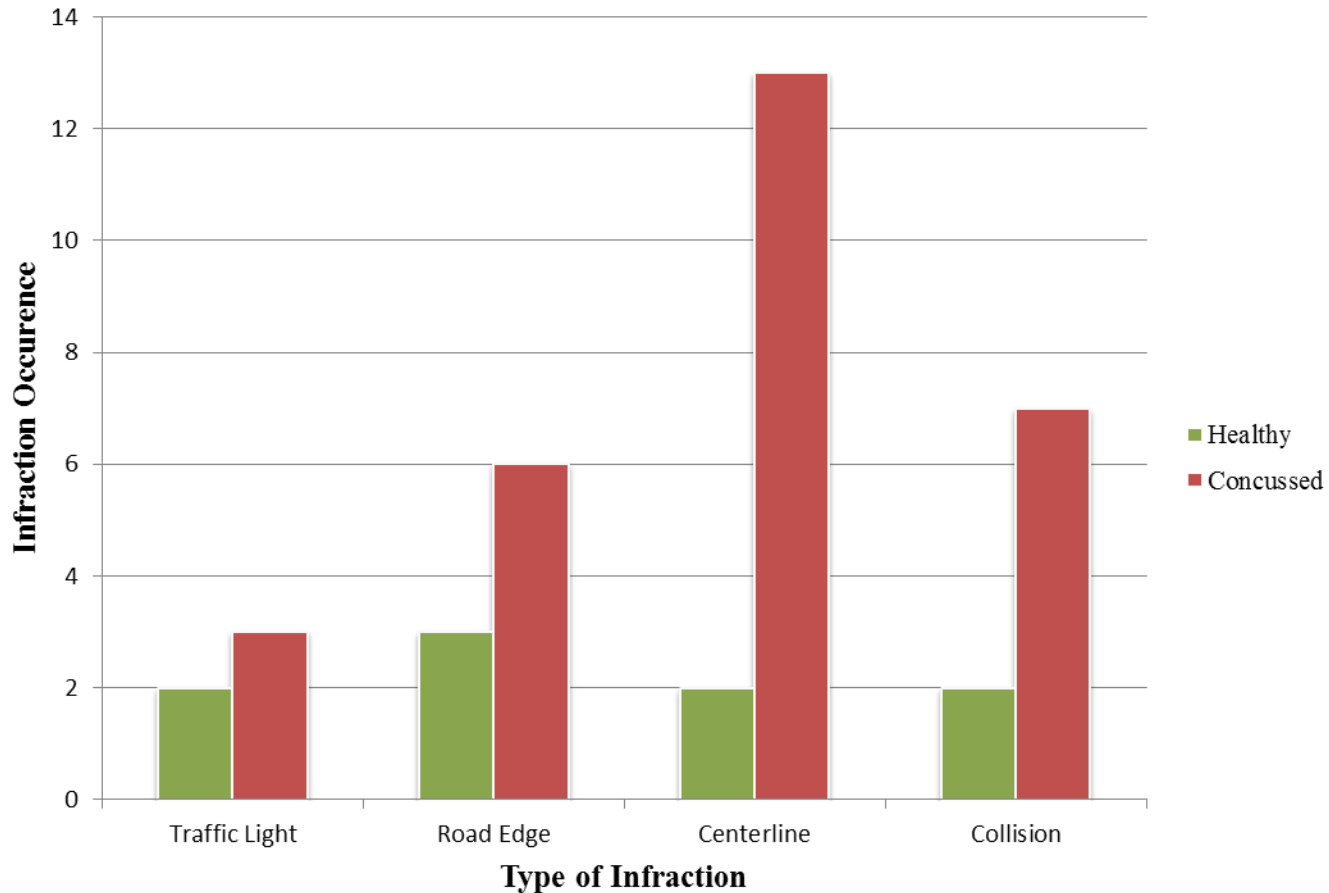
Cardiovascular: Previous MI, diabetic neuropathies, arrhythmias

Physical: Amputations, paralysis, muscular dystrophy or atrophies.



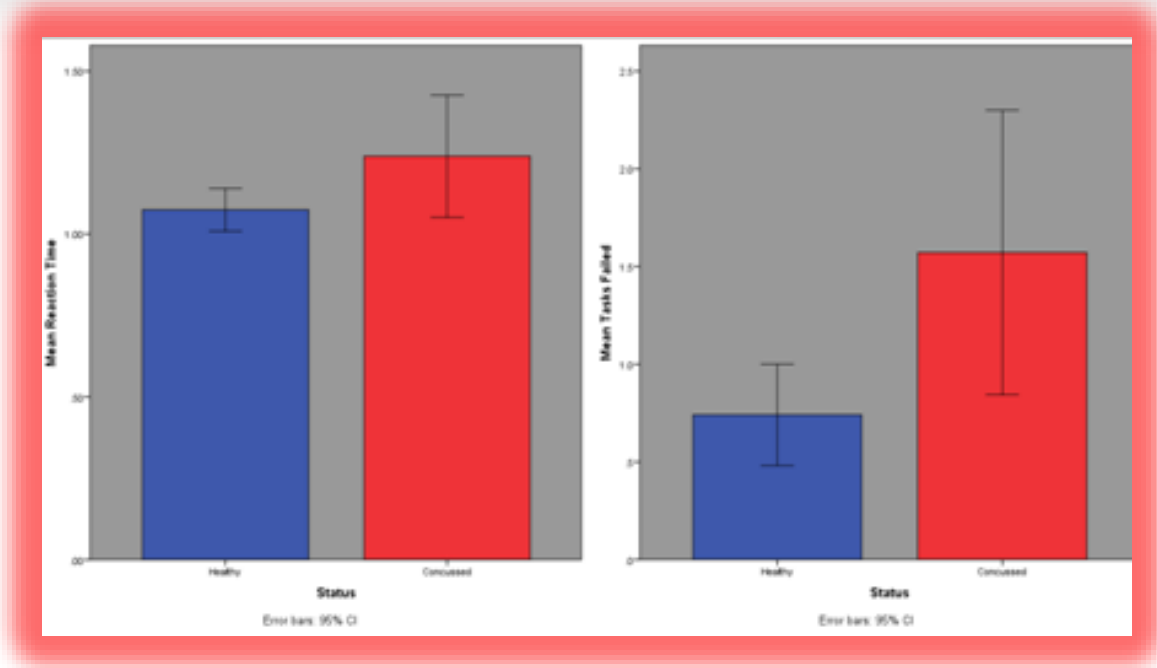
Additional Findings

Traffic Infractions





Directed Study



Statistically significant difference in **mean reaction times** between healthy and concussed participants, $t(7.578)=2.342$, $p=0.049$

Statistically significant difference in **mean dual task passes** between healthy and concussed participants, $t(8.914)=2.558$, $p=0.31$



Age Range

- Chosen based on reaction time.
- Age related decline minimized.



Reliability and Validity

- **STISIM 400** (Bedard, Parkkari, Weaver, Riendeau & Dahlquist, 2010)
 - Reproducibility of simulator assessment produced ICC of .73 to .87 ($p < 0.001$)

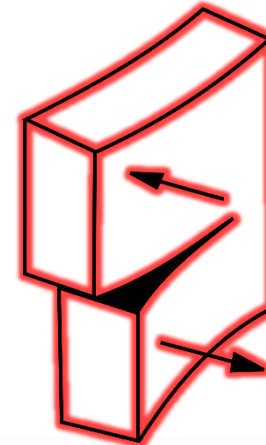


Mechanism of Injury

- ***Inertial loading.*** (Meaney & Smith, 2011)



- ***Shear deformation.*** (Adams et al., 1982; Gennarelli et al., 1982; Unterharnscheidt & Higgins, 1969)





Symptoms

Behavioural changes	Loss of consciousness***
Difficulty with balance/coordination	Amnesia
Delayed or slowed speech/responses	Slurred/unclear speech
Disorientation	Emotional instability
Vomiting	Inappropriate behaviour

***Occurs in less than 10 percent of people with concussion

(American Academy of Neurology, 2013)



Severe Symptoms

Changes in state of consciousness	Prolonged confusion
Seizures	Unilateral or bilateral muscle weakness
Walking/balance problems	Unusual eye movements
Repetitious vomiting	Anisocoria
Prolonged unconsciousness or coma	

(MedlinePlus, 2015)



Reaction Time

- **Important in safe driving.**

(Triggs & Harris, 1982)

- **Collision history.**

(Barrett, Kobayashi, & Fox, 1968; Djuric & Filipovic, 2009)

- **Obstacle avoidance.**

(Barrett et al., 1968; Pang, Yan, Ma, & Zhao, 2013)





Driving and Concussion

- **Studies on TBI subjects.**

(Lew et al., 2005)

- **Computer based hazard perception testing.**

(Preece et al., 2010)



- **Self reported fatigue and difficulty concentrating.**

(Bottari et al., 2012)

- **Self mediation of driving questionnaires.**

(Preece et al., 2013)





Research Questions

1. Was there an interaction effect between **group** and **scenario** on **reaction time** in driving simulation?
2. Was there an interaction effect between **group** and **scenario** on **dual task reaction times** in driving simulation?





Procedures

- STISIM Drive[®] Model 400.





Procedures

- STISIM Drive[®] Model 400.



(Yoo, An, Lee & Choi, 2013)



Procedures

- STISIM Drive[®] Model 400.



(Majid et al., 2013; Yoo, An, Lee & Choi, 2013)



Procedures





Procedures

- 6 reaction time events.





Procedures

- 3 dual task reaction time events.
- Dual task prompts occur above side-view mirrors.





Simulator Sickness

- Simulation could be paused.
- Food and water, if required.
- Data collection terminated.
- No incidence of simulator sickness.





Discussion

- **Agrees with previous reaction time research** (Fazio et al., 2007)
- **Hazard perception may be impaired** (Ponsford & Kinsella, 1992; Stuss et al., 1989a; Stuss et al., 1989b)
- **Reaction time within normal limits** (Johansson & Rumour, 1971; Makishita & Matsunaga, 2008)
- **Dual task reaction time increased** (Drews et al., 2009; Park et al., 2013)
- **Difficulty responding to on screen cues** (Felmingham et al., 2004; Ponsford & Kinsella, 1992; Spikman et al., 1996)
- **Impaired stimulus identification** (Strayer et al., 2003)