Tyler Stuck

Major in Electrical Engineering and Mathematics

Mentor: Dr. Yueqing Li

Research in Driving Safety

Department of Industrial Engineering

The Visual Behavior and Performance of Young Drivers in Construction Zones and Nighttime Driving

Introduction

Teens and young drivers are overrepresented in motor vehicle accidents (Mueller & Trick, 2012) (Robbins & Chapman, 2019) (Bao, Wu, & Sayer, 2020). From the years 1999 to 2019, the leading cause of death for people between the ages of 15 and 24 involved motor vehicle traffic (Centers for Disease Control and Prevention, 2020). Young drivers being killed in automotive accidents is not only a problem for the United States but for other countries as well. The World Health Organization has determined that the leading cause of death for children and young adults between the ages of 5 and 29 was from road traffic injuries (World Health Organization, 2021). Inexperience is the most accepted factor leading to these accidents (Konstantopoulos, Chapman, & Crundall, 2010) (Mueller & Trick, 2012) (Bao, Wu, & Sayer, 2020). The visual behavior of young drivers is negatively affected by inexperience and is considered to be a major factor contributing to accidents. Due to the frequency of traffic accidents involving young drivers, research focusing on the effect of inexperience on young drivers' visual behavior is necessary. In this study we will focus on the visual behavior of young and older drivers under different visibility and driving conditions to determine if there is an effect of inexperience on driver's visual behavior.

Literature Review

While their methodology differs, the objective and conclusions of (Anuj Kumar Pradhan, 2005) and (Hills, Thompson, & Pake, 2018) are similar. Both articles used potential risk

identification as a method of evaluating visual behavior patterns for drivers of different age groups. Pardhan and their co-authors employed the use of a driving simulator and eye tracking software to determine if there was a difference in visual scanning behavior between young drivers and other age groups. The youngest aged group, novice drivers, performed the worst of the three age groups with 35.1% of the group being able to identify potential driving risks, followed by 50.3% of the young driver group being able to identify potential risks, and finally 66.2% of the older driver age group was able to identify potential risks (Anuj Kumar Pradhan, 2005). Hills, Thompson, and Pake used carry over tasks and driving videos to identify any effect of driver experience of visual movement. The experienced driving group was able to identify risks within the driving videos more accurately than the other two experience groups (Hills, Thompson, & Pake, 2018). These two articles indicate that young, inexperienced drivers perform worse at visual behavior tasks and hazard identification than their older, experienced counterparts. Hazard identification is not the only measurement for one's visual behavior. Konstantopoulos sought to explore the visual behavior of drivers of two different experience groups by analyzing their visual attention under different weather conditions. The older age group had more visual fixations, shorter visual fixation durations, and broader horizontal search spreads when compared to the younger age group (Konstantopoulos, Chapman, & Crundall, 2010). These findings demonstrate that older drivers are more observant and have better visual better visual behavior than younger drivers.

Despite the similar results of the previously mentioned articles, an overall conclusion regarding the visual behavior of young drivers has not been reached. Two of the articles that provide conflicting results are (Scott-Parker, Regt, Jones, & Caldwell, 2020) and (Robbins & Chapman, 2019). Scott-Parker and their co-authors tasked participants of different age groups to provide verbal commentary on driving videos. This commentary provided insight into what the participants were focused on and allowed the researchers to analyze the participant's situational awareness. The frequency of the spoken words shared amongst the three age groups were similar (Scott-Parker, Regt, Jones, & Caldwell, 2020). This similarity of shared word frequency suggests that the situational awareness and visual behavior between the young, middle-aged, and older driver age groups were similar. Robbins and Chapman conducted an analysis of previous young driver visual behavior literature. Driving experience did not have a significant effect on the visual fixation durations, vertical search spread, or the number of fixations (Robbins & Chapman, 2019).

This observation suggests that the visual behavior between young and older drivers may not be different.

Methodology

Participants

The participants for this study fall into one of two age groups. Young drivers 18 years of age and older drivers 22 years of age and up. There were four participants in total for this study, two young drivers and two older drivers. Participants were required to have normal or corrected vision as to not negatively impact the results found from visual analysis. In addition to having corrected vision, participants were required to have a valid driver's license.

Apparatus

The driving simulator used in this study was the STISM Drive TM driving simulator (32100). The simulation was displayed on three monitors. To replicate the cab of a vehicle, we used floor mounted pedals and the Logitech G27 steering wheel. To capture the visual data from the participants, the Tobii Pro Glasses 2 was used.

Independent Variables

The independent variables are two visibility conditions, two driving conditions, and two age groups. Participants drove under nighttime and daytime visibility conditions. For the two driving conditions, the participants drove under free driving conditions and construction zone conditions.

Dependent Variables

To analyze the visual behavior, we collected the number of visual fixations and fixation duration. The number of visual fixations defines the number of times a participant focused or fixated on something on the screen while driving. A visual fixation occurred whenever the participant's gaze-point remained stable for at least 100ms. The average fixation duration was the average amount of time the participant's focused remained on the area of interest after becoming a fixation. The gaze map shows the transition between the subject's fixations. The heatmap shows a general concentration of where the participant is looking.

Design

There will be four driving scenarios. Participants drove in daytime free driving conditions, daytime construction zone driving conditions, nighttime free driving conditions, and nighttime construction zone driving conditions. The participants drove 4.5 miles for each scenario. There was a 0.5-mile warmup section. In this warmup section, the drivers were exposed to the current visibility condition for the scenario prior to the driving condition. After finishing the warmup section, the participants entered the driving condition section which lasted for 4 miles.

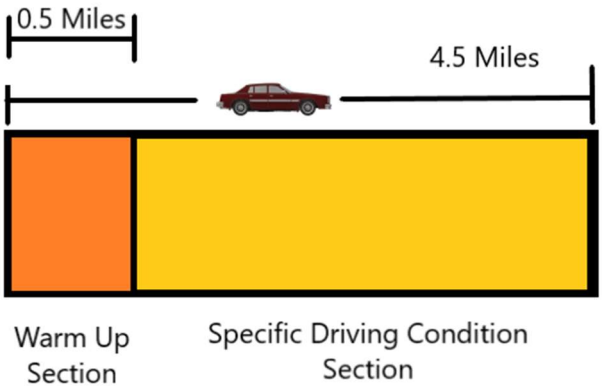

Figure 1: Experiment Design Diagram

Figure 2: Daytime Free Driving Conditions

Figure 3: Daytime Construction Zone Driving Conditions

Figure 4: Nighttime Free Driving Conditions

Figure 5: Nighttime Construction Zone Driving Conditions

Results

The visual behavior from each of the scenarios was recorded and analyzed. In all four driving scenarios, the older driver age group had more fixations and shorter fixation durations. The gaze and heat maps for each scenario were also recorded. The nighttime free driving and nighttime construction zone driving maps were chosen as they demonstrate a drastic difference between the visual behavior of young and older participants.

Participant Age Group and Number	Number of Fixations
Young Driver 1	378
Young Driver 2	170
Older Driver 1	590
Older Driver 2	753

Figure #6a: Number of Fixations for Daytime Free Driving Conditions

Participant Age Group and Number	Average Fixation Duration (ms)
Young Driver 1	574
Young Driver 2	1471
Older Driver 1	325
Older Driver 2	209

Figure #6b: Average Fixation Durations for Daytime Free Driving Conditions

Participant Age Group and Number	Number of Fixations
Young Driver 1	601
Young Driver 2	440
Older Driver 1	846
Older Driver 2	1129

Figure #7a: Number of Fixations for the Daytime Construction Zone Condition

Participant Age Group and Number	Average Fixation Duration (ms)
Young Driver 1	567
Young Driver 2	876
Older Driver 1	380
Older Driver 2	185

Figure #7b: Average Fixation Durations for the Daytime Construction Zone Driving Conditions

Participant Age Group and Number	Number of Fixations
Young Driver 1	438
Young Driver 2	463
Older Driver 1	674
Older Driver 2	672

Figure #8a: Number of Fixations for Nighttime Free Driving Conditions

Participant Age Group and Number	Number of Fixations
Young Driver 1	574
Young Driver 2	484
Older Driver 1	243
Older Driver 2	134

Figure #8b: Average Fixation Durations for Nighttime Free Driving Conditions

Participant Age Group and Number	Number of Fixations
Young Driver 1	643
Young Driver 2	611
Older Driver 1	1118
Older Driver 2	1148

Figure #9a: Number of Fixations for Nighttime Construction Zone Driving Conditions

Participant Age Group and Number	Average Fixation Duration (ms)
Young Driver 1	574
Young Driver 2	484
Older Driver 1	243
Older Driver 2	134

Figure #9b: Average Fixation Durations for Nighttime Construction Zone Driving Conditions

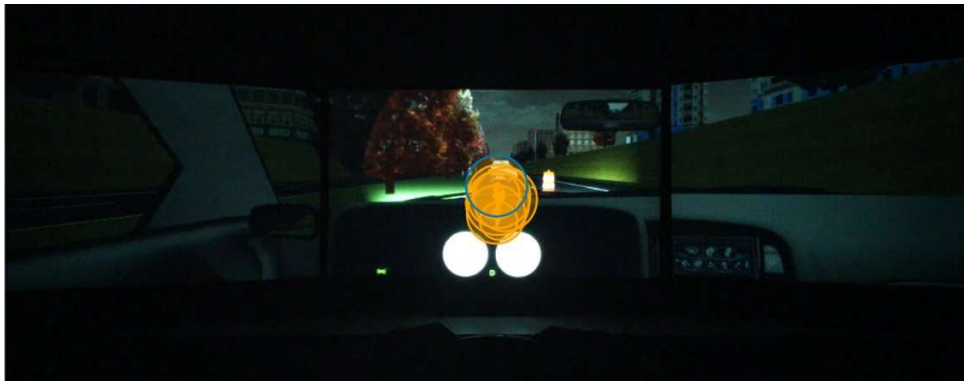

Figure #10: Young Driver 2 Gaze map for Nighttime Construction Zone Driving Conditions

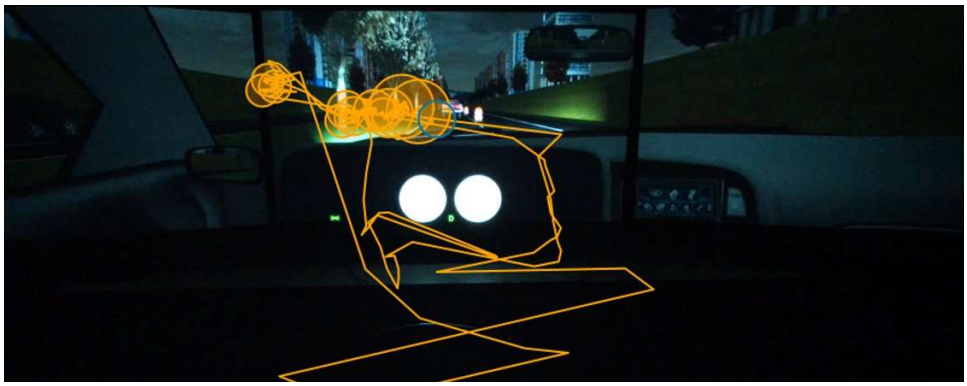

Figure #11: Older Driver 2 Gaze Map for Nighttime Construction Zone Driving Conditions

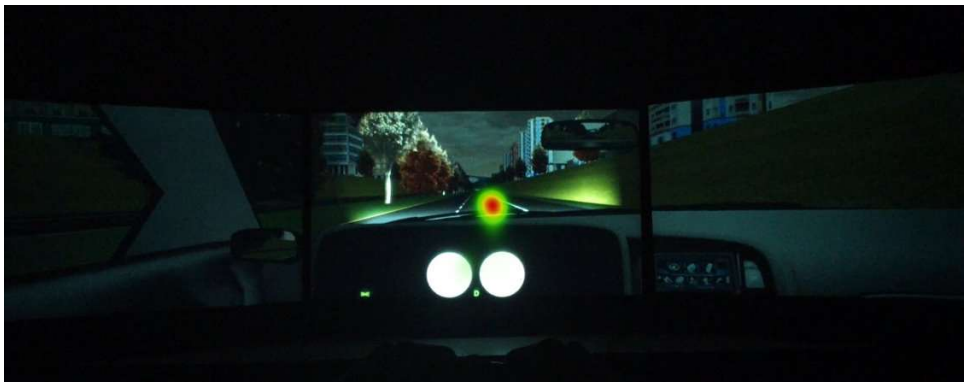

Figure #12: Young Driver 2 Heat Map for Nighttime Free Driving Conditions

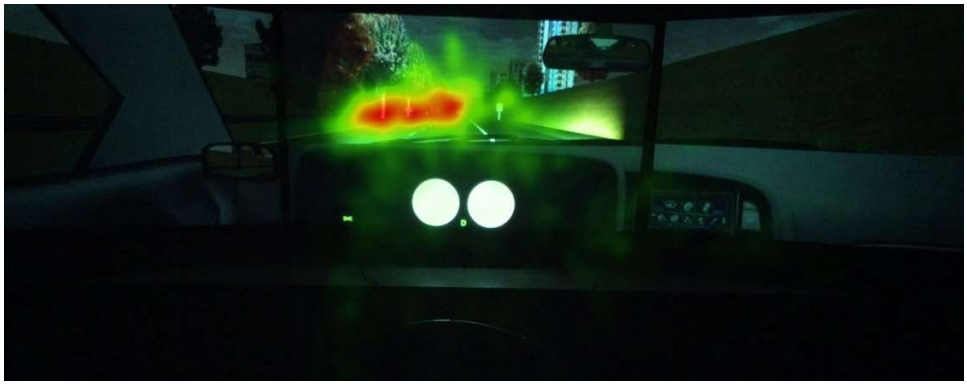

Figure #13: Older Driver 2 Heat Map for Nighttime Free Driving Conditions

Conclusions

The number of visual fixations the older age group had was greater than the younger age group for every driving scenario. The average visual fixation duration for the older age group was also less than the younger age group for every driving scenario. These results indicate that the older age group had better visual behavior than the younger age group. The gaze and heat maps also support this observation. The young driver participant did not have a safe search pattern and only focused on the leading vehicle. In contrast, the older driver fixated on both the leading vehicle and oncoming traffic. While this study demonstrates that older drivers have better visual behavior than younger drivers, further research with a larger sample size of participants is necessary to determine if there is a significant effect of inexperience on visual behavior.

Acknowledgements

I would like to thank the Office of Undergraduate Research at Lamar University for the opportunity to conduct research and present my findings at Expo 2022. I would also like to thank my mentor Dr. Yueqing Li and the driving behavior research team for their help and guidance on this study. This experience was very intriguing and has convinced me to continue to conduct research.

Bibliography

Anuj Kumar Pradhan, K. R. (2005). Using Eye Movements To Evaluate Effects of Driver Age on Risk Perception in a Driving Simulator. *Human Factors:*, 840-852.

Bao, S., Wu, L., & Sayer, J. R. (2020). An examination of teen drivers' car-following behavior under naturalistic driving conditions: With and without an advanced driving assistance system. *Accident Analysis and Prevention*, 1-7.

Centers for Disease Control and Prevention. (2020, February 20). *1999-2019, United States Unintentional Injuries Ages 15-24*. Centers for Disease Control and Prevention. Retrieved January 5, 2022, from https://wisqars.cdc.gov/fatal-leading

Article is found by submitting a request with the year parameters 1999 to 2019, then selecting the 15-24 age group.

Hills, P. J., Thompson, C., & Pake, J. M. (2018). Detrimental effects of carryover of eye movement behaviour on hazard perception accuracy: Effects of driver experience, difficulty of task, and hazardousness of road. *Transportation Research Part F*, 906-916.

Konstantopoulos, P., Chapman, P., & Crundall, D. (2010). Driver's visual attention as a function of driving experience and visibility. Using a driving simulator to explore drivers' eye movements in day, night, and rain driving. *Accident Analysis and Prevention*, 827-834.

Mueller, A. S., & Trick, L. M. (2012). Driving in fog: The effects of driving experience and visibility on speed compensation and hazard avoidance. *Accident Analysis and Prevention*, 472-479.

Robbins, C., & Chapman, P. (2019). How does drivers' visual search change as a function of experience? A systematic review and meta-analysis. *Accident Analysis and Prevention*.

Scott-Parker, B., Regt, T. D., Jones, C., & Caldwell, J. (2020). The situation awareness of young drivers, middle-aged drivers, and older drivers: Same but different? *Case Studies on Transport Policy*, 206-214.

World Health Organization. (2021, June 21). Road traffic injuries. Retrieved from https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries