Vol. 5: 41-50

THE UNIVERSITY OF CENTRAL FLORIDA
UNDERGRADUATE RESEARCH JOURNAL

Published
October 26, 2011

How Perceptual and Cognitive Factors are Involved in a Car Accident: A Case Study

By: Vanessa Dominguez & Marc Gentzler
Faculty Mentor: Dr. Andrew P. Daire

ABSTRACT: Several factors are considered in car accident analysis. Human factors research has shown that different perceptual and cognitive factors influence driving performance, leading to improvements in vehicle and road design. This case study provides a deeper understanding of the potential influence of major perceptual and cognitive variables on driving performance in general, including (a) driver expectancy effects, (b) glare, (c) general visibility such as lighting, (d) driver's dark adaptation, (e) road illusions, and (f) driver perception-reaction time. This analysis describes in detail how these certain perceptual and cognitive factors may have been involved in a particular car accident. Future research suggestions to improve driver safety and traffic regulations are provided.

KEYWORDS: car accident analysis, perception, expectancy effects, glare, general visibility, dark adaptation, road illusions, perception-reaction time

5: 41-50

INTRODUCTION

The United States Department of Transportation indicated that in 2009, more than 33,000 people died in motor vehicle crashes (National Highway Traffic Safety Administration, 2010). The Centers for Disease Control and Prevention (CDC, 2010) identified traffic collisions as one of the leading causes of death in the United States. Approximately 5 million people annually sustain injuries that require an emergency department visit. With all these costs in mind, it is important for professionals, researchers, and engineers working on improving driver safety and motor vehicles to understand what causes car accidents. Furthermore, it is essential for these researchers and practitioners to consider many factors involved in car accidents as possible, including different perceptual and cognitive factors.

Driving is one of the most complex tasks humans perform on a regular basis (Hole, 2007). Driving places significant demands on human perceptual, cognitive, and motor capabilities. Therefore research conducted in human factors is needed on these capabilities while driving. The National Highway Traffic Safety Administration (NHTSA, 2011) defines Human Factors Engineering in general as the "application of knowledge about human abilities, limitations, and other human characteristics to the design of equipment, tasks, and jobs". The role of human factors research is important for understanding human performance and disseminating and applying this knowledge to when humans interact with any system, such as with vehicles. Vehicle safety research recognizes that driver performance is affected by several situational factors such as environment, psychology, and vehicle design. Car accident analysis involves reconstructing several factors that influenced the accident. The Handbook of Human Factors in Litigation (2004) describes perceptual and cognitive factors including driver expectancy (pg. 335), glare (pg. 327), reaction time (pg. 363), visibility (pg. 342), and illusions (pg. 451) that are used to reconstruct car accidents. The following case study analysis explains the possible contribution of different perceptual and cognitive factors involved in a particular car accident: (a) driver expectancy effects, (b) glare, (c) general visibility, (d) driver's dark adaptation, (e) road illusions, and (f) driver perception-reaction time. Each factor is individually discussed, highlighting its effects on driver performance in general and its possible impact on the accident. Although alcohol, which clearly can affect all aspects of nervous system functioning, played a role in this particular accident, the combined perceptual and cognitive factors mentioned above may be influential enough to cause the accident independent of alcohol influence.

DESCRIPTION OF ACCIDENT

The following accident description is adapted from Gentzler (2010). Overnight the driver of Vehicle A hit Vehicle B head-on on a rural road. The driver of Vehicle A survived with no major injuries, whereas the driver of Vehicle B died instantly after impact. The driver of Vehicle A was intoxicated at the time of the accident (BAC taken almost an hour after the accident was .167). When the accident occurred, weather and road conditions were unfavorable. Fog, drizzle, and light rain were in the area. The windshield wipers of Vehicle A were on but in the slowest setting. The road was damp and the road markings and pavement were well worn. The rural road had no street lights.

Vehicle A was on the road's north side traveling west. Vehicle B was on the road's north side on the unpaved shoulder approximately a foot away from the road facing east. The driver of Vehicle B was on the wrong side of the road to deliver newspapers from the driver's side. This was easier than trying to reach over to the passenger side to deliver the newspapers. The driver's side on all US cars is on the left except on postal and certain other delivery trucks. According to the driver of Vehicle A, it appeared Vehicle B was in his lane driving towards him. Meanwhile, another car was traveling in the south lane going correctly towards the east. According to the deposition for the driver of Vehicle A, he was initially going to avoid Vehicle B by moving into the south lane. When the driver of Vehicle A perceived an oncoming car (Vehicle C) heading east in the south lane, he realized that option was unavailable. The headlights of Vehicle B were on at some point as the driver of Vehicle A clearly could see Vehicle B's headlights in a distance. During examination, however, the headlights of Vehicle B were in the off position suggesting they were off at least at the time of impact. After the accident, a witness stated the driver of Vehicle A seemed confused as to whether he or Vehicle B was in the wrong lane.

The accident reconstructionist determined Vehicle B was stationary at the time of impact. The driver of Vehicle A stated he was going approximately 60 miles per hour (the speed limit on this road is 55 mph). Due to the road's topography, it was estimated the earliest the driver of Vehicle A could have seen Vehicle B was 689 feet away. The driver of Vehicle A skidded off the road about 75 feet away from the point of collision. There were no skid marks due to the damp road, but tire tracks were found in the grass depicting the Vehicle A's track leading off the side of the road.

PERCEPTUAL AND COGNITIVE FACTORS POSSIBLY INVOLVED IN THE ACCIDENT

It is very easy to conclude that this accident was the result of driver intoxication; however, human factors researchers must investigate other possible factors that could have caused this accident even if the driver of Vehicle A had been completely sober. For one, Vehicle B was not in the place it should have been, which violates a driver's expectancies.

EXPECTANCY EFFECTS ON PERCEPTION

Olson and Farber (2003) define expectancy as the predisposition of people to believe that things will happen or be arranged in a certain way. Experiences resulting in particular outcomes in life that remain constant (e.g., flipping a switch to turn on a light) cause a person to develop an expectation that every other similar experience will end similarly. Once formed, this convention creates difficulty for a person to break the habit or not have the expectation. Adding to this challenge, modern design usually follows what intuitively makes sense. These expectations arise in driving as well. Drivers develop expectations for their cars, other drivers, road signs, traffic signals, etc. However, there are positive and negative aspects to developing driver expectations. Some positives include highways and road design. For instance, to improve driver information processing speed, highways and the presentation of information are simplified and consistent. Negatives include decreased attention to environmental stimuli, such as road signs and traffic changes. Research indicates that expertise develops through increasing content-specific learning (Groeger & Chapman, 1996). Therefore, an important aspect of driving accuracy relies on the experiences to remain very similar. Drivers follow schemata that underlie anticipatory behavior while driving; such as following the brake lights on the back of cars signaling to slow down and stop. Improving the conditions for drivers, such as with braking, enhances their ability to react to unexpected situations, which reduces car accidents. Also, minimizing traffic makes the driving task easier. For instance, we are not expecting a stopped car in the middle of the road due to traffic. Violating these expectations decreases the driver's ability to detect hazardous situations.

According to Olson and Farber (2003), "the effective movement of traffic relies to a great extent, on an assumption that other roadway users will behave rationally" (p. 20). Expectations might have influenced the car accident previously described. The driver of Vehicle A followed the schemata of driving. According to conventions established in the US, cars travel on the right side of the road. His expectations were not met when he perceived Vehicle B's lights facing eastward, towards him, on the same side of the road. Although Vehicle B was really on the road's shoulder, from a distance Vehicle B looked like it was on the wrong side of the road. It appears that this very unusual situation made the driver of Vehicle A question whether he or Vehicle B was in the wrong lane, with neither situation meeting his expectations. If Vehicle B were on the actual road, one would expect it to be moving. It was impossible to tell whether Vehicle B was stationary or moving until closer up. Perception of distance involves image size. When a driver is able to perceive an oncoming object's size change it usually leads to a cue that distance also changes. Similar to distance perception, drivers determine speed based on image size (West, C. G., Gildengorin, G., Haegerstrom-Portnoy, G., Lott, L. A., Schneck, M. E., & Brabyn, J. A., 2003). The rate at which the space between the driver's car and an oncoming car closes or opens up allows the driver to determine the speed of an oncoming car. Although the judgment of speed and distance use similar cues, speed perception tends to be less reliable and thus prone to errors of estimation (Olson & Farber, 2003). These violations of expectancies must have created substantial confusion. Moreover, the expectancies of what the driver of Vehicle B would do next were also in question. The driver of Vehicle A may have never been entirely sure whether he or Vehicle B was in the wrong lane. The entire situation violated the driver of Vehicle A's expectations and experience, which lowered his reaction time (reaction time will be discussed later).

GLARE

A second factor that may have contributed to this accident is glare. Glare is created when a light source or surface is much brighter than the rest of the visual field. Disability glare results when a small angle exists between the glare source (i.e. sunlight or artificial light) and a target of concern resulting in reduced capability to see the target. Psychological or discomfort glare is produced by the sensation of discomfort (Olson & Farber, 2003).

The effects of glare will increase when the light source increases, the background light decreases, and the angle between the line of sight and the direction of the light source decreases (Alferdinck, 1996; Alferdinck & Varkevisser, 1991). A direct relationship exists between the amount of glare and contrast detection performance. With increasing glare, the driver has reduced ability to perceive small contrasts (Theeuwes, J., Alferdinck, J. W. A. M., & Perel, M., 2002). Drivers experience disability glare from oncoming driver's headlights.

A small glare angle from an oncoming headlight indicates a large distance between the vehicles. As the distance closes, the angle between the glare source and the target (i.e., roadway) increases causing the eyes to move into zones where lower levels of light are used (Olson & Farber, 2003). According to Olson and Farber, when vehicles are separated by 100 to 200 feet on a two-lane road, "the maximum loss of forward visibility for low-contrast targets to the right of the vehicle is about 20%" (p. 57). Recovery from the glare can start once the vehicles are less than 100 to 200 feet apart. However, as Olson and Farber (2003) point out, the glare effect is amplified when there are multiple oncoming vehicles, as was the case in this particular accident.

As for discomfort glare, the relationship proves less direct. Discomfort glare is due to the adaptive function of the eye, the luminance at the eye from the glare sources, and the angular relationship between the glare sources and the target. This creates more subjectivity in the measurement of discomfort glare. Theeuwes, Alferdinck, and Perel (2002) researched the effects of discomfort glare on driving behavior. Their results indicated that even relatively low glare sources caused a significant drop in detecting simulated pedestrians along the roadside, causing participants to drive significantly slower on dark and winding roads.

Discomfort glare depends on task difficulty. In other words, discomfort glare is judged more uncomfortable on a road with a more difficult task than on one with an easier task. This relationship suggests that discomfort glare affects driving behavior.

Glare likely contributed to the described car accident by causing the driver of Vehicle A to experience both disability and discomfort glare. There were three main sources of glare during the incident: from the headlights of Vehicle B that were on the side of the road (right side of Vehicle A), from Vehicle C's headlights in the south lane (left side of the driver of Vehicle A), and that of Vehicle A's own headlights. The combined sources of glare likely had significant damaging effects on driver performance. The driver of Vehicle A had greater difficulty distinguishing the oncoming vehicles especially given there were more than one source of glare.

In most standard cars, low-beam headlights point slightly down and to the right (Olson & Farber, 2003). This is to reduce glare for oncoming cars, pointing the light beam slightly away from the driver. With Vehicle B placed on the side of the road facing toward the driver of Vehicle A on his right side, the lights were pointing directly toward him. The human factors development of headlights pointing to the right actually caused more glare in this situation. Further, the weight of the newspapers found in the back of Vehicle B likely tilted the car slightly upward, pointing the light more directly toward his eyes. As the driver of Vehicle A approached Vehicle C in the correct lane going in the opposite direction, the angle between the glare of Vehicle C's headlights and of Vehicle A began to increase, possibly decreasing the effects of glare. However, it is unknown as to when Vehicle C passed Vehicle A, or when the headlights of Vehicle B were turned off. The headlights of Vehicle A shining on the road and on other objects possibly caused some glare as well. The glare may have been amplified by the wet roads, turning the road into a more reflective surface. This could have also made the glare worse originating from Vehicle B and C. When the driver of Vehicle A was approximately 100 to 200 feet away from Vehicle B, even if he had recovered from the glare, the adjustment would have occurred too late to react successfully.

GENERAL VISIBILITY

The human eye functions best at high levels of illumination. This is due to visual receptors called cones, which are densely packed in the fovea of the retina that control vision in brighter light. Since cones allow for better determination of fine details and color, they provide higher levels of visual acuity in the fovea. Night driving uses mostly the peripheral vision (outside of the fovea), however there is still some light hitting the eye making the cones still somewhat operative. The peripheral area is mostly filled with rod receptors that are more sensitive to light than cones, but have very poor ability to perceive detail. Thus humans have lower visual acuity at night. Environmental factors such as driving at night and rain degrades the visual acuity of cones, increasing the risk of a crash. Konstantopoulos, Chapman, and Crundall (2010) explained that both of these factors may be related to drivers' visual search strategies that become more efficient with increased experience.

Clarke and team (2006) showed that time of day influenced both the severity and rate of crashes. Furthermore, it has been found that the fatal crash risk is increased up to four times when driving at night compared to daytime (Williams, 2003). Visual problems associated with low light conditions leading to an increase in reaction times contribute to the higher number of nighttime car crashes (Plainis & Murray, 2002). Leibowitz and Owens (1977) found that although night driving conditions produced little effect on peripheral vision, it contributed to focal vision impairment, resulting in the neglect of low luminance objects while driving at night.

Factors contributing to the lack of general visibility in the described accident included night driving, poor weather conditions such as fog and rain, worn road markings, glare from wet roads, and an absence of roadside lighting. Being able to judge depth perception, distance, and speed all prove important for safe driving (Baumberger et. al, 2005; Chan et. al, 2010; Nawrot et. al, 2004). Depth cues, which are important in determining where objects are in space and their speed are largely absent at night. A lack of street lighting did not help the situation. Fog and rain clearly reduce visibility, particularly with headlights shining on the precipitation. Glare as mentioned in the previous section reduces visibility by scattering light in the eyeball, making it less focused. It is difficult to see worn and wet road markings at night. This can make someone question which lane they are in and where the boarders of the road are, especially in confusing situations. These factors influenced the decisions the driver of Vehicle A had to make. Furthermore, his low-beam headlights reach approximately 150 to 200 feet away from his viewpoint, thus limiting visibility beyond that point. Going almost 100 feet a second, a stationary obstacle on the road that a driver perceives 200 feet away would be unavoidable.

DARK ADAPTATION

Another contributor to this accident may have been dark adaptation. Its implications for research led to further understanding of our visual system and the improvement of nighttime driving and vision by providing more and improved roadside lighting. The process of dark adaptation causes the eye to increase its sensitivity in the dark. The earliest research conducted on dark adaptation identified two aspects to this night vision process. Hecht, Haig, and Chase, (1937) found that the first portion of dark adaptation begins at once. This half is rapid and due to our cone function. The second portion, due to rod function, occurs much slower. Cone adaptation completes in 3 to 4 minutes, whereas rod adaptation takes at least 30 minutes. Their research indicated that the course of human eye dark adaptation depended on the intensity of light used before adaptation occurs. The adaptation time varied depending on the light level preceding the process. For example, their research showed that rod adaptation only occurs after exposure to light intensities below 200 photons. However, exposure to light intensities of 4000 photons or more caused cone adaptation first, followed by rod adaptation. Rod dark adaptation appeared in two types- a rapid and a delayed. The rapid rod dark adaptation became evident after pre-adaptations to low intensities corresponding to those usually associated with rod function (Goldstein, 2010). In the accident previously described, dark adaptation occurred in two phases- cone adaptation first, then rod adaptation.

In a 2004 study, Lamb and Pugh examined the effects of dark adaptation on the retinoid visual cycle. They found that adaptational ability breaks down in one situation. When exposed to intense or prolonged light, a bleaching occurred to a great portion of the visual pigment in photoreceptors of the human eye. This was activated by light in its colorless form. After exposure, it took several minutes before full visual sensitivity returned to normal. Their results showed that the most intense exposure, which produced an almost total bleach of pigment, had an initial increase five times the normal magnitude that occurred in participants' visual threshold. Their eyes then proceeded to recover in the normal two-part form. The first part of recovery occurred rapidly due to cone functioning and, after about 11 minutes, the rods began to recover. After a total of 40 minutes, participants' eyes were fully dark-adapted. With vitamin A deficiency, this process happened even slower.

The effect of dark adaptation on nighttime automobile accidents proves to be an important research area. An example would be nocturnal myopia, also known as night myopia or twilight myopia. Individuals with this condition possess a greater difficulty seeing in low illumination areas, even though his or her daytime vision is normal. This results from the eye's far point for an individual's focus varying with the level of light. Research indicated that night myopia was caused by pupils dilating, allowing in more light causing a person to become more nearsighted. Usually, those with myopic vision require a stronger prescription for night driving. Additionally, night myopia, usually found in younger people than older people (Chen, Schmid, & Brown B, 2003; Cohen, et al. 2007), contribute to more nighttime accidents; implying that selected groups of drivers should be examined for night myopia.

Dark adaptation potentially had a major influence on the car accident described. Driving for about ten minutes started the dark adaptation process. Coming from a bright room, the driver of Vehicle A's sensitivity to light would have been still quite low compared to if he were completely dark adapted, but significantly more sensitive than when he started his drive. As mentioned in the section on glare, the driver of Vehicle A suddenly had two sources of headlights pointing toward him, one set on each side of him, creating a large amount of light hitting his eyes. This illumination from both cars' headlights almost completely reset the dark adaptation process. The driver of Vehicle A's exposure to intense lighting of the oncoming headlights, after driving in the dark for some time, caused the photoreceptors in his retina to become bleached. Even though cone adaptation occurs rapidly after light exposure, the rods would have taken several minutes before they could have recovered. Essentially the driver of Vehicle A became blind once Vehicle C passed and the driver of Vehicle B turned off her lights, given his eyes' sensitivity level was very low leaving the driver of Vehicle A with only his headlights for illumination. It was as if he stepped into a bright room again but then turned off the lights. The driver of Vehicle B probably saw Vehicle A coming toward her and turned off her lights so she would not blind him. However, this actually caused a worse problem. There was not enough time for the driver of Vehicle A to adapt again to the lower level of light.

ROAD ILLUSIONS

Road illusions such as linear perspective and corridor illusion greatly impact the decision making of a driver at high speeds (Hamer, 1994; Svenson, 2009). Linear perspective, also known as perspective convergence, occurs when parallel lines extend out from an observer and appear to merge together as distance increases (Goldstein, 2010). Linear perspective is a monocular pictorial depth cue, because a person only needs one eye to perceive depth. Road illusions could have influenced the outcome of the described car accident because linear perspective impacted the driver of Vehicle A's ability to tell whether Vehicle B was actually in the lane or off to the side. The lack of streetlights at night made it difficult to determine whether Vehicle B was in Vehicle A's lane or on the side of the road. This is due to the tendency of objects that are further away from the viewer to merge as the width of the road in the distance decreases. Other than the size of Vehicle B's headlights, depth cues were absent due to the lack of lighting. The driver of Vehicle A could only rely on linear perspective as a monocular depth cue to determine its location on or off the road, which can be misleading. Even if just based on the size of Vehicle B's headlights, the driver of Vehicle A could have determined Vehicle B's distance. However, the driver of Vehicle A's ability to determine Vehicle B's exact location was hindered by the optical road illusion, where objects merge together at a far distance. The appearance of Vehicle B driving on the wrong side of the road was a costly misrepresentation of reality.

PERCEPTION - REACTION TIME

There are different relationships between perception-reaction (P-R) time and the occurrence of car accidents. Chang et al. (2008) researching traffic accidents occurring at intersections found a positive correlation between average speed and P-R time. The positive correlation indicated that as average speed increases, the driver's P-R time increases. A negative correlation depicted an inverse relationship between P-R time and speed reduction in this study. As P-R time decreased, the amount of speed reduction increased. Their results also indicated that when a driver had reduced P-R time, the driver had enough time to apply the brakes, and thereby reduce driving speed. Car crashes can often be attributed to driver performance; when P-R time increases by 1 second, the possibility of a car crash increases by four times. In addition, a decrease in driving speed reduces the odds ratio of a crash.

These odds likely determined the outcome described in the accident. Several considerations were involved in the driver of Vehicle A's decision-making process. Going 90 feet per second, the driver at most would have had about 7.5 seconds before collision, which means he had to perceive, decide, and react in that time fast enough to avoid the collision. First, the driver of Vehicle A needed time to perceive what was happening. A clear violation of expectancies, that is, perceiving Vehicle B on the wrong side of the road, significantly reduced P-R time. It is a confusing situation not normally encountered, thus the driver needed time to understand what was really happening. As mentioned earlier, he questioned whether he was in the wrong lane. Secondly, the driver of Vehicle A needed time to decide what to do in response to this strange situation. He needed time to decide how to evade Vehicle B to prevent an accident, regardless of whether he or Vehicle B was in the wrong lane. His first plan was to move to the left lane, however this plan was foiled when he realized Vehicle C was coming in that left lane. This change of plans delayed response time significantly. Lastly, the driver of Vehicle A needed time to react. However, by the time the driver decided what to do, there was probably not enough time to take action. It is very likely that he never really understood what was happening, which delayed his decision and reaction. Making the situation even more confusing was Vehicle B's headlights being turned off at some point; further increasing P-R time. The compounding effects of these decisions the driver of Vehicle A had to make in a short amount of time contributed to his decrease in reaction time.

CONCLUSION

In the United States, car accident related deaths and injuries contribute thousands of dollars each year. Approximately half of all Americans have been affected by a serious motor vehicle accident, including 23% who were involved in a motor vehicle accident in which someone went to the hospital, 39% who had a friend or relative seriously injured or killed, and 49% who were involved in a serious accident where a friend or relative was seriously injured and/or killed (AAA Foundation for Traffic Safety, 2010). Seventy-four percent of Americans agree that they would benefit if the government were to give more attention to traffic safety issues (AAA Foundation for Traffic Safety, 2010). Research and development on road safety is essential for creating improved driver safety regulations. It is necessary for key organizations such as the government and legislative bodies, researchers, police, car-makers, media, etc. involved in policy development to research the causes and effects of car accidents to improve driver safety and reduce the number of car-related accidents; especially the different perceptual and cognitive factors that influence car accidents.

This particular accident was possibly due to several perceptual and cognitive factors involved independent of the influence of alcohol. It is not clear how much of a role any of these perceptual and cognitive factors discussed played in the accident, nevertheless it is clear that they all need to be considered as possible contributors to the accident. Human factors analysis of this crash could provide enough reasonable doubt about whether the driver of Vehicle A is guilty of vehicular manslaughter due to the potential contribution of these perceptual and cognitive factors. Just before the accident occurred, several events could have transpired, such as (a) the driver of Vehicle A may have lost sight of Vehicle B when its headlights were extinguished, and tried to avoid it by moving to the other side or by pulling off to the shoulder, (b) the driver of Vehicle A failed to see Vehicle B in the last few seconds, but thought maybe the road curved to his right earlier than he previously thought. Also, (c) the driver of Vehicle A possibly thought Vehicle C in the south lane was the car he saw the entire time, or (d) the driver of Vehicle A may have seen Vehicle B in the last few seconds with his headlights shining on it and tried to avoid it by moving to the other side.

For the purposes of this study, perceptual and cognitive factors were examined as possibly playing a role in a specific car accident. A limitation of this research is addressing these six factors for one particular car accident. Human factors driving performance research and car accident reconstruction involves several other factors not thoroughly discussed here. However, the assessment of these perceptual and cognitive factors involved in car accident analyses motivates the need for further research in these areas. Continuing the research performed in driving performance including these six factors can continue to unify the laws and regulations around the United States to improve driver safety and decrease the number of car accidents.

This case study has shown that learning more about driver's expectations can help develop better ways to improve driving, such as road sign development and traffic communication. Research on glare can improve headlight development and implementation of ideal roadside lighting on rural roads. Further knowledge on general visibility and dark adaptation can help develop stricter regulations for eye-sight requirements and safety procedures for nighttime driving. Research on road illusions will improve the design of roads and highways to reduce traffic flow, decrease speeding, and increase awareness of the driver's perspective. Understanding P-R time will improve braking mechanisms in vehicles and front and side airbag deployment. This accident also shows the importance of road maintenance, keeping the road markings as clear and reflective as possible, replacing or reinforcing them on a regular basis.

Through continuing research, car accidents and the death rates that result from can be preventable. Reviewing different perceptual and cognitive factors such as the six previously described creates alternative ways for a car accident to be caused other than what may be obvious. More research needs to be focused on the compounding effects of other perceptual and cognitive factors on driving performance to better analyze accidents and develop improved ways to prevent them. No matter what discipline a person may be in, car accident analysis and the factors contributing to car accidents are generalizable to the public. Almost everyone knows someone who was involved in a car accident.

ACKNOWLEDGEMENTS

I would like to thank my mentor, Dr. Andrew P. Daire, for encouraging me to pursue this research topic. Also, I would like to thank my co-author, Marc Gentzler, for guiding me through the process of writing this paper and providing feedback.

REFERENCES

AAA Foundation for Traffic Safety. (2010). 2010 *traffic safety culture index* (3rd ed.). Washington, DC: AAA Foundation for Traffic Safety. www.aaafoundation.org/reports.

Alferdinck, J. (1996). Traffic safety aspects of high-intensity discharge headlamps: Discomfort glare and direction indicator conspicuity. *Proceedings of Vision in Vehicles, 5*.

Alferdinck, J., & Varkevisser, J. (1991). Discomfort glare from D1 headlamps of different size, report IZF 1991 C-21. *Soesterberg, Netherlands: TNO Institute for Perception.*

Baumberger, B., Flückiger, M., Paquette, M., Bergeron, J., & Delorme, A. (2005). Perception of relative distance in a driving simulator. *Japanese Psychological Research, 47(3)*, 230-37.

Centers for Disease Control and Prevention. (2010 October 17). *Injury prevention and control: Motor vehicle safety*. Atlanta, GA: US Department of Health and Human Services, CDC.

Chan, E., Pradhan, A. K., Pollatsek, A., Knodler, M. A., & Fisher, D. L. (2010). Are driving simulators effective tools for evaluating novice drivers' hazard anticipation, speed management, and attention maintenance skills? *Transportation Research: Part F, 13(5)*, 343-53.

Chang, S., Lin, C., Fung, C., Hwang, J., & Doong, J. (2008). Driving performance assessment: Effects of traffic accident location and alarm content. *Accident Analysis & Prevention, 40(5)*, 1637-43.

Chen, J. C., Schmid, K. L., & Brown, B. (2003). The autonomic control of accommodation and implications for human myopia development: A review. *Ophthalmic and Physiological Optics, 23(5)*, 401-22.

Clarke, D. D., Ward, P., Bartle, C., Truman, W. (2006). Young driver accidents in the UK: The influence of age, experience, and time of day. *Accident Analysis and Prevention 38(5)*, 871–78.

Cohen, Y., Zadok, D., Barkana, Y., Shochat, Z., Ashkenazi, I., Avni, I., & Morad, Y. (2007). Relationship between night myopia and night-time motor vehicle accidents. *Acta Ophthalmologica Scandinavica, 85(4)*, 367-70.

Gentzler, M. (2010). Car accident case study. [PowerPoint slides].

Goldstein, B. E. (2010). *Sensation and perception*. Canada: Wadsworth Cengage Learning.

Groeger, J. A., & Chapman, P. R. (1996). Judgment of traffic scenes: The role of danger and difficulty. *Applied Cognitive Psychology, 10(4)*, 349-64.

Hamer, M. (1994). Deadly illusion brings death on the roads. *New Scientist, 142(1930)*, 4.

Hecht, S., Haig, C., & Chase, A. M. (1937). The influence of light adaptation on subsequent dark adaptation of the eye. *Journal of General Physiology, 20(6)*, 831.

Hole, G. J. (2007). *The psychology of driving*. Mahwah, NJ: Erlbaum.

Karwowski, W. & Noy, Y. I. (Eds.). (2004). *Handbook of human factors in litigation*. Florida: CRC Press.

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 & Prevention, 42(3)*, 827-34.

Lamb, T., & Pugh, E. (2004). Dark adaptation and the retinoid cycle of vision. *Progress in Retinal and Eye Research, 23(3)*, 307-80.

Leibowitz, H.W., & Owens, D.A., 1977. Nighttime driving accidents and selective visual degradation. *Science 197(4302)*, 422–23.

National Highway Traffic Safety Administration. (2010). Highlights of 2009 Motor Vehicle Crashes. Report no. DOT HS 811 393. Washington, DC: National Highway Traffic Safety Administration. http://www-nrd.nhtsa.dot.gov/Pubs/811363.pdf

National Highway Traffic Safety Administration. (2011). *What is human factors?* Retrieved from http://www.nhtsa.gov/Research/Human+Factors/What+is+Human+Factors.

Nawrot, M., Nordenstrom, B., & Olson, A. (2004). Disruption of eye movements by ethanol intoxication affects perception of depth from motion parallax. *Psychological Science (Wiley-Blackwell), 15(12)*, 858-65.

Olson, P. L., & Farber, E. (2003). *Forensic aspects of driver perception and response*. Lawyers & Judges Pub Co.

Plainis, S., & Murray, I.J., 2002. Reaction times as an index of visual conspicuity when driving at night. *Ophthalmic and Physiological Optics 22(5)*, 409–15.

Svenson, O. (2009). Driving speed changes and subjective estimates of time savings, accident risks and braking. *Applied Cognitive Psychology, 23(4)*, 543-60.

Theeuwes, J., Alferdinck, J. W. A. M., & Perel, M. (2002). *Relation between glare and driving performance. Human Factors, 44(1)*, 95.

West, C. G., Gildengorin, G., Haegerstrom-Portnoy, G., Lott, L. A., Schneck, M. E., & Brabyn, J. A. (2003). Vision and driving self-restriction in older adults. *Journal of the American Geriatrics Society, 51(10)*, 1348.

Williams, A.F. 2003. Teenage drivers: Patterns of risk. *Journal of Safety Research 34(1)*, 5–15.