LEBANESE AMERICAN UNIVERSITY

Analysis of The Lebanese Driver's Behavior at The Onset of Yellow Lights at Signalized Intersections

By

Ricardo Hammam Chahine

A thesis submitted in partial fulfillment of the requirements

For the degree of Master of Science in Civil and Environmental Engineering

School of Engineering

October 2020

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Thesis Title : Analysis of The Lebanese Driver's Behavior at The Onset of Yellow Lights at Signalized Intersections
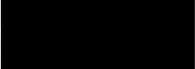
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Dedication

This thesis is dedicated to my beloved family and friends.

Acknowledgments

I would like to thank my thesis advisor, Dr. John Khoury, for his continuous support and effort during the research process.

I would also like to thank the committee members, Dr. Jordan Srour and Dr. Maria Jose Sanchez Ruiz, for their guidance and advice.

Finally, I would like to show appreciation to the Engineering Laboratory Supervisor, Mr. Georges Chaccour, for helping me in the equipment setup.

Analysis of The Lebanese Driver's Behavior at The Onset of Yellow Lights

Ricardo Hammam Chahine

Abstract

Intersections are critical points within the highway system at which the risk of crashes increases. This study seeks to better understand the behavior of the Lebanese driver at an intersection by examining the relationship between his/her decisions and psychological attributes. A driving simulator and a self-reporting personality questionnaire are used to assess the decision-making at the onset of the yellow. The driving simulator measures driving outcomes such as speed, braking, and throttle across four different intersections. The questionnaire helps measuring demographics and psychological traits such as mindfulness, impulsiveness, anxiety driving, and safe driving. A total of 102 participants completed the questionnaire as well as the driving simulator test. Hierarchical clustering is used to classify drivers into four groups according to their driving outcomes: Driving Styles (DS): 1 or safest drivers, 2 or safe drivers, 3 or speed demons, and 4 or aggressive drivers. These driving styles moderate the relation between the psychological traits and drivers' decision whether to stop or to pass at each intersection. Results show that mindfulness was highly related to DS 1 drivers' decision at the first intersection, impulsiveness and anxiety driving are also related to DS 3 drivers' decision at the third, and safe driving has a significant influence on DS 1 drivers at the third. These findings provide support for research linking driving performance and personality factors and can have implications on future driving enforcement and education for the Lebanese drivers.

Keywords: Driving behavior, Yellow light, Driving simulation, Driver personality, Road Safety, Decision, Hierarchical clustering.

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Chapter One

Introduction

Intersections are critical points within the highway system. According to the Federal Highway Administration (Federal Highway Administration [FHWA], 2020), in the last years, over one quarter of all the road fatalities and half of all the road injuries in the US occurred at or around intersections. Signalized intersections present numerous conflicting movements which require high cognitive skills from drivers. One major confusing event when passing through an intersection is the signal change from green to yellow. This signal change is a warning of a change in the right of way to the approaching driver. Thus, at the yellow onset, drivers have to immediately take a decision whether to stop or continue through the intersection at the yellow light. A conflicting decision at this critical point in the roadway could be detrimental.

For this reason, researchers have been interested in thoroughly observing this roadway point and have come up with the Dilemma Zone (DZ) concept which was first introduced by Gazis et al. (1960). The DZ is the upstream distance from the intersection approach where drivers are considered to be too close to stop safely and too far to clear the intersection on time (Abbas et al., 2014). Thus, drivers would not be able to clear the intersection before the signal turns red nor can they stop before the stop bar at a comfortable deceleration rate (3 m/s^2). This dilemma leaves the drivers with two options, either to abruptly stop and be at a risk of rear-end collision in case the driver behind makes a conflicting decision, or to pass at risk of side crash in case the driver fails to clear the intersection before the red (Jahangiri et al., 2015). In other words, drivers trapped in the dilemma zone face major hesitations, which lead to an increase in

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the number of red violations and can be a main cause for angle and rear end crashes (Elmitny et al. 2010). Therefore, a considerable amount of research has examined many solutions to address the traffic light violations. Most of them highlighted the role of drivers' behavior in the stop or run decision and its influence on the DZ (Bar-Gera et al., 2016; Choudhary & Velaga, 2019; El-Shawarby et al., 2006; Hurwitz et al., 2012; Rakha et al., 2007). For instance, Hurwitz et al. (2012) used fuzzy logic to demonstrate how the elimination of DZ uncertainty would result in a major decrease in the probability of rear-end and right-angle crashes around the intersection.

To date, several countermeasures ranging between engineering and enforcement have been tested and implemented to discourage red-light running (Bonneson & Zimmerman, 2004). However, in Lebanon this issue has not been given enough consideration. Highway violations still happen s even with the adoption and implementation of a modernized law that penalizes red-light runners. With the aim of reducing crashes caused by red-light running violations in Lebanon, potential countermeasures should be studied and investigated. These measures should be based on a comprehensive understanding of the behavior of the targeted population.

In this thesis, we studied the behavioral dispositions of the Lebanese drivers and their personality traits to determine their willingness to stop or continue at the onset of the yellow light. An experiment using state-of-the-art driving simulator was conducted with 102 participants, who were asked to fill two surveys, pre-simulation and post-simulation. Psychological predictors such as mindfulness, impulsiveness, anxiety driving, and safety driving were collected from the survey and used to profile drivers. A relationship was found between these psychological variables and the drivers' decision to whether stop or proceed at the onset of the yellow.

Chapter Two

Literature Review

Several studies have focused on analyzing drivers' behavior at the onset of the yellow light at signalized intersections. As yellow and red-light behavior explains much of the intersection's safety record, researchers have been trying to understand such behavior and the factors that influence it. One study (Zhang et al., 2016), which focuses on red light violators classifies them into three categories. One of these categories comprises of drivers who were caught in the DZ but decided to cross the intersection.

The concept of the DZ has been a subject of research since 1960, when Gazis et al., (1960) discussed the possibility of being unable to stop at a yellow indication due to intersection errors. Subsequent studies have since then scrutinized this concept and its relationship with driving behavior (Liu et al., 2007; Papaioannou, 2007). For instance, Liu et al., (2007) show that the DZ has a dynamic nature and that it highly varies with the behavior of the driver.

In order to characterize drivers' behavior at a signalized intersection, prior research has considered various driving performance measures such as speed, acceleration, and deceleration (Rakha et al. 2007). All of these measures are ultimately related to the drivers' decision to whether stop or go at the onset of the yellow indication. Researchers have inherently been interested in modeling for and predicting the decision to stop or proceed at the yellow (Elhenawy et al., 2015; Gates et al., 2007; Ghanipoor Machiani & Abbas, 2016; Jahangiri et al., 2016; Kim et al., 2016; Palat & Delhomme, 2012). These studies have thoroughly explored how various factors such as demographics, speed, distraction, site properties, traffic volume, and personality

significantly affect the driving behavior and are strongly associated with the likelihood of the stop or go decision. A summary of these factors is listed in Table 1.

Table 1: Summary table of the factors that affect drivers' behavior at an intersection

Factor	Studies
Age	Caird et al. (2007), El-Shawarby et al. (2006), Haque et al. (2015), Liu et al. (2011), Mather et al. (2009), Ohlhauser et al. (2011), Savolainen (2016), Xiong et al. (2016)
Gender	El-Shawarby et al. (2006), Haque et al. (2015), Liu et al. (2011), Rakha et al. (2007), Savolainen (2016),
Time to intersection (TTI), Distance to intersection (DTI), and approach speed	Aswad Mohammed et al. (2020), Elmitiny et al. (2010), Gates et al. (2007), Haque et al. (2015), Jahangiri et al. (2016), Ohlhauser et al. (2011), Palat & Delhomme (2016), Papaioannou (2007), Pathivada & Perumal (2019), Rakha et al. (2007), Wu et al. (2013), Xiong et al. (2016)
Flow rate and presence of other cars on the road	Aswad Mohammed et al. (2020), Duan et al. (2012), Elmitiny et al. (2010), Gates et al. (2007), Kim et al. (2016), Liu et al. (2011), Palat & Delhomme (2012 (2016), Wu et al. (2013)
Distraction	Choudhary & Velaga (2019), Haque et al. (2015), Ohlhauser et al. (2011), Savolainen (2016), Xiong et al. (2016)
Vehicle Type	(Palat & Delhomme (2012), Pathivada & Perumal (2019), Savolainen (2016)
Driver personality, anger, and aggressiveness	Abdu et al. (2012), Elhenawy et al. (2015), Gates et al. (2007), Hamdar et al. (2008), Linkov et al. (2019), Mather et al. (2009),

Ābele et al. (2020), Danaf et al. (2015), Linkov et al. (2019),

Riendeau et al. (2018), Zhang et al. (2016)

Demographics

To start with, studies exploring the role of demographics on driving behavior have focused specifically on age (Caird et al., 2007; El-Shawarby et al., 2006; Haque et al., 2015; Liu et al., 2011; Mather et al., 2009; Ohlhauser et al., 2011; Savolainen, 2016; Xiong et al., 2016) and gender (El-Shawarby et al., 2006; Haque et al., 2015; Liu et al., 2011; Rakha et al., 2007; Savolainen, 2016). One such study is that by Caird et al. (2007) which established in a driving simulator study a logistic regression model that predicted the stop/go decision of drivers. The study found that Canadian drivers across various ages are less likely to cross an intersection at the onset of the yellow light when the time to stop is high. Another study conducted by Ohlhauser et al. (2011) obtained participants data through the National Advanced Driving Simulator (NADS) at the University of Iowa, US. The study established a logistic regression model to analyze the data, and found that novice drivers, when compared to middle-aged drivers, were more likely to go through a yellow indication. Similarly, Savolainen (2016) used NADS data and examined using several logit models the role of age and gender in a driving simulator setup. The study found that young male drivers (18-45) were more likely to stop at the intersection. Also, El-Shawarby et al. (2006) used Chi-square analysis to examine the probability of stopping with respect to distance from stop bar and gender. This was obtained from field data at the Virginia Tech Transportation Institute (VTTI) in New Jersey. They found that female drivers were less likely to cross an intersection at the onset of the yellow when compared to male drivers.

Time to intersection and speed

Other factors that influence the driving behavior is time to intersection (TTI), approach speed, and distance to interaction (DTI) at the onset of the yellow (Aswad Mohammed et al., 2020; Elmitiny et al., 2010; Gates et al., 2007; Haque et al., 2015; Jahangiri et al., 2016; Ohlhauser et al., 2011; Palat & Delhomme, 2016; Papaioannou, 2007; Pathivada & Perumal, 2019; Rakha et al., 2007; Wu et al., 2013; Xiong et al., 2016). Rakha et al. (2007) performed a field study with 60 participants who drove an instrumented vehicle on an empty 2.1 km track. Drivers had to pass through traffic lights multiple times with the yellow trigger changing after each crossing. The study carried out Chi-square and ANOVA tests and found that both speed and distance to intersection are among many other factors that significantly influence the stopping probability. Using video-based data, Elmitiny et al. (2010) examined a set of drivers at a high-speed signalized intersection. A series of ANOVA tests and decision trees analyses found that high operative speed and shorter distance to stop bar are highly conductive to intersection crossing during a yellow or red. Gates et al. (2007) collected driver behavior characteristics using video-based data from four high speed intersections and two low speed intersections. They carried out a multiple linear regression and a logistic regression, and found that among other factors, distance to stop bar had the strongest effect on the stop or go decision and that the stopping probability increases when distance to stop bar was longer.

Psychology

A considerable research effort has focused on exploring the relationship between human factors and certain driving behavior (Abdu et al., 2012; Elhenawy et al., 2015; Gates et al., 2007; Hamdar et al., 2008; Linkov et al., 2019; Mather et al., 2009). It has been shown that a significant variability in the driving behavior is explained by human factors. For instance, a study

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by Zhang et al. (2016) used descriptive statistics and regression analyses, and revealed that when in an angry state, drivers drove faster and closer to in front vehicles, and kept shorter headways when performing left-turns. Another study by Elhenawy et al. (2015) used field data to model driving behavior at the intersection to establish logistic regression models and random forest learning algorithms. This study found that introducing a new variable related to driver aggressiveness increased the model accuracy and helped explain part of the stop or go decision variability.

Impulsiveness

A study by Berdoulat et al. (2013) found that impulsivity, driving anger, and aggressiveness were positively correlated with driving behaviors such as lapses and errors, violations, and aggressive violations. In the same study, impulsivity, driving anger, and aggression also predicted aggressive and transgressive driving. In another study, impulsivity was linked to driving behaviors including violations, driving anger, anger expression, and aggression (Bıçaksız & Özkan, 2016). Another study showed that young impulsive males had a higher tendency for risky driving than females did (Hine, Ingram, & Glendon, 2015). Moreover, in a study by Smorti et al. (2018), impulsivity also predicted self-reported risky driving. According to Hatfield et al. (2017), more speeding and unsafe responding to critical events such as running through a yellow light during simulated driving were associated with poorer impulse control amongst young drivers. The results of the aforementioned studies support the evidence for a relationship between impulsivity, aggressiveness, and risky driving.

Emotional Intelligence

Additionally, emotional intelligence (EI) has been associated with risky driving behavior. A recent study found that lower scores on specific indices of EI are linked with increased rates of risky driving behavior, suggesting that poor emotional control may impede individuals' ability to

make safe behavioral decisions when driving (Hayley et al., 2017). A study by Smorti et al. (2018) showed that trait EI did not significantly predict dangerous driving dimensions over and above gender, personality traits, and social desirability; however, it was the sole incremental predictor of a lower number of tickets for dangerous driving.

Mindfulness and distraction

Another variable that has been linked to risky driving behaviors is mindfulness. Several studies have indicated that distraction significantly impacts drivers' stop or go decision (Choudhary & Velaga, 2019; Haque et al., 2015; Ohlhauser et al., 2011; Savolainen, 2016; Xiong et al., 2016). Choudhary & Velaga (2019) investigated the effect of distraction caused by the use of a cellphone or music player using a driving simulator. The study used a combined approach of both decision tree analysis and logistic regression. Results showed that both distraction tasks reduced the crossing likelihood, which can be considered as a strategy to compensate for that added cognitive demand beside the driving task. Also, according to Haque et al. (2015), cellphone use at an intersection resulted in an increased stopping probability for young and middle age drivers. In contrast, older drivers were more likely to cross a yellow while distracted. In another study that examined mindfulness training in relation to drivers' situation awareness and performance, mindfulness and concentration levels were both significantly related to situation awareness for driving, which in turn was proven to enable drivers to block out distractions and identify hazards (Kass et al., 2011). In addition, the results of the study by Valero-Mora et. al (2015) showed that there were significant correlations between driving performance and inattention while driving.

Other factors

Traffic flow

A fair amount of studies has also explored the influence of traffic flow and the presence of other vehicles on the road in estimating the conditional probability that a driver will continue through the yellow (Aswad Mohammed et al., 2020; Duan et al., 2012; Elmitiny et al., 2010; Gates et al., 2007; Kim et al., 2016; Liu et al., 2011; Palat & Delhomme, 2012, 2016; Wu et al., 2013). Gates et al. (2007) reported that the actions of adjacent vehicles on the road influence the stop or go decision. The study also found that vehicles, bicycles, and pedestrians present on the side-street increased the likelihood of stopping at the yellow. Duan et al. (2012) conducted a driving simulator study in China to examine the drivers' decision and used descriptive statistics and ANOVA test to compare different behaviors. Participants had to follow a model car in the scenario and were asked to keep a comfortable headway with the leading car. Results showed that when the model car crossed the intersection at a yellow, 65% of the drivers did the same even though they were 30 meters behind, whereas when the model car stopped, 25% of the drivers only proceeded.

Vehicle type

Vehicle type is another factor that was found to have a significant effect on yellow light running occurrences (Palat & Delhomme, 2012; Pathivada & Perumal, 2019; Savolainen, 2016). Pathivada and Perumal (2019) collected field data using video capturing techniques at five signalized intersections with mixed traffic conditions. A logistic regression analysis showed that the type of vehicle significantly influenced the stop or go decision. Two-wheeler motorbikes had the highest yellow passing likelihood whereas passenger cars had the lowest when compared to other types of vehicles. Palat and Delhomme (2012) also found using a Chi-squared analysis that two wheelers motorbikes were more likely to run a yellow light compared to passenger cars.

Data collection methods

To study drivers' behavior at an intersection, various data collecting methods have been adopted in many studies, alternating between naturalistic data, driving simulator data, and surveys. Data collection methods dictate the nature and number of factors that can be examined and play therefore a vital role in understanding drivers' behavior. For instance, Yan et al. (2016) designed a naturalistic study to record red light running violations at five intersections in the city of Changsha, China for three days and four time periods using portable digital cameras and smart phones with high-definition camera. Sahnoon et al. (2016) used a 4-year crash data of 36 intersections located in Abu Dhabi obtained from the Traffic and Patrols Directorate of the Abu Dhabi police. Jahangiri et al. (2015) used naturalistic data which was derived from radars, video cameras, and signal phase sniffers at six stop-controlled intersections and three signalized intersections in South Virginia in addition to driving simulator data. Field data reflects the most natural behavior of drivers on the road, however it does not allow researchers to examine the effect of age, experience, and gender of drivers since the identity of violators on the road is unknown (Gates et al., 2007). Also, driving behavior has been explored extensively using simulator/lab studies. Caird et al. (2007) used a driving simulator on yellow decision of 77 participants. The study examined the influence of the yellow light phase length, coupled with age on the Perception Reaction Time at the onset of the yellow light on the stop or go decision. Rakha et al. (2007) studied the behavior of drivers during a controlled-road experiment at the Virginia Department of Transportation's Smart Road facility. The setup was artificial, despite the vehicles being real, which classifies this study as experimental rather than naturalistic. This type of data collection simulates real-world conditions but does not describe the natural behavior of the drivers since they know they are being tested and may adjust their behavior. The advantage

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of using a driving simulator is that it allows researchers to safely determine the relationship between human factors and the stop or go decision. This method provides high precision when measuring parameters of interest such as speed, braking, and position. Also, simulator data allows flexibility and control in the identification of the stop or go decision.

Literature gap and present study

Although existing literature suggests a strong relationship between human factors and driving behavior, researchers are still examining such relationship. Most reviewed studies have used driving simulators to collect driving data, coupled with questionnaires to examine the psychological traits of the drivers (Ābele et al., 2020; Danaf et al., 2015; Linkov et al., 2019; Riendeau et al., 2018; Zhang et al., 2016). In one of these studies, Riendeau et al. (2018) demonstrated the association between basic personality traits and driving performance using a driving simulator and the Big Five Personality questionnaire. The study found that Big Five Extraversion and Neuroticism were negatively associated with safe driving performance (i.e., average speed, number of speed exceedances) and lateral control (i.e., road edge and lane excursions).

There is a considerable amount of research that explores the effect of various driving characteristics on the driving behavior at intersections. The literature indicates that while variables such as speed, demographics, vehicle type, flow rate, and distraction affect the driving behavior, so do personality traits and driver's psychology. The majority of research that assessed the relation between personality and driving behavior, however, explored the overall effect on driving behavior and did not examine the influence of psychological factors while crossing the intersection at various indications, such as yellow crossing decision. Also, a limitation of previous literature is that they focus on traditional personality traits such as the Big Five, while

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in this study the measured psychological factors are key based on previous literature, plus newer less explored factors such as mindfulness. In addition, this topic remains understudied in Lebanon and the Middle East region. While it is well established that cultural difference is a key factor in driving behavior research, very few if any studies conducted in the region examined the driving behavior at the yellow intersection in the region. Thus, the main aim of this study is to better understand the possible influence of human factors and psychological traits in the Lebanese context. It will model for the yellow decision-making using a driving simulator and a self-reporting personality questionnaire. The study attempts to couple driving parameters such as speed and braking with personality latent constructs such as mindfulness, impulsiveness, safe driving, emotional intelligence, and aggressive driving to predict the driver decision at the onset of the yellow.

Chapter Three

Methodology

Participants

A total of 104 drivers participated in this study. All participants were volunteers as no monetary incentive was offered. Students, staff and faculty at LAU comprised the large portion of the participants. All the participants were licensed drivers over the age of 18. Participants were recruited through email, electronic forms, and by personal invitation. Two participants did not complete the test due to the feelings of dizziness and motion sickness leading to a sample size of 102 (n male = 69, n female = 33). All participants were originally Lebanese national with a couple of drivers who have lived and driven outside. All the drivers were living in Lebanon, commuting to work or school and are familiar with the road conditions in Lebanon. As such, they are accustomed to the driving environment comprising aggressive driving, violations due to the lack of traffic law enforcement and daily traffic congestion.

Driving simulator

Figure 1: Simulator automobile and LCD screens

The Forum8 3D VR driving simulator is located in the Lebanese American university's Engineering Lab and Research Center (ELRC). It consists of a full Mercedes Smart car with real driver controls and three 7-inches LCD screens to simulate one rearview and two side mirrors. This automobile is equipped with four D-Box actuators mounted on a skid under the car, a full 500W RMS 5.1 digital sound system with subwoofer and stereo speakers, and a force feedback steering rack providing real car driving sounds along with tactile feedback. In addition, the driving simulator is placed in front of a 180 degrees screen onto which an image measuring 6.1 m wide by 1.5 m high is displayed using three synchronized overhead projectors as shown in Figure 2. The driving simulator is linked to VR-Design Studio interactive 3D VR driving simulation software (UC-win/road) which was used to create scenarios, access FORUM8 VR data library, and export log files.
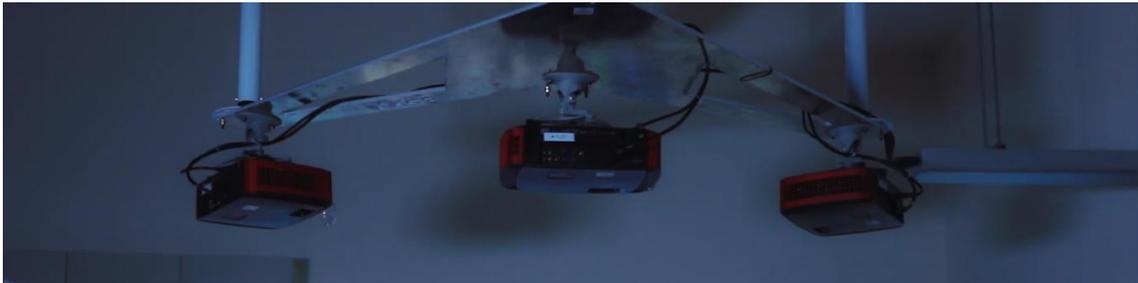
Figure 2: Overhead projectors

Figure 3: Participant taking the test

Simulation scenario

Figure 4: Aerial snapshot of the road

The roadway created for this simulation was a 6-km section resembling the urban collector highway from Sin El Fil to Jal El Dib as shown in Figure 4, including all four intersections along the way.

Figure 5: Layout of intersection 1

Figure 6: Layout of intersection 2, 3, and 4 respectively

Figures 5 and 6 present snapshots of the four intersections. They include all road markings, traffic lights, curbs, and traffic islands. The scenario started with a long road section to allow the participants to get accustomed to the simulator. Towards the end of the study section, the urban collector transforms into a freeway, along which a work zone was created, also

representing real life conditions. The road characteristics and measurements were based on official AutoCAD drawings obtained from the Ministry of Public Works. Road traffic, signs and markings were also obtained from the traffic management center of Beirut, to match the real-life conditions of the road. Roadside objects, comprising sidewalks, trees, buildings and parked cars were designed following site investigation in an attempt to mimic the current roadside environment. Speed limit signs were placed along the section, 70 km/h from the start until the last intersection (1.82 Km) and then changed to 80 Km/h until the end (4.18 Km). The traffic lights on the four intersections were timed to turn from green to yellow, then red when the participant's car was at a specific distance from the intersection to observe the driver's reaction. There were barriers and obstructions in the work zone along the road also to monitor the driver's behavior, as well as billboards to increase the levels of distraction.

Questionnaire design and reliability

The pre and post surveys are presented in appendix A.

Psychological scales

The questionnaire included demographic questions (e.g., age and gender), scales assessing different driver-related and situational characteristics (e.g., state anxiety, impulsiveness), as well as other questions relating to driving experience (e.g., "How do you classify yourself as a driver?" and "How much driving experience do you have?") and history of accidents (e.g., "Have you been in an accident before?" and "How many accidents have you experienced"?).

The State-Trait Anxiety Inventory - Form Y1 (STAI-Y1; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983)

The STAI-Y1 was used in the present study to measure state anxiety. It consists of 20 items that are rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Sample items are "I feel calm" and "I feel nervous". Various studies have reported high reliability for the STAI, an internal consistency ranging from α=0.65-0.96 (Spielberger et al., 1983; Barnes, Harp, & Jung, 2002), and test-retest coefficients ranging from 0.34-0.96. (Spielberger, 1989; Barnes, Harp, & Jung, 2002). The scale has also been tested and validated in various countries including Saudi Arabia (α=0.989; Bahammam, 2016), France (Bergeron, 1983) and China (Shek, 1993), indicating high cultural validity.

The Trait Emotional Intelligence Questionnaire - Short Form (TEIQue-SF; Petrides, 2009)

The TEIQue-SF consists of 30 items rated on a 7-point Likert Scale, ranging from 1 (completely disagree) to 7 (completely agree). An example item is "I usually find it difficult to regulate my emotions". The TEIQue-SF yields a global emotional intelligence score and scores on four factors (i.e., Wellbeing, Emotionality, Sociability, Self-control). Various studies have reported good internal consistency for the TEIQue-SF ranging from 0.84-0.88 (Cooper & Petrides, 2010; Sanchez-Ruiz & Baaklini, 2018; O'Connor, Nguyen, & Anglim, 2016; Sanchez-Ruiz, El-Jor, Kharma, Bassil, & Zeeni, 2019). The scale has also shown strong evidence for high incremental and construct validity in relation to established personality theories such as the Big Five (e.g., Gardner & Qualter, 2010). The TEIQue has been replicated across various cultures and languages, including Lebanese (α = 0.84; Sanchez-Ruiz & Baaklini, 2018; Sanchez-Ruiz et al., 2019), Greek (α = 0.89; Stamatopoulou, Galanis, & Prezerakos, 2016), Urdu (α = 0.713-0.82;

Shahzad, Riaz , Begum, & Khanum, 2014), Turkish (Ozir & Isik, 2018), and Chinese (Feher et al, 2019).

Neo-PI Impulsivity subscale (NEO-PI-3; McCrae ,Costa, and Martin, 2005)

The NEO-PI-3 Impulsivity subscale consists of eight items rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). An example item is "I'm always in control of myself". The scale has an internal consistency of $\alpha = 0.66$, along with strong congruent validity, with coefficients ranging between 0.94 and 0.98 (McCrae, Costa, & Martin, 2005). In addition, evidence has been provided for its high cultural validity as it has been tested and validated in various countries including Greece (Fountoulakis et al., 2014) and India (Piedmont & Braganza, 2015).

Mindfulness Attention Awareness Scale (MAAS; Brown & Rayan, 2003)

The MAAS was used in the present study to assess mindfulness, i.e., the ability to attend to and remain aware of present life events and experiences. It consists of 15 items rated on a 6-point Likert Scale, ranging from 1 (almost never) to 6 (almost always), with higher scores indicating greater mindfulness. An example item is "I could be experiencing some emotion and not be conscious of it until sometime later". A series of studies have provided evidence for the scale's concurrent and discriminant validity (Brown & Ryan, 2003) and high internal consistency (e.g., $\alpha = .89$; MacKillop & Anderson, 2007). The MAAS has been validated and translated to many languages including French (Jermann et al., 2009), Swedish (Hansen, Lundh, Homman & Wangby-Lundh, 2009), Spanish (Soler et al, 2012), and Jordanian ($\alpha = 0.87$; Rayan & Ahmad, 2017).

Meditation behavior questionnaire (adapted from Baer et al., 2008)

Meditation behavior was assessed based on the characteristics of meditation practice measured in Baer et al. (2008). The four items that were used to assess meditation behavior in the present study are "Do you practice meditation?", "How long have you been practicing meditation?", "How many hours do you meditate per week?", and "What is the length of your typical meditation session?".

Driving Behavior Survey (DBS; Clapp et al., 2011)

The DBS consists of 21 items assessing the frequency of anxious driving behavior across three domains: exaggerated safety/caution behavior, anxiety-based performance deficits, and hostile/aggressive behavior. It is rated on a 7-point Likert Scale, ranging from 1 (never) to 7 (always), with higher mean scores indicating greater frequency of anxious driving behavior. An example item is "I slow down when approaching intersections, even when the light is green". Baker et al. (2014) reported high internal consistency (α = 0.85-0.93) for DBS, and Clapp et al. (2014) reported excellent internal consistency Figures for all three factors of the DBS, independently; safety/caution (α = .78 to .90), performance deficit (α = .75 to .85), and hostile/aggressive scales (α = .86 to .91). The scale has also been tested and validated in various countries including Iran (Khanipour, Tavallaii, & Ahmadi, 2015), evidencing its cultural validity.

Procedure

Before testing started, the university's Institutional Review Board (IRB)'s consent was obtained to ensure protection of human participants in this study. Noting that data was acquired following strict means to ensure that the identity of participants remained anonymous such as destroying cell phone number after calling, using only IDs for analysis and not asking for names. Additionally, all records were stored and only members of the research team are granted access

to them. Upon arrival, participants were briefed on the different parts of the experiment and its purpose. They were then asked to fill a pre-survey in which they signed an informed consent form. The pre-survey consisted of demographics questions as shown in Table 2 (e.g., age, gender, socioeconomic status) and the STAI-Y1.

Table 2: Demographics Variables

Variables	Count
Gender	
Male	69
Female	33
Age	
18-19	10
20-21	30
22-27	19
28-39	20
40-64	23
Occupation	
I don't work	40
Academic field-Education	30
Other private sector	10
Private sector-Services	8
Private sector-Industry	5
Own Business	1
Public sector	1
Voluntary and charitable work	1
Academic Degree	
High School Degree or equivalent	43
Bachelor's Degree or equivalent	29
Doctoral degree or Medical doctor	13
MA Degree or equivalent	11

No degree	6
Monthly Income	
Less than $500	45
$500 - $750	10
$750 - $1000	3
$1000 - $1500	9
$1500 - $2000	11
$2000 - $2500	4
$2500 - $3000	5
$3000 - $4000	3
More than $4000	12
Marital Status	
Single	68
Married	30
Widowed	2
Divorced	1
Separated	1
Children	
No	70
Yes	32

After completing the pre-survey, participants were asked to get in the driving simulator

and were given general instructions, which included asking the drivers to drive straight and not

turn left or right at the intersections, to get a feel of the inside of the car including the seat, the

steering wheel, gas and brake pedals, and to report any feeling of dizziness while driving so the

simulator is stopped. Most importantly, they were instructed to drive as they would normally do

in real life. The driving time on the simulator was approximately five minutes during which

participants received a phone call without prior warning. A video camera was also installed in

the car to record the participant's facial expressions. Both the phone call and facial expressions data weren't used in this study..

After completing the driving simulation experience, participants were asked to complete the post-survey, which consisted of the STAI-Y1-Post, TEIQue-SF, Neo-PI-3 Impulsivity subscale, MAAS, meditation behavior questionnaire, DBS, and other demographic questions pertaining to medical conditions or psychological difficulties, in addition to driving-related questions and history of accidents. Participants filled the post-survey in a room next to the simulator to avoid any distraction.

Before leaving, participants were debriefed by explaining to them the purpose of the study, leaving them the choice to either withdraw from the study or not.

Reliability Analysis

Cronbach's Alpha is a coefficient of reliability. It describes how closely related a set of items are as a group pertaining to a single latent construct. This measure of scale reliability is represented by a number between 0 and 1.0. Generally, a significant Cronbach's Alpha indicates high correlated items (Cronbach, 1951). In this study, Cronbach's Alpha was applied to measure the internal reliability of the above latent variables. The Alpha coefficients for the study's corresponding sample were obtained using psych package in R (Revelle, 2020). The coefficients are presented in Table 3.

Table 3: Cronbach's Alpha coefficient for the personality factors

Scale Name/ Latent Variable	Number of items	Reliability Cronbach Alpha
StateAnxietyPre	20	0.91
StateAnxietyPost	20	0.91

Mindfulness	15	0.78
Impulsiveness	7	0.74
AnxietyDriving	7	0.76
SafetyDriving	7	0.78
HostileDriving	7	0.85
TEIAll	30	0.84

Table 3 shows that the reliability coefficients values for all scales are higher than 0.7. This indicates that the used scales and the number of items in each are adequate.

Chapter Four

Analysis and Results

The study sought to analyze the driving behavior of the Lebanese driver at the onset of the yellow light. Driving behavior was characterized by the decision of stopping or proceeding at the intersection at the signal change. A stopping instance was considered in case the driver stopped at a distance between 20 meters before and 15 meters after the stopping bar. Whereas a crossing instance was considered in case the driver decided to pass the intersection at the onset of the yellow. In total, 408 instances were observed at four intersections from 102 participants. A descriptive analysis backed up by a student t-test showed that psychological traits influence the driver's decision at the onset of the yellow.

Driving performance data

Driving performance data was recorded for each participant via the driving simulator. A data point was recorded every 0.05 seconds. The gathered data included time (seconds), speed (Km/h), distance travelled (m), stirring (Ratio), throttle (Ratio), braking (Ratio), lane position (m), acceleration (m/s2), and a case number for change to yellow light indicator (0-4). Each participant had a file named after the corresponding ID number which is linked to its corresponding one in the questionnaires' while ensuring full anonymity.

Driving profiles

To analyze the driving behavior at the intersections, driving profiles upstream of the intersections were extracted from the full data profile for each participant. Yellow driving profiles started the moment the signal changed from green to yellow and ended the moment the

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driver crossed the stop bar. The profiles' parameters included numerical summaries for each of speed, braking, and throttle.
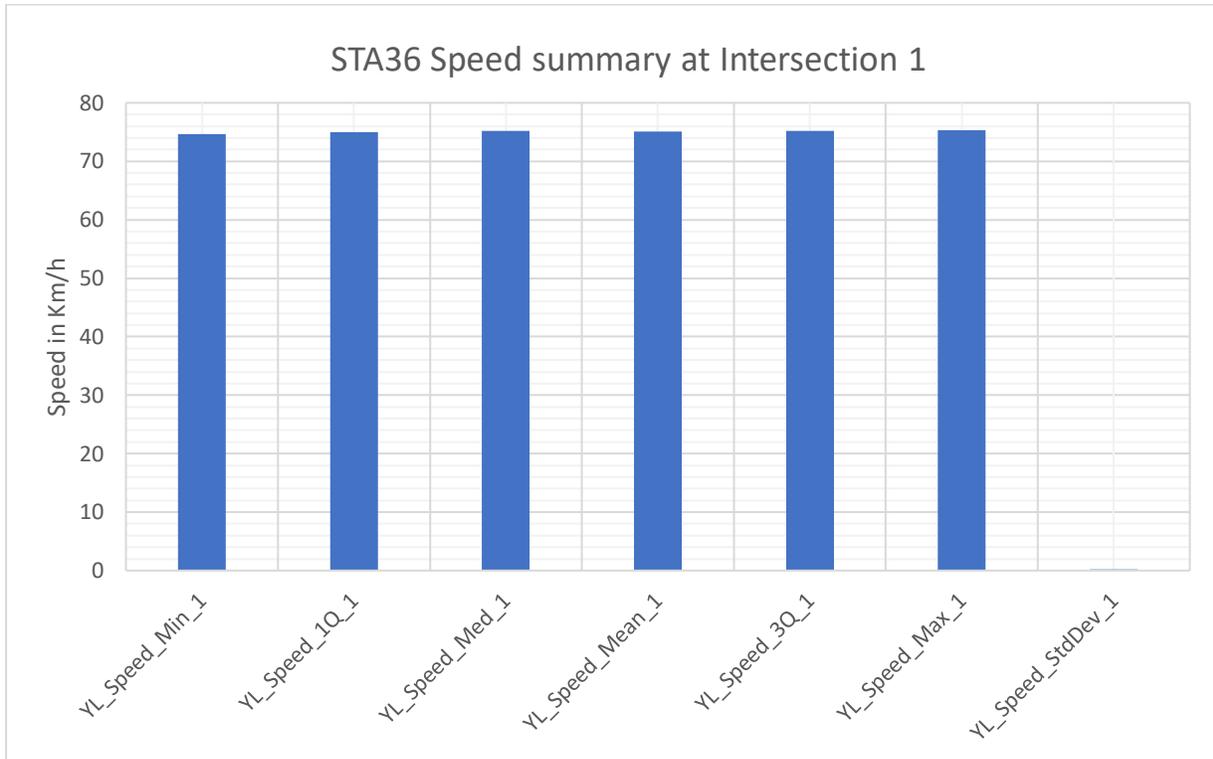
Figure 7: STA36 speed summary at intersection 1

For instance, Figure 7 shows the speed profile at the first intersection for STA36. The graph shows that the participant was driving at a constant speed of 75 Km/h. This is indicated by the

small standard deviation value and the similar min/max speed values. It can be inferred from this graph that the driver decided to pass at the yellow light through the intersection.
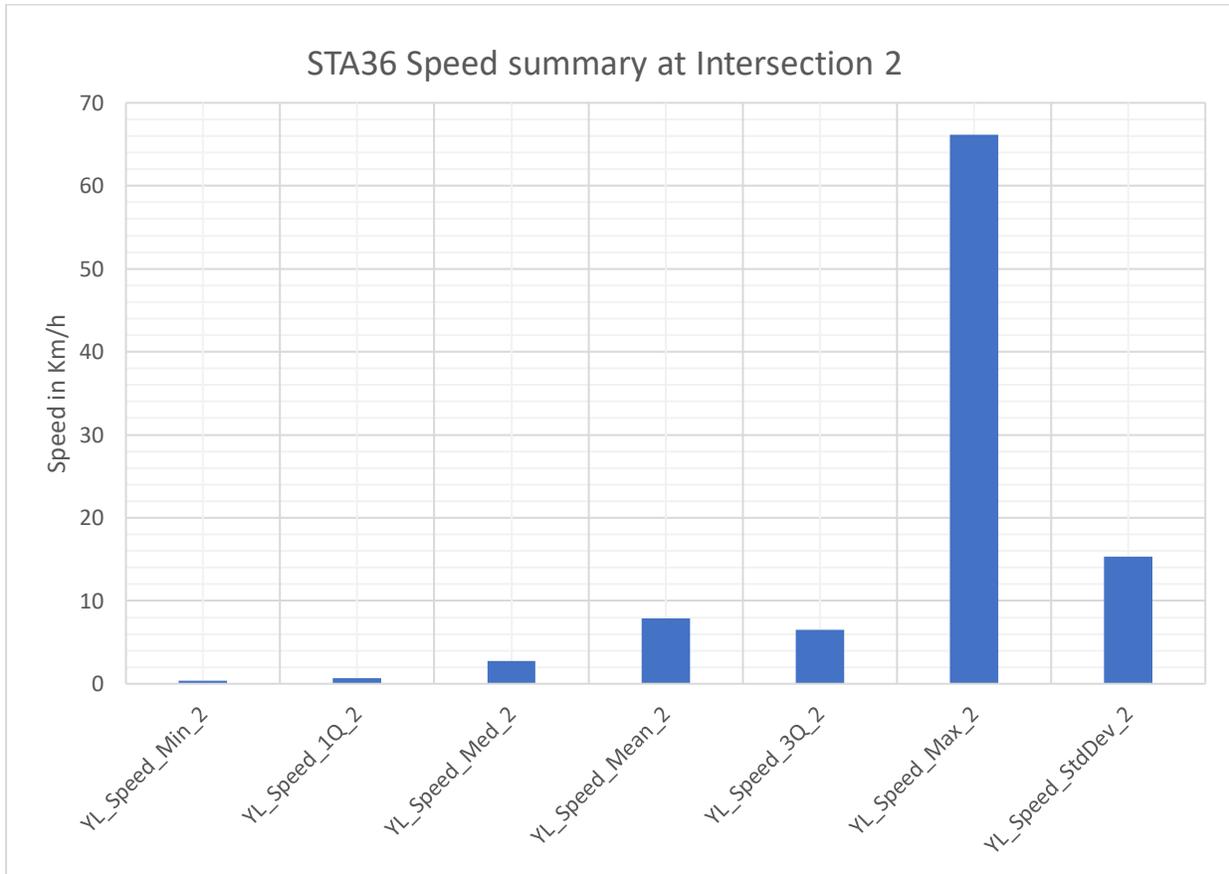
Figure 8: STA36 Speed Summary at Intersection 2

The same participant exhibited a different behavior at the second intersection. The values given in Figure 8 indicate the drastic change in speed of STA36 at the second intersection. A null value for the minimum speed and a 66 Km/h for the maximum. The significant standard

deviation and low mean show that the driver changed speed on the road section and mainly decided to stop at the intersection.
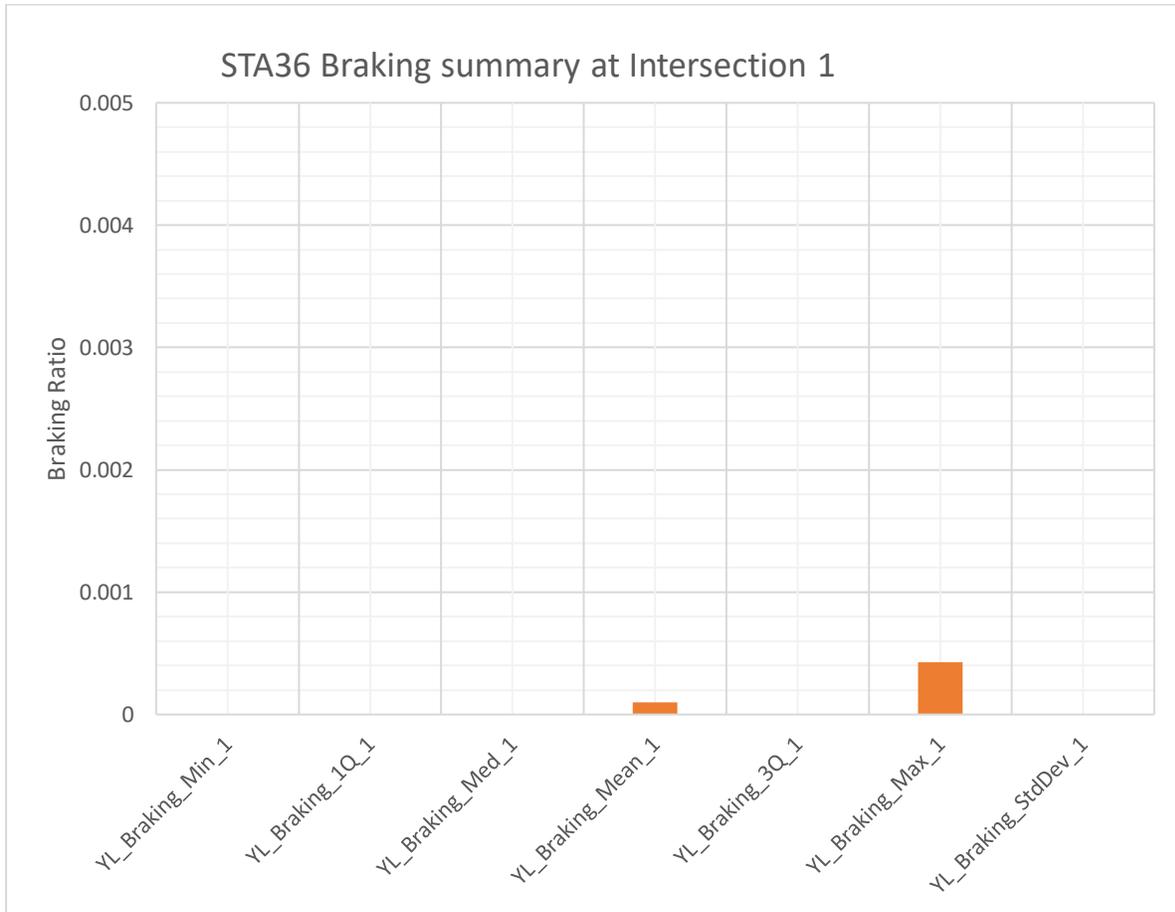
Figure 9: STA36 Braking summary at Intersection 1

Additionally, numerical summaries were calculated for braking. Figure 9 represents those summaries for STA36 at the first intersection. The graph shows that very minimal braking was exhibited at this intersection (ratio for max is less than 0.0005) and that the driver cruised through the intersection with no change in speed.
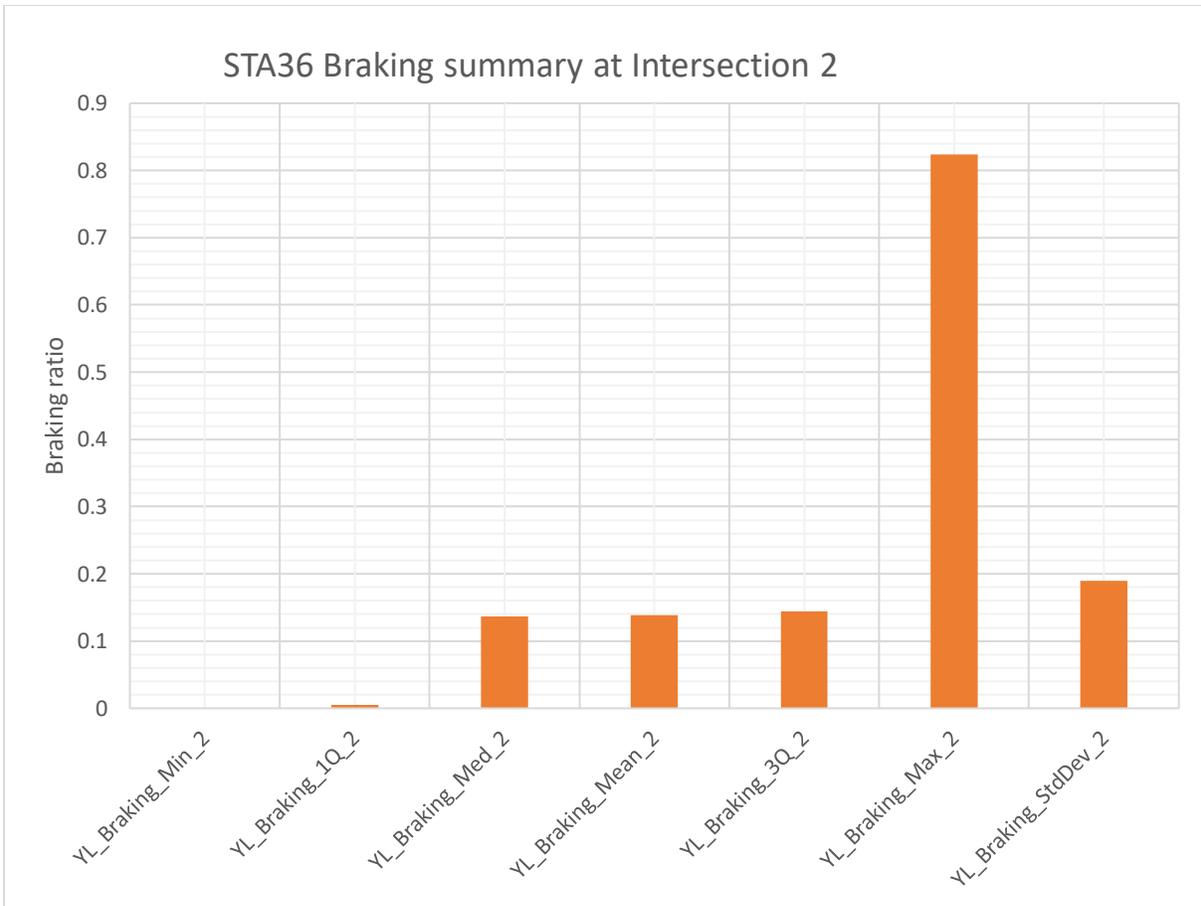
Figure 10: STA36 Braking summary at Intersection 2

In contrast, Values shown in Figure 10 indicate a different behavior. The maximum braking was higher than 0.8 (ratio), showing that the driver exhibited full braking at this intersection, and eventually stopped.

Hierarchical clustering

A cluster analysis was carried out using the extracted driving profiles. A cluster analysis is an algorithm that helps classifying similar objects (in this case participants) into distinct groups (or what is called clusters). In this experiment, Hierarchical clustering (HC) was used to group the drivers with respect to the aforementioned driving parameters (speed, throttle, and

braking) and classify them into different driving styles. To implement this method, the R

software, and "cluster" package were used (Maechler et al., 2019; R Core Team, 2020).

There are different approaches to conduct HC. The four most common types are: complete linkage clustering, single linkage clustering, average linkage clustering, and ward's minimum variance method. All these methods use Euclidian distance values of objects' variables to calculate dissimilarity and find the strongest clustering structure. In order to identify the most adequate method, the agglomerative coefficient was obtained for the four methods (values closer to 1 suggest stronger structure). Table 3 shows that Ward was the optimal method for clustering with a coefficient of 0.89.

Table 4: Agglomerative coefficients for the four clusters

Cluster Method	Agglomerative coefficient
Average	0.60
Single	0.46
Complete	0.73
Ward	0.89

The data was then scaled, and a HC analysis was performed. The optimal number of clusters was obtained by analyzing multiple dendrograms for different number of groups. Four groups were adopted as shown in the dendrogram in Figure 13 and the cluster graph to better visualize in Figure 12. The number of participants in each cluster is given in Figure 11.
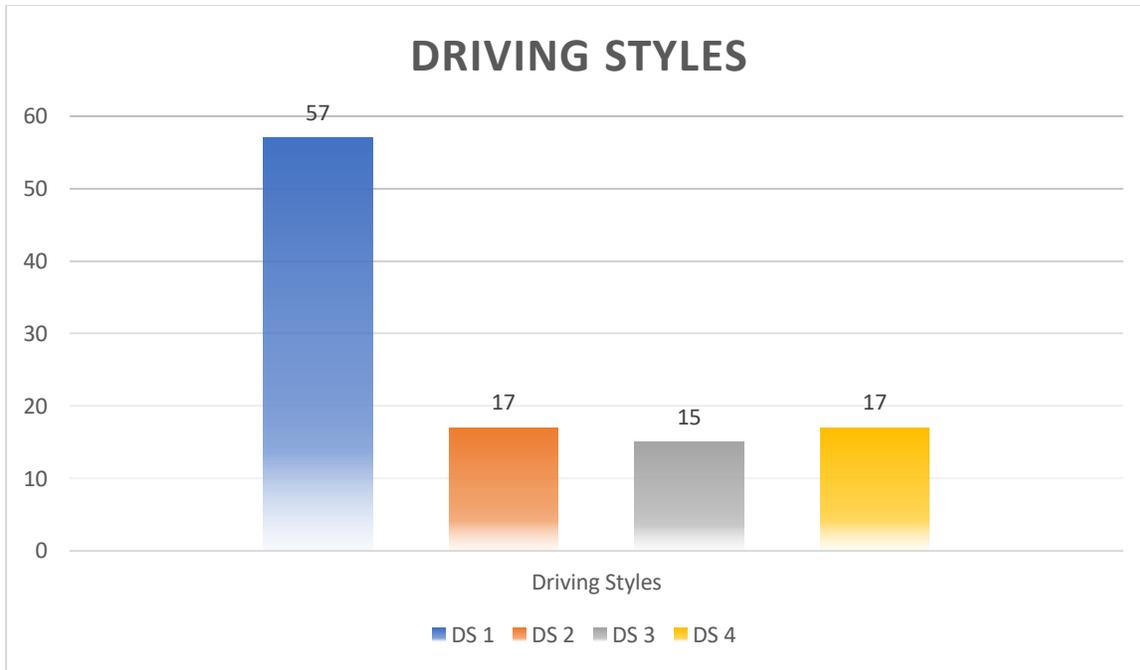
Figure 11: Number of participants in each style
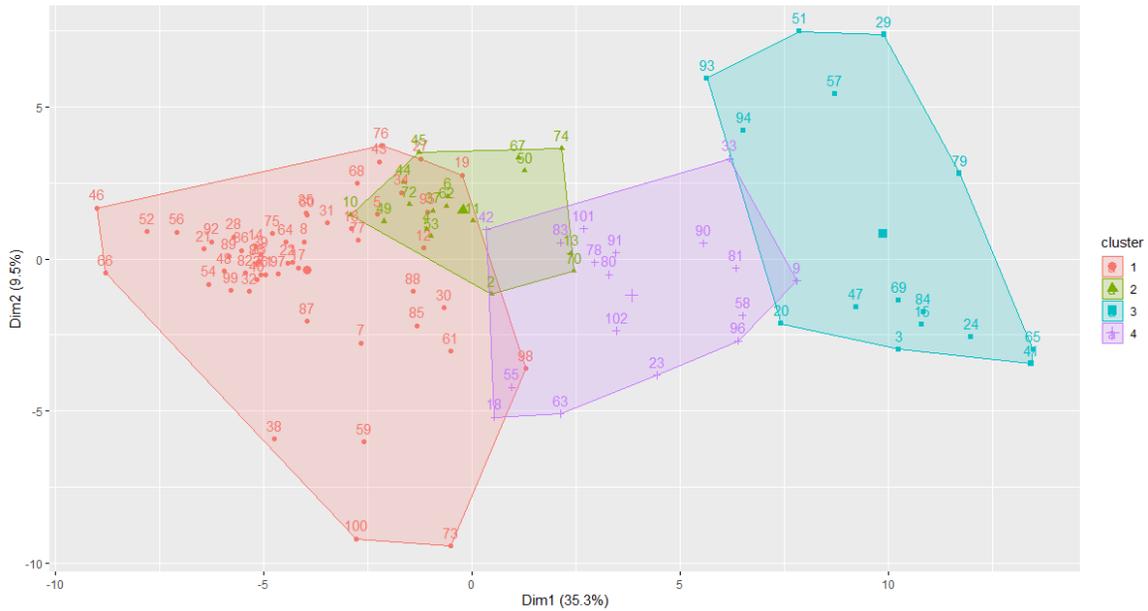
Figure 12: Visualization of the Euclidian distances for the four clusters
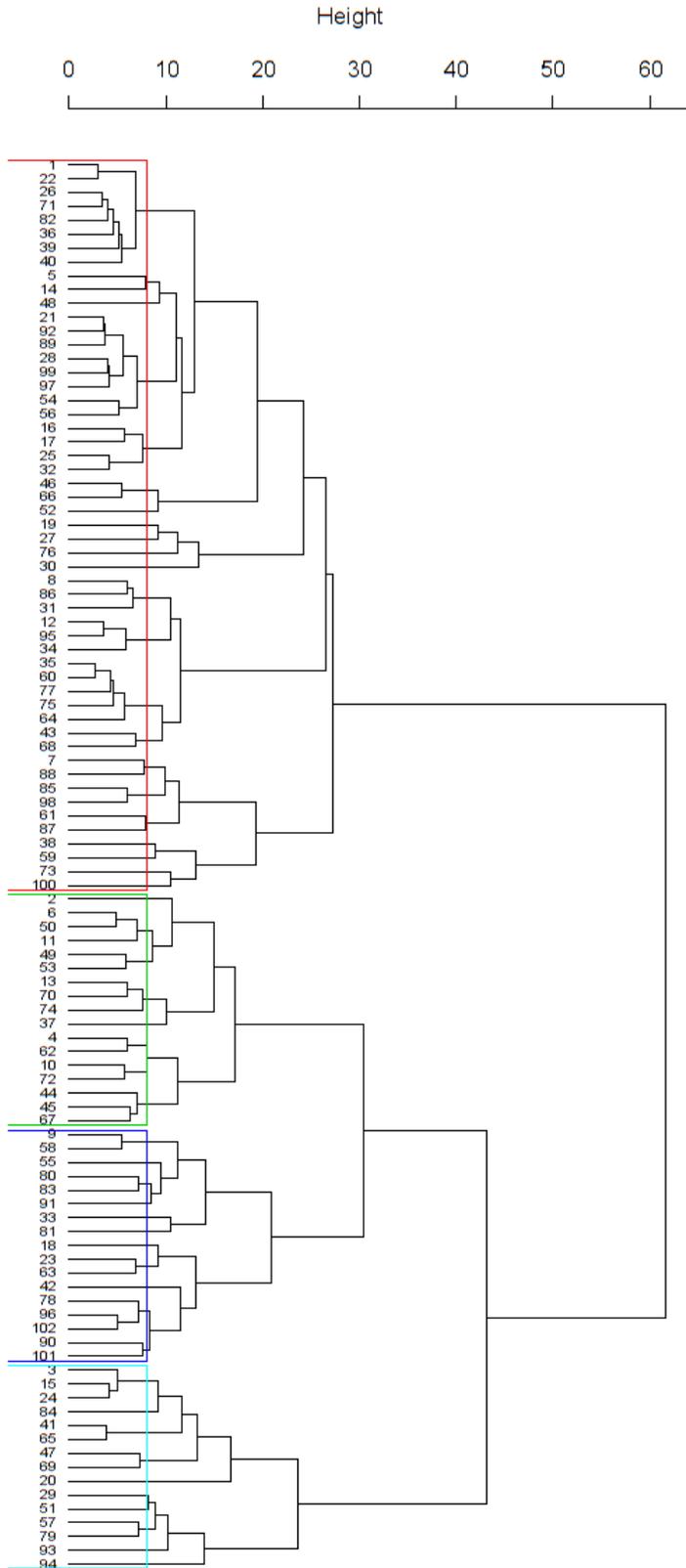
Figure 13: Dendrogram for the four clusters
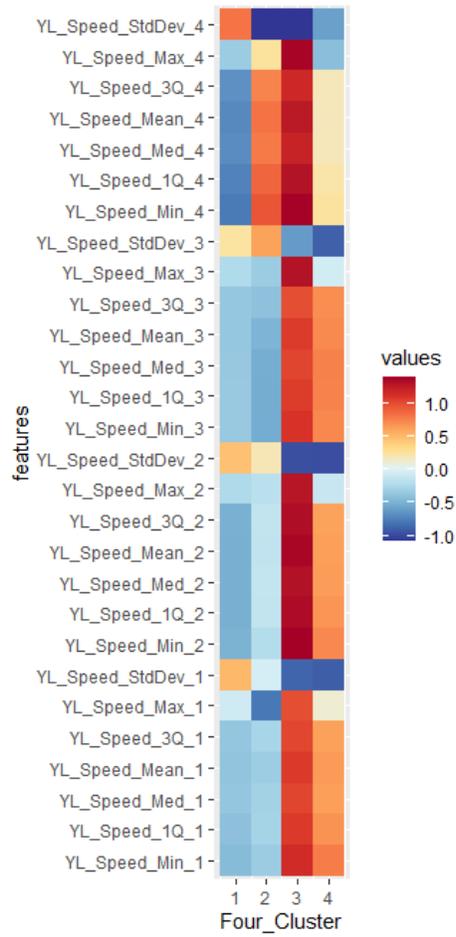
Figure 11: Comparison of the speed numerical summaries with respect to DS at each intersection
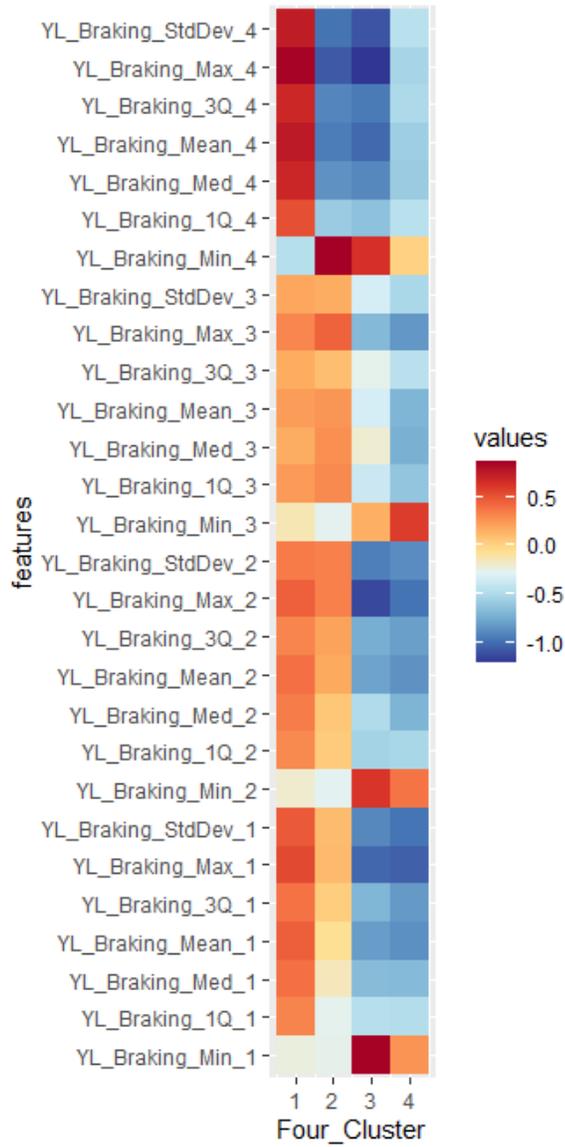
Figure 12: Comparison of the braking numerical summaries with respect to DS at each intersection
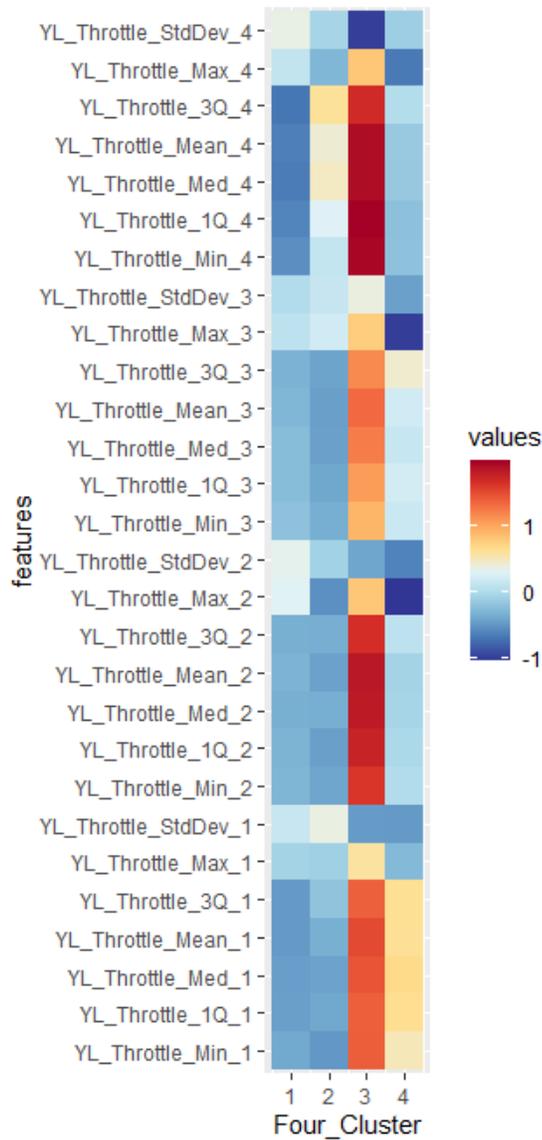
Figure 13: Comparison of the throttle numerical summaries with respect to DS at each intersection

The clustering classified the participants into four groups. Participants in each group were similar relative to driving parameters. As shown in Figures 14, 15, and 16, each driving cluster had a different driving behavior. The three Figures demonstrate the difference in the variables across the four clusters (vertically).

Drivers pertaining to driving cluster or Driving Style (DS) number 1 had the lowest speed and throttle summary variables across the four intersections as given in Figures 14, and 16. Also, DS 1 drivers had the lowest braking ratios compared to others as indicated in Figure 15. Thus, participants classified in DS 1 were considered to be safe drivers characterized by overall low speed and throttle, and stiffer braking at an intersection.

DS 2 drivers also showed low speed, low throttle, and high braking at the first three intersection and resembled somehow to the driving style of DS 1. However, the difference between the two DSs was indicated at intersection 4 where DS 2 showed a different behavior characterized by higher speed, high throttle, and lower braking than the three other intersections. Thus, DS 2 showed safe driving signs only across the three first intersections and exerted a different, more risky behavior, at the fourth intersection.

Drivers of DS 3 had generally the highest speed, highest throttle, and lowest braking at the four intersections. DS 3 drivers had the lowest speed standard deviations compared to other DS meaning that their driving wasn't much affected by the signal change and most probably did not stop. This is also validated by low values of braking and high values of throttle, meaning that DS 3 drivers proceeded through the intersection without much braking while increasing their speed.

Lastly, DS4 drivers showed higher speed, higher throttle, lower braking than DS1 and DS2. However, they had lower speed, lower throttle and higher braking than DS3. This behavior was consistent across the four intersections. Thus, DS4 are neither the fastest driving participants among the four clusters, nor the safest.

Aggressive   **DS3**   **DS4**   **DS2**   **DS1**   **Safe**

Figure 14: Driving Style Safe-Aggressive scale

As a result, the four driving styles were given names based on their classification and driving outcome. Driver from Driving Style 1 were named "Safest Drivers", Driving Style 2 drivers were named as "Safe Drivers", the name "Speed Demons" was given to Driving Style 3 drivers, and "Mildly Aggressive Drivers" to drivers from Driving Style 4. Figure 17 shows a scale from safe to aggressive and the placement of each DS on this scale

Psychological data

The dependent categorical variable was the stop/go decision (1 if the driver decides to proceed and 0 if otherwise). To model for this variable a set of valid independent variables was selected using exploratory analysis. The results were then analyzed using descriptive statistics and the relationship between the driving decision and the psychological traits, moderated by the driving parameters (Four Driving styles), was explored. Table 4 represents descriptive statistics for the age, gender, and all the other psychological scales before the selection process.

Table 5: Descriptive statistics for all the scales

Variable	Mean	SD	Range
StateAnxietyPre	2.04	0.53	1.0 - 3.1
StateAnxietyPost	2.13	0.57	1.0 - 4.0

Mindfulness	4.17	0.61	2.3 - 5.7
Impulsiveness	2.73	0.61	1.3 - 4.4
Anxiety-based performance deficits	2.28	0.78	1.0 - 4.6
Exaggerated safety/caution behavior	4.67	1.06	1.8 - 7.0
Hostile/aggressive behavior	2.95	1.07	1.0 - 6.0
Trait EI	5.23	0.65	3.4 - 6.6
WellBeing	5.76	0.84	2.7 - 7.0
SelfControl	4.88	0.82	3.2 - 6.7
Emotionality	4.91	0.79	2.8 - 6.8
Sociability	5.30	0.82	2.7 - 7.0
Gender (female = 0, male = 1)	0.68	0.47	0 - 1
Age	30.09	12.19	18.0 – 64

Exploratory analysis and Independent variables selection

In order to select the suitable set of psychological variables for the analysis, an exploratory analysis was performed. The selection process used multiple Pearson's correlation tests. The tests showed low significance Trait EI, State Anxiety Pre and Post, and Hostile Driving Behavior and for all the demographics such as age and gender. Thus, these were dropped from the analysis and were not considered as independent variables.

Results

Each intersection had different characteristics such as a different distance at which the yellow light changes and a different yellow light duration as presented in Table 6.

Table 6: Design characteristics of the intersections

Intersection #	Distance of signal change to stop bar in meters	Yellow signal duration in seconds
1	65.8	3
2	69.6	4
3	61.8	3
4	56.1	3

Thus, each intersection was analyzed separately with respect to every psychological variable with the help of boxplots and t-tests. A series of unpaired student's t-tests was performed to test whether the means of psychological scales were different with respect to the drivers' decision. Before performing any t-test, the normality assumption and variance were assessed using the Shapiro-Wilk and the F-test. Table 7 present unpaired t-tests that were performed to examine mindfulness. Overall, the tests showed that there wasn't a significant difference between scores with respect to decision expect for the Safest Drivers (DS1) at intersection 1 with p-value of 0.046 (<0.05). Also, a Man-Whitney U-test was used instead of t-test for non-normal samples.

Table 7: Unpaired t-tests for mindfulness between the stop/go decisions

Psychological traits	Intersection	Driving Style	Mean		t	p-value
			Passed	Stopped		
Mindfulness	1	1	3.98	4.36	-2.04	0.046*
		2	4.28	4.23	0.19	0.848
		3	Low sample size (most passed)			
		4	Low sample size (most passed)			

2	1	4.19	4.24	-0.22	0.825
	2	4.37	4.2	0.74	0.469
	3	Low sample size (most passed)			
	4	Low sample size (most passed)			
3	1	4.00	4.28	-1.17	0.246
	2	Low sample size			
	3	4.13	4.25	-0.40	0.693
	4	**Not normal, Mann Whitney p-value = 0.1851**			
4	1	4.52	4.21	1.03	0.307
	2	Low sample size			
	3	Low sample size			
	4	3.79	4.20	-1.19	0.253

Note: *p < .05. **p < .01. *** p < .001

Table 8 shows all the unpaired t-test that gave back significant results. Those instances show that the decision was affected by the psychological trait. For instance, speed demons who stopped at intersection three had higher scores of impulsiveness than those who decided to pass. The other instances are discussed below each under the corresponding psychological trait.

Table 8: Unpaired t-test with significant results

Psychological traits	Intersection	Driving Style	Mean		t	p
			Passed	Stopped		
Mindfulness	1	1	3.98	4.36	-2.04	0.046*
Impulsiveness	3	3	2.56	3.46	-2.24	0.043*

Anxiety-based performance deficits	3	3	1.90	2.68	-2.22	0.045*
Exaggerated safety	3	1	3.93	4.86	-2.21	0.031*

*Note: *p < .05. **p < .01. *** p < .001*

The below boxplots describe mindfulness, impulsiveness, anxiety driving, and safe driving in order to compare all those psychological variables in all the driving styles, particularly between those who passed or stopped at the yellow light of each intersection.

Mindfulness
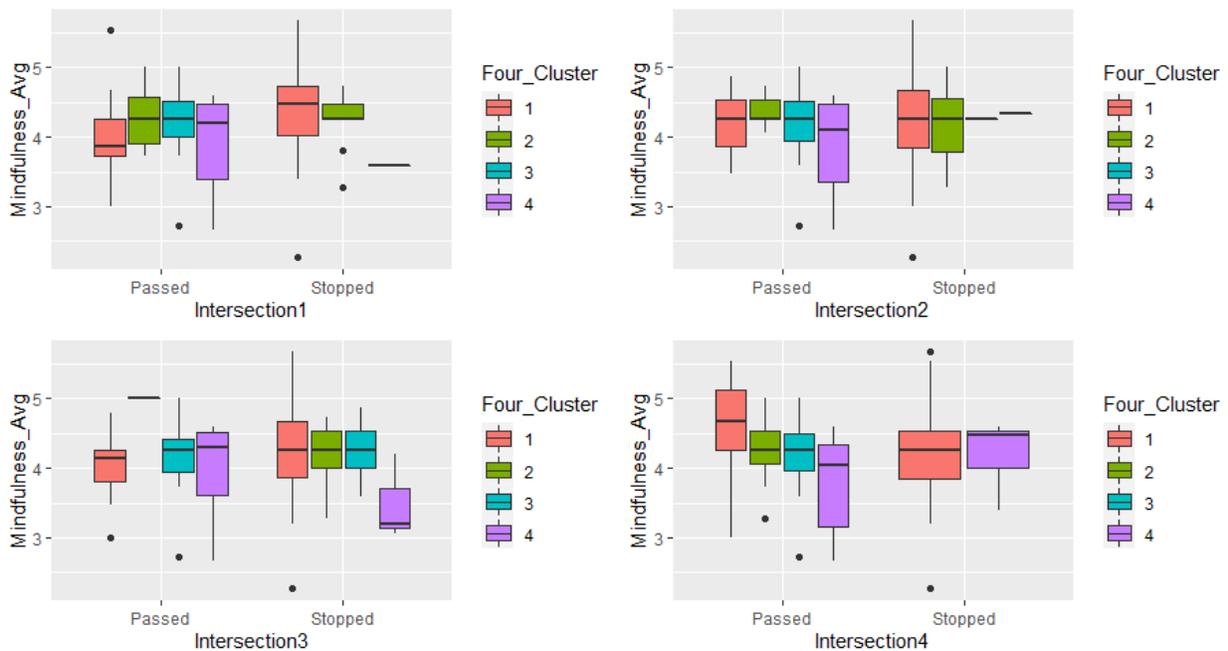
Figure 15: Boxplots for mindfulness

      Intersection 1. For the safest drivers (Driving style 1), the median of mindfulness for drivers who stopped, 4.5, was larger than that for those who passed 3.8. Overall, a big percentage

of these drivers (cluster of safest drivers) who passed had lower mindfulness scores than those who stopped. In other words, more than 50% of those who stopped, had higher than 4.5 mindfulness average scores with maximum of 5.7 whereas more than 75% of those who passed had lower than 4.3 scores with a maximum of 4.6. The t-test results shown in Table 6 also indicate that there is a difference in means and it is significant ($p<0.05$). Regarding safe drivers (DS2), which have mainly the same safe driving characteristics as the safest drivers at intersection 1, there was less variability among drivers who stopped than those who passed. It was shown also that most speed demons (DS3) and all mildly aggressive drivers (DS4) decided to proceed. Also, the participant with the lowest minimum mindfulness score pertained to the mildly aggressive drivers. In other words, drivers who stopped had more consistent scores opposed to those who did not.

Intersection 2. The medians for all psychological traits were almost similar with a very minimal difference. Participants with the highest mindfulness scores (almost 5.7) at this intersection pertained to the safest drivers and decided to stop. Whereas, participants with lowest minimum mindfulness scores (2.6) at this intersection were mildly aggressive drivers. Also, most speed demons and mildly aggressive drivers took the decision to pass at this intersection opposed to the safest and safe drivers.

Intersection 3. At this intersection, safest drivers who passed had slightly lower mindfulness scores than those who stopped. There was a higher variability in scores for those who decided to stop as well. Only one safe driver decided to continue, and the rest stopped. As for speed demons, they had almost the same scores and variation. mildly aggressive drivers who passed had overall higher center (median) than those who stopped.

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Intersection 4. Safest drivers at this intersection had somehow same mindfulness scores range regardless of the decision. Those who stopped had a higher center than those who did not. Also, the sample size for those who stopped was much larger than for those who passed (ten times bigger). As for safe and 3 drivers, all the participants on this intersection decided to continue. mildly aggressive drivers who stopped had overall higher median score (4.5 vs. 4), lower variation, same maximum, and lower mindfulness score minimum (3.5 vs. 2.6) than those who passed.

Impulsiveness
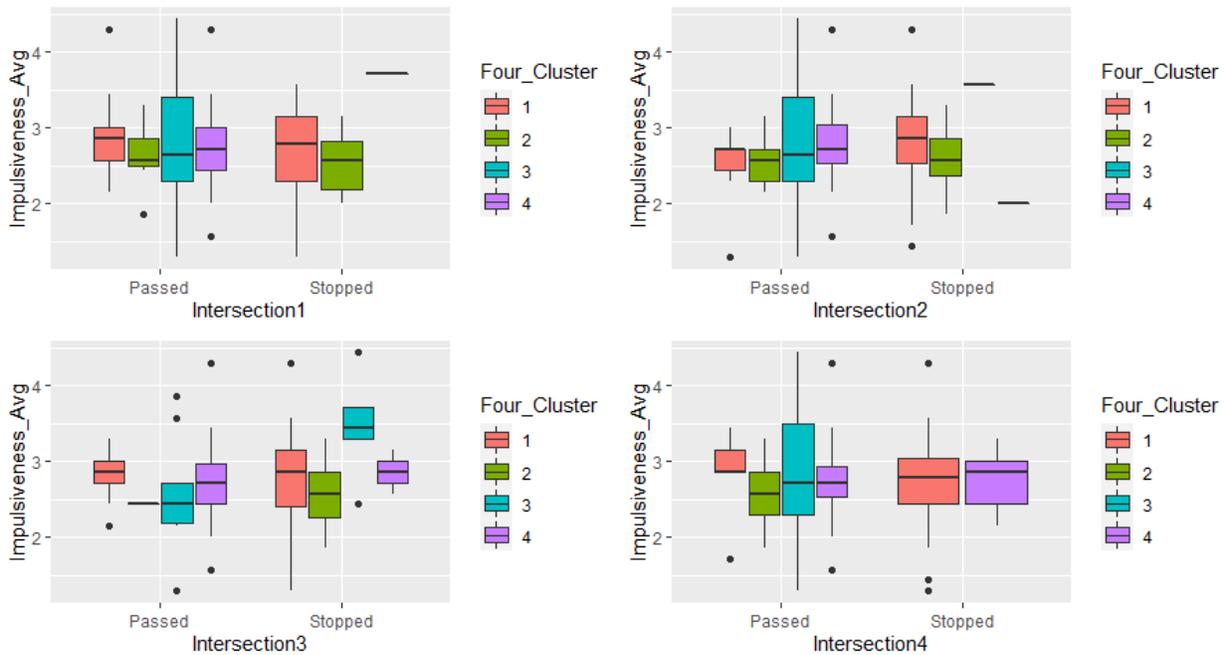
Figure 16: Boxplots for impulsiveness

Intersection 1. safest drivers who passed had slightly higher median than those who did not. Also, the variation in impulsiveness scores for those who stopped was very significant, ranging from 3.5 to 1.3 (which is the lowest minimum among all the DS). More than 25% of safest drivers who stopped had impulsiveness scores of less than 2.5 whereas more than 75% of

safest drivers who passed had 2.3 scores and above. Regarding safe drivers, they had almost similar impulsiveness median scores but those who passed had higher maximum and those who stopped lower minimum. All DS3 drivers decided to pass. These drivers had the most variability in scores among the other groups, having scores that range from maximum scores to minimum. DS3 was the only cluster with a significant number of participants (almost 25%) that had impulsiveness scores of more than 3.5.

Intersection 2. Safest drivers who passed had lower median impulsiveness scores and were less variable. However, 25% of safest drivers who stopped had lower than 2.5 impulsiveness scores. safe drivers who stopped had the same median values as those who did not. The scores for speed demons and mildly aggressive drivers were almost similar to those at the first intersection.

Intersection 3. Safest drivers had similar medians regardless of their stop/go decision. However, the variation in impulsiveness scores for those who stopped was much more significant than those who passed. More than 25% of safest drivers who stopped had impulsiveness scores of less than 2.5 whereas all of safest drivers who passed had scores higher than 2.5. The most apparent change is that safe drivers who are considered as safe drivers, yet less cautious than safest drivers, all decided to stop. Also, a significant number of speed demons decided to stop and had noticeably higher impulsiveness values (the highest among the rest). A t-test showed that the difference was significant with a p=0.043 as indicated in Table 6.

Intersection 4. Safest drivers who passed had higher median impulsiveness scores than those who stopped. Other DS drivers had similar scores regardless of the decision.

Anxiety-based performance deficits
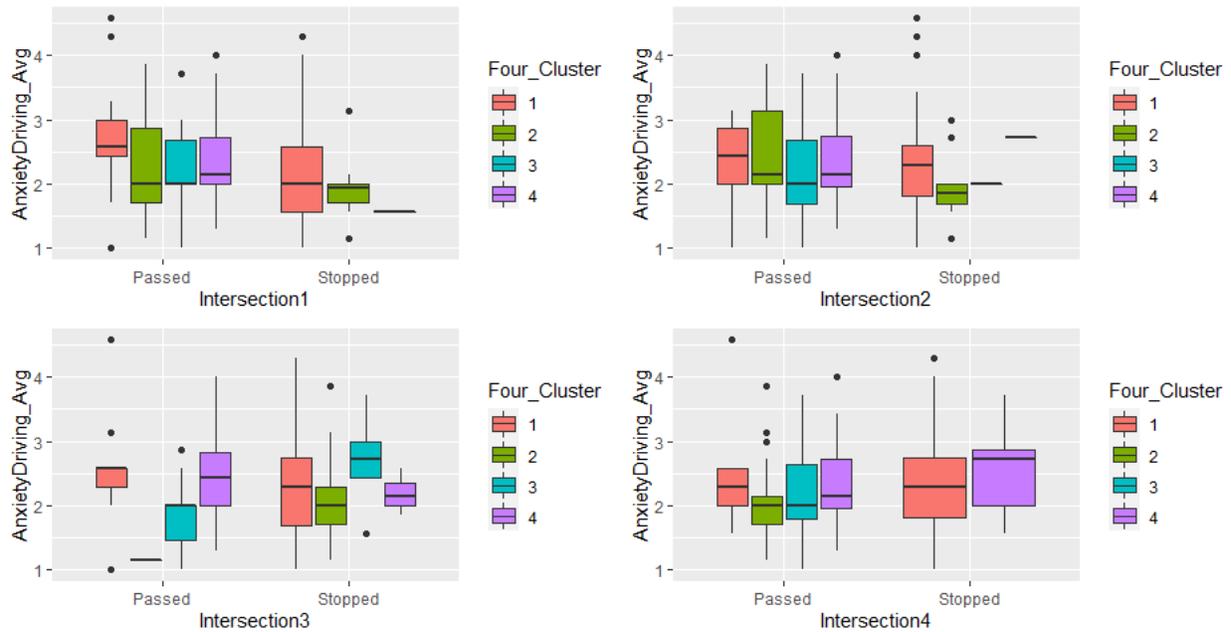
Figure 17: Boxplots for Anxiety-based performance deficits

  Intersection 1. DS 1 drivers who passed had higher median anxiety scores than those who stopped. 75% of the scores for those who passed were higher than 2.5 as opposed to only 25% for those who stopped. After failing the normality test, the scores for the two decisions were compared using a Mann-Whitney U test and the difference was significant (p=0.01315). safe drivers who passed had higher variation than those who did not. The maximum for those who crossed was almost 3.9 with 25% of the scores higher than 3 whereas those who stopped had a maximum score of 2.3 and a much smaller range.

  Intersection 2. Anxiety scores for safest drivers were less more similar at this intersection and varied less. As for safe drivers, those who decided to proceed had also higher scores than those who did not. The difference slightly increased, 75% of the scores for those who passed were higher than 2 whereas 100% of the scores for those who stopped were less than 2.

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Intersection 3. safest drivers who passed had slightly higher median but the scores for those who stopped had more variability. For safest drivers, the difference wasn't significant as shown in Table 6. speed demons had who passed had lower anxiety driving scores (almost 100% less than 2.5) than those who stopped (almost 100% higher than 2.5). A significant difference was indicated in Table 6 with a p=0.045.

mildly aggressive drivers who decided to stop had less variation, lower median, and lower maximum than those who decided to pass.

Intersection 4. Decision did not affect the scores for safest drivers. mildly aggressive drivers who passed had lower anxiety median than those who stopped.

Exaggerated safety/caution behavior
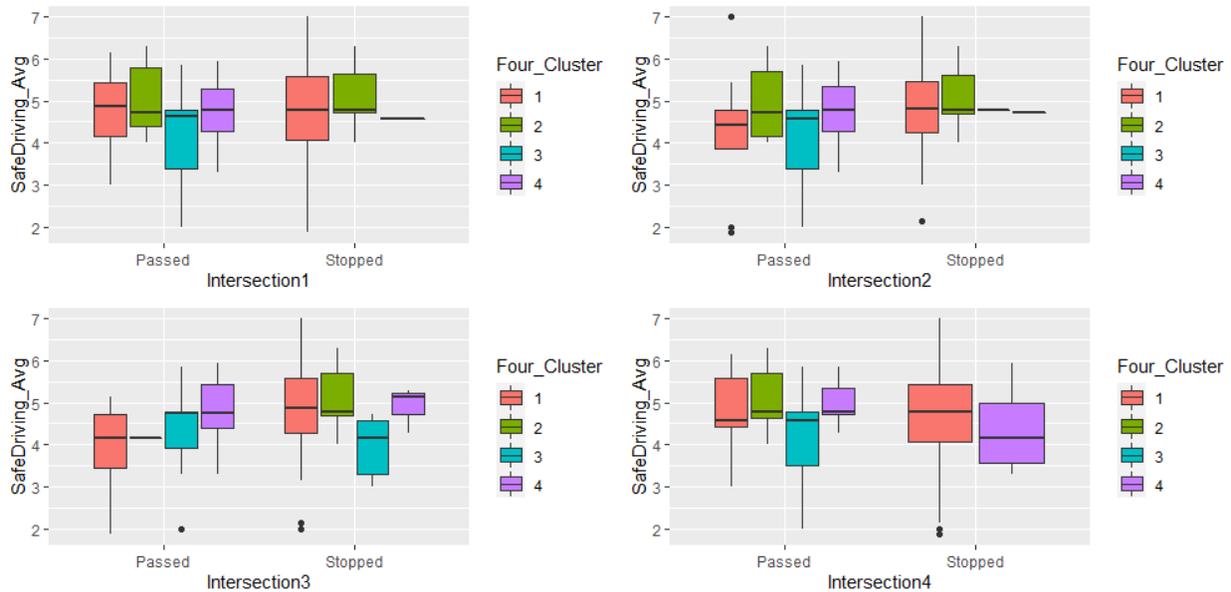
Figure 18: Boxplots for Exaggerated safety/caution behavior

Intersection 1. Overall, the scores were similarly distributed. Safest drivers who stopped had the most variability in scores (higher maximum and lower minimum) than those who continued but both had equal medians. Also, safe drivers had similar medians regardless of their decision.

Intersection 2. Relatively higher scores for safest drivers who stopped. These drivers had the highest median and maximum whereas speed demons who passed had the lowest minimum. Safe drivers had similar scores regardless of the decision. Overall, the scores at this intersection weren't very different.

Intersection 3. Safest drivers who passed had a lower median, lower maximum, and a lower minimum than those who stopped. A significant difference in means (p=0.031) was obtained using a t-test as given in Table 6. These safest drivers also had the lowest minimum among all other driver styles (under 2) whereas those who stopped had a highest maximum of 7.

Speed demons who passed had higher maximum scores, lower minimum scores, and higher median values than those who stopped. As for mildly aggressive drivers, those who stopped had a median higher than 5 whereas those who passed had one lower than 5.

Intersection 4. Safest drivers who stopped had higher variation and slightly higher median scores than those who passed. Mildly aggressive drivers who passed had also higher median scores. Also, safe drivers (all decided to pass) had a median higher than the medians of mildly aggressive drivers who decided to stop.

Chapter Five

Discussion and Conclusion

Discussion

This study investigated the influence of the drivers' personality traits on the driving behavior at the onset of the yellow. They drove across four intersections with differing yellow light lengths and differing distances of green-yellow signal change. The driving outcomes were assessed by a driving simulator whereas the psychological measures by a questionnaire. One hundred and two drivers participated in the study and the findings were notable.Using hierarchical clustering and t-tests, a significant relationship was found between the psychological factors, driving outcomes, and different intersections characteristics.

Intersection 1

Being the first intersection in the simulator, intersection one can be considered as a novel experience. Given that only five drivers out of 102 (approx. 0.05%) had driven on a simulator before, the surprise factor cannot be ignored at this intersection.

Despite that, the t-test for safest drivers (DS1) at this intersection showed that the difference in mindfulness scores was significant. A big portion of those who decided to stop from this group were more mindful than those who passed. Safest drivers were expected to show higher mindfulness scores for when they decide to stop, considering their safe driving outcomes such as lower speed and higher braking ratios. In other words, given a new experience, safe drivers with high mindfulness are more likely to stop at a yellow light as opposed to drivers with lower mindfulness. This comes in line with previous studies stating that trait mindfulness is

associated with a reduced engagement in violations and risky behavior (Murphy & Matvienko-Sikar, 2019).

At this intersection also, a significant number of safe drivers (DS2) who stopped were less impulsive as those who decided to proceed. Moreover, among safe drivers the participant with the highest impulsiveness score decided to pass whereas the one with the least decided to stop. Thus, passing behavior at a yellow light is linked to impulsiveness, in line with previous findings (e.g., Berdoulat et al., 2013; Hatfield et al., 2017). As for "speed demons" (DS3) all of them decided to pass, and this can be explained by how almost 25% of them have higher impulsiveness scores than all the rest. In other words, aggressive drivers are more likely to be highly impulsive and pass a yellow light for the first time at a new intersection.

Both anxiety-based performance and exaggerated safety scores did not differ much among the driving styles and the decision. This mostly pertained to the novelty of the experience. Drivers were apparently unable to perceive the danger or risk related to their actions on the first intersection.

Intersection 2

There was not a significant difference in psychological variables between driving styles at this intersection. The surprise factor was lower at this intersection and drivers had developed some expectations regarding what is going to happen. Also, among all the other intersections, this intersection had the longest distance at which the signal changed along with the longest yellow time (4 s vs. 3 s for the others). All these factors made this intersection robust to the driving styles and psychological traits. Nevertheless, some observations can still be noteworthy. For instance, higher number of safe and safest drivers stopped at this intersection than at the first one which was expected. Also, safe drivers who stopped showed slightly higher exaggerated

safety than those who passed. In other words, results at this intersection show that the influence of intersection design and driver anticipation overrides that of the psychological traits.

Intersection 3

At the third intersection, a notable transition in behavior was observed mostly for safe and aggressive drivers. This intersection had a much lower distance of signal change to stop bar than the preceding one (61 m vs. 69 m). This change in design resulted in a change in the distribution of the driving styles among the stop/go decision. The changes in intersection 3 are mostly reflected by the change in aggressive drivers' behavior. For instance, most of these drivers decided to pass all the intersections expect for at intersection three where drivers were almost split in half. Aggressive drivers had a significant difference in both impulsiveness and anxiety driving as previously shown in the t-tests. For such drivers, stopping at an intersection after some changes in the design is itself challenging. Thus, drivers who are more impulsive stopped, which was not how these aggressive drivers would normally behave.

According to McCrae et al. (2005), one of four impulsivity constructs is "urgency" which is explained by a rashly behavior in response to a distress. For such group of drivers, stopping is considered to be a rashly behavior especially that they did not consider stopping at any intersection except for this one. Though mostly associated with driver anger and increased violations (Constantinou et al., 2011; Dahlen et al., 2005), it is noteworthy that the findings for this scenario were different. It is likely that these findings are caused by the unique Lebanese driving environment and behavior. Lack of laws and a behavior more inclined towards unsafe driving could be strong factors as to why an "impulsive" act would be associated with stopping and not passing. Because passing would be more appealing and logical in that case. This supports the probability that the aggressive drivers (DS3) from this sample most likely

correspond with those from the Lebanese population. Another possible explanation to this scenario could be that the findings indeed present a general understudied characteristic related to impulsiveness and further research is needed.

In other words, at a borderline intersection such as intersection three, impulsive drivers similar to these drivers are more likely to stop than to proceed. The same can be said about anxiety driving because for these drivers, such change was maybe not anticipated, which caused the more anxious drivers to stop. Thus, impulsive and non-anxious drivers who drive fast are more likely to stop than continue at a confusing intersection.

In addition, the t-test showed a significant difference between safest drivers (DS1) at the safe driving (score) behavior level. Those who stopped were more likely to exhibit a safe driving behavior. Thus, safest drivers (DS1) would still consider taking a safe decision at a confusing intersection.

Intersection 4

Distance of signal change became much shorter at this intersection. This intersection was tricky, and most drivers apparently felt that it would rather be safer to pass than to stop. For instance, a good number of safe drivers who passed were more mindful than those who stopped. Also, All safe drivers which had safe driving outcomes from the simulator decided to pass at this intersection. Adding that mildly aggressive drivers who decided to stop at this intersection were less of safe drivers than those who passed. This shows that at such distance, the decision gets highly influenced by the perception that passing would be possible without any problems.

Also, both Anxiety-based performance and exaggerated safety scales can be used as a validation for the driving styles classification. Both driving styles 1 and 2 that were considered to be the safer among the 4 groups (with respect to their simulator driving outcomes) were

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associated with higher exaggerated safety scores. In addition, aggressive drivers in DS 3 and 4 were associated with higher anxiety-based performance scores. In other words, this self-reported behavior was reflected by the revealed behavior in the simulator.

Implications

This study highlights the relationship between the psychological attributes and the driving behavior of Lebanese drivers at an intersection. It also supports the premise that personality types influence the driver's decision whether to pass or not at a signal change. Results showed that more mindful drivers were more likely to stop at a yellow light than pass. It was also found that impulsive drivers decided to stop at a confusing scenario (i.e.: intersection three), and that the same group of drivers have lower stated anxiety behavior than those who passed.

The research results highlights the influence of psychology on the driving behavior. The study also exposed the need to further explore this research area, knowing its benefits in reducing highway risk and increasing safety. Previous research found that many effective resolutions can be adapted to address this matter such as provisions in signal interval times (Bonneson & Zimmerman, 2004; Gates et al., 2007; Schattler & Datta, 2004), pavement marking (Yan et al., 2005), and type of signal light (Hussain et al., 2020). For instance, Bonneson & Zimmerman (2004) found that a 1.0 s increase in the yellow light duration (given that signal's time does not exceed 5.5 s) would lead to a 50% decrease in the number of red-light violations. This study also showed that drivers' adaptation to such increase doesn't undo the benefits. Schattler & Datta (2004) found that providing adequate lengths for all-red clearance intervals (ARI) helps decrease the probability of occurrence of right-angle crashes. Moreover, Yan et al. (2005) conducted a driving simulator study that assessed the influence of pavement marking on the driving behavior

at the yellow change interval. The distance to intersection of the dynamic pavement marking changes based on dilemma zone calculations. Results showed that such implementation was responsible for almost 75% percent of reduction in red-light running occurrences. Results also found that the marking helped decrease deceleration rates of those who decided to stop. In addition, Hussain et al. (2020) examined the influence of different traffic light settings on red-light running occurrences. The driving simulator study found on one hand that red led ground lights synchronized with the traffic signals (R-LED) significantly reduced red-light running probability. On the other hand, it was found that other traffic light settings such as flashing green and countdown clock did not help reducing such occurrences. There is a myriad of effective solutions for improving crashes prevention at an intersection. The next step is to conduct more definitive studies in this area addressing the Lebanese driver behavior. Further developed and focused studies relating yellow light behavior to road safety will help push for more implementations of countermeasures and stronger law enforcement in Lebanon. Other educational activities and public awareness campaigns are also needed to target drivers' personality attributes. By addressing one of the most prevalent road safety issues, this will help create a safer environment and reduce fatalities.

Limitations

This study is among the first attempts in Lebanon to explore the drivers' behavior at an intersection. Herein, there are some limitations that have to be highlighted and tackled in future studies. The sample may not be representative of all the Lebanese drivers since it largely consists of university students, staff, and faculty. Further, the sample size is relatively small and not proportionally distributed by age, gender, and occupation. This might have affected some outcomes related to some factors. For instance, the sample was skewed more towards younger

participants. The used sample also had more male participants than females. This could explain why age and gender weren't significantly related to drivers' decision at the intersection.

Additionally, participants in the simulator may have altered their choice on whether to pass or not and may have behaved in a different way in reality. There is also a concern about participants' response bias in the surveys. Sometimes participants underreport data on questionnaires or exaggerate which could have happened here. A driving simulator is a safe and effective measure to examine the driving behavior. However, it does not necessarily deliver the same level of complexity of those of the real world. For this reason, naturalistic studies, which highly depend on in-vehicle driving cameras, may be explored in the future to validate the results of this research study and other similar studies.

References

"Intersection Safety." Federal Highway Administration. Retrieved July 13, 2020, from https://safety.fhwa.dot.gov/intersection/

Abbas, M., Machiani, S. G., Garvey, P. M., Farkas, A., & Lord-Attivor, R. (2014). *Modeling the Dynamics of Driver's Dilemma Zone Perception Using Machine Learning Methods for Safer Intersection Control*. https://doi.org/10.1061/(ASCE)TE.1943-5436.0000885

Abdu, R., Shinar, D., & Meiran, N. (2012). Situational (state) anger and driving. *Transportation Research Part F: Psychology and Behaviour*, *15*(5), 575–580. https://doi.org/10.1016/j.trf.2012.05.007

Ābele, L., Haustein, S., Møller, M., & Zettler, I. (2020). Links between observed and self-reported driving anger, observed and self-reported aggressive driving, and personality traits. *Accident Analysis and Prevention*, *140*(January). https://doi.org/10.1016/j.aap.2020.105516

Aswad Mohammed, H., Hurwitz, D. S., & Macuga, K. L. (2020). Drivers' visual attention during the onset of the circular yellow indication at high-speed signalized intersections. *Traffic Injury Prevention*, *21*(4), 259–264. https://doi.org/10.1080/15389588.2020.1741559

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., Walsh, E., Duggan, D., & Williams, J. M. G. (2008). Construct Validity of the Five Facet Mindfulness Questionnaire in Meditating and Nonmeditating Samples. *Assessment, 15*(3), 329–342. https://doi.org/10.1177/1073191107313003

Bahammam, M. (2016). Validity and reliability of an Arabic version of the state-trait anxiety inventory in a Saudi dental setting. *Saudi Medical Journal, 37*(6), 668–674. https://doi.org/10.15537/smj.2016.6.13935

Baker, A. S., Litwack, S. D., Clapp, J. D., Beck, G., & Sloan, D. M. (2014). The driving behavior survey as a measure of behavioral stress responses to MVA-related PTSD. *Behavior therapy, 45*(3), 444–453. https://doi.org/10.1016/j.beth.2014.02.005

Bar-Gera, H., Musicant, O., Schechtman, E., & Ze'evi, T. (2016). Quantifying the yellow signal driver behavior based on naturalistic data from digital enforcement cameras. *Accident Analysis and Prevention*, *96*, 371–381. https://doi.org/10.1016/j.aap.2015.03.040

Barnes, L. L. B., Harp, D., & Jung, W. S. (2002). Reliability Generalization of Scores on the Spielberger State-Trait Anxiety Inventory. *Educational and Psychological Measurement, 62(4)*, 603–618. https://doi.org/10.1177/0013164402062004005

Berdoulat, E., Vavassori, D., & Sastre, M. T. M. (2013). Driving anger, emotional and instrumental aggressiveness, and impulsiveness in the prediction of aggressive and transgressive driving. *Accident Analysis & Prevention, 50*, 758–767. https://doi.org/10.1016/j.aap.2012.06.029

Bergeron, J. (1983). State-trait anxiety in French-English bilinguals: Cross-cultural considerations. Series in Clinical & Community Psychology: Stress & Anxiety, 2, 157–176.

Bıçaksız, P., & Özkan, T. (2016). Impulsivity and driver behaviors, offences and accident involvement: A systematic review. *Transportation Research Part F: Traffic Psychology and Behaviour, 38*, 194–223. https://doi.org/10.1016/j.trf.2015.06.001

Bonneson, J. A., & Zimmerman, K. H. (2004). Effect of yellow-interval timing on the frequency of red-light violations at Urban intersections. *Transportation Research Record*, *1865*, 20–27. https://doi.org/10.3141/1865-04

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822–848. https://doi.org/10.1037/0022-3514.84.4.822

Caird, J. K., Chisholm, S. L., Edwards, C. J., & Creaser, J. I. (2007). The effect of yellow light onset time on older and younger drivers' perception response time (PRT) and intersection behavior. *Transportation Research Part F: Traffic Psychology and Behaviour*, *10*(5), 383–396. https://doi.org/10.1016/j.trf.2007.03.002

Choudhary, P., & Velaga, N. R. (2019). Driver behaviour at the onset of yellow signal: A comparative study of distraction caused by use of a phone and a music player. *Transportation Research Part F: Traffic Psychology and Behaviour*, *62*, 135–148. https://doi.org/10.1016/j.trf.2018.12.022

Clapp, J. D., Olsen, S. A., Beck, J. G., Palyo, S. A., Grant, D. M., Gudmundsdottir, B., & Marques, L. (2011). The Driving Behavior Survey: Scale construction and validation. *Journal of Anxiety Disorders, 25*(1), 96–105. https://doi.org/10.1016/j.janxdis.2010.08.008

Constantinou, E., Panayiotou, G., Konstantinou, N., Loutsiou-Ladd, A., & Kapardis, A. (2011). Risky and aggressive driving in young adults: Personality matters. *Accident Analysis & Prevention, 43*(4), 1323–1331. doi:10.1016/j.aap.2011.02.002

Cooper, A., & Petrides, K. V. (2010). A Psychometric Analysis of the Trait Emotional Intelligence Questionnaire–Short Form (TEIQue–SF) Using Item Response Theory. *Journal of Personality Assessment, 92*(5), 449–457. https://doi.org/10.1080/00223891.2010.497426

Dahlen, E. R., Martin, R. C., Ragan, K., & Kuhlman, M. M. (2005). Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. *Accident Analysis & Prevention, 37*(2), 341–348. doi:10.1016/j.aap.2004.10.006

Danaf, M., Abou-Zeid, M., & Kaysi, I. (2015). Modeling anger and aggressive driving behavior in a dynamic choice-latent variable model. *Accident Analysis and Prevention*, *75*(2015), 105–118. https://doi.org/10.1016/j.aap.2014.11.012

Duan, J., Li, Z., & Salvendy, G. (2012). Automatic Imitation of Risky Behavior: A Study of Simulated Driving in China. *Traffic Injury Prevention*, *13*(5), 442–449. https://doi.org/10.1080/15389588.2012.655430

Elhenawy, M., Jahangiri, A., Rakha, H. A., & El-Shawarby, I. (2015). Modeling driver stop/run behavior at the onset of a yellow indication considering driver run tendency and roadway surface conditions. *Accident Analysis and Prevention*, *83*, 90–100. https://doi.org/10.1016/j.aap.2015.06.016

Elmitiny, N., Yan, X., Radwan, E., Russo, C., & Nashar, D. (2010). Classification analysis of driver's stop/go decision and red-light running violation. *Accident Analysis and Prevention*, *42*(1), 101–111. https://doi.org/10.1016/j.aap.2009.07.007

El-Shawarby, I., Rakha, H., Inman, V., & Davis, G. (2006). Effect of yellow-phase trigger on driver behavior at high-speed signalized intersections. *IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC*, 683–688. https://doi.org/10.1109/itsc.2006.1706821

Feher, A., Yan, G., Saklofske, D. H., Plouffe, R. A., & Gao, Y. (2019). An Investigation of the Psychometric Properties of the Chinese Trait Emotional Intelligence Questionnaire Short Form (Chinese TEIQue-SF). *Frontiers in Psychology*, 10. https://doi.org/10.3389/fpsyg.2019.00435

Fountoulakis, K. N., Siamouli, M., Moysidou, S., Pantoula, E., Moutou, K., Panagiotidis, P., Kemeridou, M., Mavridou, E., Loli, E., Batsiari, E., Preti, A., Tondo, L., Gonda, X., Mobayed, N., Akiskal, K., Akiskal, H., Costa, P., & McCrae, R. (2014). Standardization of the NEO-PI-3 in the Greek general population. *Annals of General Psychiatry*, 13(1). https://doi.org/10.1186/s12991-014-0036-9

Gardner, K. J., & Qualter, P. (n.d.). Concurrent and incremental validity of three trait emotional intelligence measures. *Australian Journal of Psychology*, 62(1), 5–13. Retrieved from https://www.academia.edu/16510787/Concurrent_and_incremental_validity_of_three_trait_emotional_intelligence_measures

Gates, T. J., Noyce, D. A., Laracuente, L., & Nordheim, E. V. (2007). Analysis of driver behavior in dilemma zones at signalized intersections. *Transportation Research Record*, *2030*, 29–

39. https://doi.org/10.3141/2030-05

Gazis, D., Herman, R., & Maradudin, A. (1960). The Problem of the Amber Signal Light in Traffic Flow. *Operations Resaerch*, *8(1)*(August 2015), 112–132.

Ghanipoor Machiani, S., & Abbas, M. (2016). Assessment of driver stopping prediction models before and after the onset of yellow using two driving simulator datasets. *Accident Analysis and Prevention*, *96*, 308–315. https://doi.org/10.1016/j.aap.2015.04.040

Hamdar, S. H., Mahmassani, H. S., & Chen, R. B. (2008). Aggressiveness propensity index for driving behavior at signalized intersections. *Accident Analysis and Prevention*, *40*(1), 315–326. https://doi.org/10.1016/j.aap.2007.06.013

Haque, M. M., Ohlhauser, A. D., Washington, S., & Boyle, L. N. (2015). Decisions and actions of distracted drivers at the onset of yellow lights. *Accident Analysis and Prevention*, *96*, 290–299. https://doi.org/10.1016/j.aap.2015.03.042

Hatfield, J., Williamson, A., Kehoe, E. J., & Prabhakharan, P. (2017). An examination of the relationship between measures of impulsivity and risky simulated driving amongst young drivers. *Accident Analysis & Prevention*, 103, 37–43. https://doi.org/10.1016/j.aap.2017.03.019

Hayley, A. C., Ridder, B. de, Stough, C., Ford, T. C., & Downey, L. A. (2017). Emotional intelligence and risky driving behaviour in adults. *Transportation Research Part F: Traffic Psychology and Behaviour*, 49, 124–131. https://doi.org/10.1016/j.trf.2017.06.009

Hine, T., Ingram, B., & Glendon, I. (2015). Impulsivity and Aggression in Young Drivers Assessed in Short Driving Simulator Scenarios. *Research-Repository.Griffith.Edu.Au; Australasian College of Road Safety*. https://research-repository.griffith.edu.au/handle/10072/110938

Hurwitz, D. S., Wang, H., Knodler, M. A., Ni, D., & Moore, D. (2012). Fuzzy sets to describe driver behavior in the dilemma zone of high-speed signalized intersections. *Transportation Research Part F: Traffic Psychology and Behaviour*, *15*(2), 132–143. https://doi.org/10.1016/j.trf.2011.11.003

Hussain, Q., Alhajyaseen, W. K. M., Brijs, K., Pirdavani, A., & Brijs, T. (2020). Innovative countermeasures for red light running prevention at signalized intersections: A driving simulator study. *Accident Analysis and Prevention*, *134*(September 2019), 105349. https://doi.org/10.1016/j.aap.2019.105349

Jahangiri, A., Rakha, H., & Dingus, T. A. (2016). Red-light running violation prediction using observational and simulator data. *Accident Analysis and Prevention*, *96*, 316–328. https://doi.org/10.1016/j.aap.2016.06.009

Jermann, F., Billieux, J., Larøi, F., d'Argembeau, A., Bondolfi, G.,Zermatten, A., & Van der Linden, M. (2009). Mindful attention awareness scale (MAAS): psychometric properties of the French translation and exploration of its relations with emotion regulation strategies. *Psychological Assessment*, 21(4), 506–514.https://doi.org/10.1037/a0017032.

Kass, S. J., VanWormer, L. A., Mikulas, W. L., Legan, S., & Bumgarner, D. (2011). Effects of Mindfulness Training on Simulated Driving: Preliminary Results. *Mindfulness*, 2(4), 236–241. https://doi.org/10.1007/s12671-011-0066-1

Khanipour, H., Tavallaii, S. A., Ahmadi, K. (2015). Psychometric Properties of the Driving Behavior Survey among Iranian Drivers. *Practice in Clinical Psychology*, 3(4), 259-266.

Kim, S., Son, Y. J., Chiu, Y. C., Jeffers, M. A. B., & Yang, C. Y. D. (2016). Impact of road environment on drivers' behaviors in dilemma zone: Application of agent-based simulation. *Accident Analysis and Prevention*, *96*, 329–340. https://doi.org/10.1016/j.aap.2015.08.019

Linkov, V., Zaoral, A., Řezáč, P., & Pai, C. W. (2019). Personality and professional drivers' driving behavior. *Transportation Research Part F: Traffic Psychology and Behaviour*, *60*, 105–110. https://doi.org/10.1016/j.trf.2018.10.017

Liu, Y., Chang, G. L., & Yu, J. (2011). Empirical study of driver responses during the yellow signal phase at six maryland intersections. *Journal of Transportation Engineering*, *138*(1), 31–42. https://doi.org/10.1061/(ASCE)TE.1943-5436.0000278

Liu, Y., Chang, G., Tao, R., Hicks, T., & Tabacek, E. (2007). Empirical Observations of Dynamic Dilemma Zones at Signalized Intersections. *Transportation Research Record: Journal of the Transportation Research Board*, *2035*(1), 122–133. https://doi.org/10.3141/2035-14

MacKillop, J., & Anderson, E. J. (2007). Further Psychometric Validation of the Mindful Attention Awareness Scale (MAAS). *Journal of Psychopathology and Behavioral Assessment*, 29(4), 289–293. https://doi.org/10.1007/s10862-007-9045-1

Maechler, M., Rousseeuw, P., Struyf, A., Hubert, M., Hornik, K.(2019). cluster: Cluster Analysis Basics and Extensions. *R package version 2.1.0.*

Mather, M., Gorlick, M. A., & Lighthall, N. R. (2009). To brake or accelerate when the light turns yellow? Stress reduces older adults' risk taking in a driving game. *Psychological Science*, *20*(2), 174–176. https://doi.org/10.1111/j.1467-9280.2009.02275.x

McCrae, R. R., Costa, Jr., P. T., & Martin, T. A. (2005). The NEO–PI–3: A More Readable Revised NEO Personality Inventory. *Journal of Personality Assessment*, 84(3), 261–270. https://doi.org/10.1207/s15327752jpa8403_05

Murphy, G., & Matvienko-Sikar, K. (2019). Trait mindfulness & self-reported driving behaviour. *Personality and Individual Differences*, 147, 250-255.

O'Connor, P., Nguyen, J., & Anglim, J. (2016). Effectively Coping With Task Stress: A Study of the Validity of the Trait Emotional Intelligence Questionnaire–Short Form (TEIQue–SF). *Journal of Personality Assessment*, 99(3), 304–314. https://doi.org/10.1080/00223891.2016.1226175

Ohlhauser, A. D., Boyle, L. N., Marshall, D., & Ahmad, O. (2011). Drivers' Behavior Through a Yellow Light: Effects of Distraction and Age. *Proceedings of the Human Factors and Ergonomics Society*, 1919–1923.

Palat, B., & Delhomme, P. (2012). What factors can predict why drivers go through yellow traffic lights? An approach based on an extended Theory of Planned Behavior. *Safety Science*, *50*(3), 408–417. https://doi.org/10.1016/j.ssci.2011.09.020

Palat, B., & Delhomme, P. (2016). A simulator study of factors influencing drivers' behavior at traffic lights. *Transportation Research Part F: Traffic Psychology and Behaviour*, *37*, 107–118. https://doi.org/10.1016/j.trf.2015.11.009

Papaioannou, P. (2007). Driver behaviour, dilemma zone and safety effects at urban signalised intersections in Greece. *Accident Analysis and Prevention*, *39*(1), 147–158. https://doi.org/10.1016/j.aap.2006.06.014

Pathivada, B. K., & Perumal, V. (2019). Analyzing dilemma driver behavior at signalized intersection under mixed traffic conditions. *Transportation Research Part F: Traffic Psychology and Behaviour*, *60*, 111–120. https://doi.org/10.1016/j.trf.2018.10.010

Petrides, K. V. (2009). Psychometric properties of the Trait Emotional Intelligence Questionnaire. In C. Stough, D. H. Saklofske, and J. D. Parker, Advances in the assessment of emotional intelligence. New York: Springer. DOI: 10.1007/978-0-387-88370-0_5

Piedmont, R. L., & Braganza, D. J. (2015). Psychometric evaluation of responses to the NEO-PI-3 in a multi-ethnic sample of adults in India. *Psychological Assessment*, 27(4), 1253–1263. https://doi.org/10.1037/pas0000135

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rakha, H., El-Shawarby, I., & Setti, J. R. (2007). Characterizing Driver Behavior on Signalized Intersection Approaches at the Onset of a Yellow-Phase Trigger. *IEEE Transactions on Intelligent Transportation Systems*, *8*(4), 630–640. https://doi.org/10.1109/TITS.2007.908146

Rayan, A., & Ahmad, M. (2016). Effectiveness of Mindfulness-Based Intervention on Perceived Stress, Anxiety, and Depression Among Parents of Children with Autism Spectrum Disorder. *Mindfulness*, 8(3), 677–690. https://doi.org/10.1007/s12671-016-0595-8

Revelle, W. (2020). *psych: Procedures for Psychological, Psychometric, and Personality Research*. Northwestern University, Evanston, Illinois. R package version 2.0.8, https://CRAN.R-project.org/package=psych.

Riendeau, J., Stinchcombe, A., Weaver, B., & Bédard, M. (2018). Personality factors are associated with simulated driving outcomes across the driving lifespan. *Transportation Research Part F: Traffic Psychology and Behaviour*, *54*, 171–187. https://doi.org/10.1016/j.trf.2018.01.022

Sahnoon, I., Sarhan, M., Hassan, H. M., Garib, A., & Al Harthei, H. (2016). Impact of Red Light Enforcement Cameras on Safety Performance at Signalized Intersections in Abu Dhabi, United Arab Emirates. *Transportation Research Record: Journal of the Transportation Research Board*, 2584(1), 16–23. https://doi.org/10.3141/2584-03

Sanchez-Ruiz, M. J., El-Jor, C., Abi Kharma, J., Bassil, M., & Zeeni, N. (2017). Personality, emotion-related variables, and media pressure predict eating disorders via disordered eating in Lebanese university students. Eating and Weight Disorders - Studies on Anorexia, *Bulimia and Obesity*, 24(2), 313–322. https://doi.org/10.1007/s40519-017-0387-8

Sanchez-Ruiz, M.-J., & Baaklini, A. (2018). Individual and social correlates of aggressive behavior in Lebanese undergraduates: The role of trait emotional intelligence. *The Journal of Social Psychology,* 158(3), 350–360. https://doi.org/10.1080/00224545.2017.1353476

Savolainen, P. T. (2016). Examining driver behavior at the onset of yellow in a traffic simulator environment: Comparisons between random parameters and latent class logit models. *Accident Analysis and Prevention*, *96*, 300–307. https://doi.org/10.1016/j.aap.2016.01.006

Schattler, K. L., & Datta, T. K. (2004). Driver behavior characteristics at Urban signalized intersections. *Transportation Research Record*, *1862*, 17–23. https://doi.org/10.3141/1862-03

Shahzad, S., Riaz, Z., Begum, N., & Khanum, J. (2014). Urdu translation and psychometric properties of trait emotional intelligence questionnaire short form (teique-sf). *Asian Journal Of Management Sciences & Education*, 3(1), 130-140. Retrieved from http://www.ajmse.leena-luna.co.jp/AJMSEPDFs/Vol.3(1)/AJMSE2014(3.1-13).pdf

Shek, D. T. (1993). The Chinese version of the State-Trait Anxiety Inventory: Its relationship to different measures of psychological well-being. *Journal of Clinical Psychology*, 49(3), 349–358.

Smorti, M., Andrei, F., & Trombini, E. (2018). Trait emotional intelligence, personality traits and social desirability in dangerous driving. *Transportation Research Part F: Traffic Psychology and Behaviour,* 58, 115–122. https://doi.org/10.1016/j.trf.2018.06.012

Soler, J., Tejedor, R., Feliu-Soler, A., Pascual, J. C., Cebolla, A., Soriano, J., et al. (2012). Psychometric proprieties of Spanish version of Mindful Attention Awareness Scale (MAAS). *Actas Españolas De Psiquiatría*, 40(1), 19–26.

Spielberger, C. D. (1989). State-Trait Anxiety Inventory: Bibliography (2nd ed.). Palo Alto, CA: Consulting Psychologists Press.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). Manual for the State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologists Press.

Stamatopoulou, M., Galanis, P., & Prezerakos, P. (2016). Psychometric properties of the Greek translation of the Trait Emotional Intelligence Questionnaire-Short Form (TEIQue-SF). *Personality and Individual Differences*, 95, 80–84. Retrieved from https://doi.org/10.1016/j.paid.2016.02.035

Valero-Mora, P., Pareja, I., Montes, S. A., Sánchez, M., Ledesma, R. D., & Pons, D. (2015). Mindfulness, inattention and performance in a driving simulator. *IET Intelligent Transport Systems*, 9(7), 690–693. https://doi.org/10.1049/iet-its.2014.0172

Wu, X., Vall, N., Liu, H., Cheng, W., & Jia, X. (2013). Analysis of drivers' stop-or-run behavior at signalized intersections with high-resolution traffic and signal event data. *Transportation Research Record*, *2365*, 99–108. https://doi.org/10.3141/2365-13

Xiong, H., Narayanaswamy, P., Bao, S., Flannagan, C., & Sayer, J. (2016). How do drivers behave during indecision zone maneuvers? *Accident Analysis and Prevention*, *96*, 274–279. https://doi.org/10.1016/j.aap.2015.04.023

Yan, X. P. ., Radwan, E. P. D., Klee, H. P. D., & Guo, D. P. . (2005). *Driver Behavior During Yellow Change Interval*. 88–97.

Zhang, Y., Houston, R., & Wu, C. (2016). Psychometric examination and validation of the aggressive driving scale (ADS). *Aggressive Behavior*, *42*(4), 313–323. https://doi.org/10.1002/ab.21627

Appendix A

Pre-Simulator Survey

1. What is your gender?
o Male
o Female
o Other: _____

2. What is your age?

   _____

3. What is your current occupation?

o Private sector-Industry

o Private sector-Services

o Other private sector

o Public sector

o Armed forces

o Health services

o Voluntary and charitable work

o Academic field-Education

o Own business

o I don't work

o Other

4. What is your highest academic degree?

o No degree

o High School Degree or equivalent

o Bachelor's Degree (B.A., B.S., B.E.) or equivalent

o MA Degree or equivalent

o Doctoral degree or Medical doctor

o Other: _____

5. **What is your <u>monthly</u> income?**
- ○ Less than $500
- ○ $500 - $750
- ○ $750 - $1000
- ○ $1000 - $1500
- ○ $1500 - $2000
- ○ $2000 - $2500
- ○ $2500 - $3000
- ○ $3000 - $4000
- ○ More than $4000

6. **What is your marital status**
- ○ Single
- ○ Married
- ○ Widowed
- ○ Divorced
- ○ Separated
- ○ Others

7. **Do you have children?**
- ○ Yes
- ○ No

The Driving Behavior Survey

Directions	The following questions are about driving. Select the item that best describes your regular (non-simulator) driving behavior for every statement. **(1)** <u>Never</u> (7) <u>Always</u>	Never	Very Infrequently	Infrequently	Sometimes	Frequently	Very Frequently	Always
1.	I lose track of where I am going.	1	2	3	4	5	6	7
2.	I yell at the driver/drivers who make me nervous.	1	2	3	4	5	6	7
3.	I slow down when approaching intersections, even when the light is green.	1	2	3	4	5	6	7
4.	I have trouble staying in the correct lane.	1	2	3	4	5	6	7
5.	I drift into other lanes.	1	2	3	4	5	6	7
6.	I forget to make appropriate adjustments in speed.	1	2	3	4	5	6	7
7.	I let the driver who made me nervous know that I am upset.	1	2	3	4	5	6	7
8.	I maintain a large distance between myself and the driver in front of me.	1	2	3	4	5	6	7
9.	I forget where I am driving to.	1	2	3	4	5	6	7
10.	I make gestures at the driver/drivers who made me nervous.	1	2	3	4	5	6	7
11.	I try to put distance between myself and other cars.	1	2	3	4	5	6	7
12.	I maintain my speed in order to calm myself down.	1	2	3	4	5	6	7
13.	I try to stay away from other cars.	1	2	3	4	5	6	7
14.	I have trouble finding the correct lane.	1	2	3	4	5	6	7
15.	I pound on the steering wheel when I'm nervous	1	2	3	4	5	6	7
16.	I decrease my speed until I feel comfortable.	1	2	3	4	5	6	7
17.	I honk my horn at the driver who made me nervous.	1	2	3	4	5	6	7
18.	I try to find ways to let other drivers know that they are making me nervous.	1	2	3	4	5	6	7
19.	When driving past roadway construction, I drive more cautiously than other vehicles on the road.	1	2	3	4	5	6	7
20.	I swear/use profanity while I am driving.	1	2	3	4	5	6	7
21.	I have difficulty merging into traffic.	1	2	3	4	5	6	7

The Mindfulness Attention Awareness Scale (MAAS)

Directions	Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item. (2) Almost Never -> (6) Almost Always	Almost Never	Very Infrequently	Somewhat Infrequently	Somewhat Frequently	Very Frequently	Almost Always
1.	I could be experiencing some emotion and not be conscious of it until some time later.	1	2	3	4	5	6
2.	I break or spill things because of carelessness, not paying attention, or thinking of something else.	1	2	3	4	5	6
3.	I find it difficult to stay focused on what's happening in the present.	1	2	3	4	5	6
4.	I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	1	2	3	4	5	6
5.	I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	1	2	3	4	5	6
6.	I forget a person's name almost as soon as I've been told it for the first time.	1	2	3	4	5	6
7.	It seems I am "running on automatic," without much awareness of what I'm doing.	1	2	3	4	5	6
8.	I rush through activities without being really attentive to them.	1	2	3	4	5	6
9.	I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.	1	2	3	4	5	6
10.	I do jobs or tasks automatically, without being aware of what I'm doing.	1	2	3	4	5	6
11.	I find myself listening to someone with one ear, doing something else at the same time.	1	2	3	4	5	6
12.	I drive places on 'automatic pilot' and then wonder why I went there.	1	2	3	4	5	6
13.	I find myself preoccupied with the future or the past.	1	2	3	4	5	6
14.	I find myself doing things without paying attention.	1	2	3	4	5	6
15.	I snack without being aware that I'm eating.	1	2	3	4	5	6

Neo-PI Impulsivity sub-scale					
Directions	Please read each of the following items carefully and circle the one answer that best corresponds to your agreement or disagreement. There are no right or wrong answers, and you need not be an "expert" to complete this questionnaire. Describe yourself honestly and state your opinions as accurately as possible. Record your responses by filling in the appropriate circle as follows: **(1)** Strongly Disagree ⮕ (5) Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	It does not bother me too much if I cannot get what I want.	1	2	3	4	5
2.	I have trouble resisting my cravings.	1	2	3	4	5
3.	I'm always in control of myself.	1	2	3	4	5
4.	When I am having my favorite foods, I tend to eat too much.	1	2	3	4	5
5.	I seldom give in to my impulses.	1	2	3	4	5
6.	I sometimes eat myself sick.	1	2	3	4	5
7.	Sometimes I do things on impulse that I later regret.	1	2	3	4	5
8.	I am always able to keep my feelings under control.	1	2	3	4	5

Instructions: Please answer each statement below by putting a circle around the number that best reflects your degree of agreement or disagreement with that statement. Do not think too long about the exact meaning of the statements. Work quickly and try to answer as accurately as possible. There are no right or wrong answers. There are seven possible responses to each statement ranging from 'Completely Disagree' (number 1) to 'Completely Agree' (number 7).

1.........2..........3..........4..........5..........6..........7

Completely
Disagree

Completely
Agree

TEIQue-SF							
1. Expressing my emotions with words is not a problem for me.	1	2	3	4	5	6	7
2. I often find it difficult to see things from another person's viewpoint.	1	2	3	4	5	6	7
3. On the whole, I'm a highly motivated person.	1	2	3	4	5	6	7
4. I usually find it difficult to regulate my emotions.	1	2	3	4	5	6	7
5. I generally don't find life enjoyable.	1	2	3	4	5	6	7
6. I can deal effectively with people.	1	2	3	4	5	6	7
7. I tend to change my mind frequently.	1	2	3	4	5	6	7
8. Many times, I can't figure out what emotion I'm feeling.	1	2	3	4	5	6	7
9. I feel that I have a number of good qualities.	1	2	3	4	5	6	7
10. I often find it difficult to stand up for my rights.	1	2	3	4	5	6	7
11. I'm usually able to influence the way other people feel.	1	2	3	4	5	6	7
12. On the whole, I have a negative perspective on most things.	1	2	3	4	5	6	7
13. Those close to me often complain that I don't treat them right.	1	2	3	4	5	6	7
14. I often find it difficult to adjust my life according to the circumstances.	1	2	3	4	5	6	7
15. On the whole, I'm able to deal with stress.	1	2	3	4	5	6	7
16. I often find it difficult to show my affection to those close to me.	1	2	3	4	5	6	7
17. I'm normally able to "get into someone's shoes" and experience their emotions.	1	2	3	4	5	6	7
18. I normally find it difficult to keep myself motivated.	1	2	3	4	5	6	7
19. I'm usually able to find ways to control my emotions when I want to.	1	2	3	4	5	6	7
20. On the whole, I'm pleased with my life.	1	2	3	4	5	6	7
21. I would describe myself as a good negotiator.	1	2	3	4	5	6	7
22. I tend to get involved in things I later wish I could get out of.	1	2	3	4	5	6	7
23. I often pause and think about my feelings.	1	2	3	4	5	6	7
24. I believe I'm full of personal strengths.	1	2	3	4	5	6	7
25. I tend to "back down" (surrender, submit) even if I know I'm right.	1	2	3	4	5	6	7
26. I don't seem to have any power at all over other people's feelings.	1	2	3	4	5	6	7
27. I generally believe that things will work out fine in my life.	1	2	3	4	5	6	7
28. I find it difficult to connect well even with those close to me.	1	2	3	4	5	6	7
29. Generally, I'm able to adapt to new environments.	1	2	3	4	5	6	7
30. Others admire me for being relaxed.	1	2	3	4	5	6	7

Post-Simulator Survey

Directions	A number of statements which people have used to describe themselves are given below. Read each statement and then blacken the appropriate circle to the right of the statement to indicate **how you feel right** now, that is, *at this moment.* There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe *your present feelings best.* **(1)** Strongly Disagree ☐ (5) Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I feel steady	1	2	3	4	5
2.	I feel at ease	1	2	3	4	5
3.	I feel secure	1	2	3	4	5
4.	I feel strained	1	2	3	4	5
5.	I am tense	1	2	3	4	5
6.	I feel confused	1	2	3	4	5
7.	I feel content	1	2	3	4	5
8.	I am relaxed	1	2	3	4	5
9.	I am presently worrying over possible misfortunes	1	2	3	4	5
10.	I am jittery	1	2	3	4	5
11.	I feel upset	1	2	3	4	5
12.	I feel self-confident	1	2	3	4	5
13.	I feel pleasant	1	2	3	4	5
14.	I am worried	1	2	3	4	5
15.	I feel comfortable	1	2	3	4	5
16.	I feel indecisive	1	2	3	4	5
17.	I feel calm	1	2	3	4	5
18.	I feel nervous	1	2	3	4	5
19.	I feel frightened	1	2	3	4	5
20.	I feel satisfied	1	2	3	4	5

Pre-STAI						

Directions	A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate **how you feel _right_** now, that is, **_at this moment_**. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe **_your present feelings best._** **(1)** Strongly Disagree ▯ (5) Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I feel calm	1	2	3	4	5
2.	I feel secure	1	2	3	4	5
3.	I am tense	1	2	3	4	5
4.	I feel strained	1	2	3	4	5
5.	I feel at ease	1	2	3	4	5
6.	I feel upset	1	2	3	4	5
7.	I am presently worrying over possible misfortunes	1	2	3	4	5
8.	I feel satisfied	1	2	3	4	5
9.	I feel frightened	1	2	3	4	5
10.	I feel comfortable	1	2	3	4	5
11.	I feel self-confident	1	2	3	4	5
12.	I feel nervous	1	2	3	4	5
13.	I am jittery	1	2	3	4	5
14.	I feel indecisive	1	2	3	4	5
15.	I am relaxed	1	2	3	4	5
16.	I feel content	1	2	3	4	5
17.	I am worried	1	2	3	4	5
18.	I feel confused	1	2	3	4	5
19.	I feel steady	1	2	3	4	5
20.	I feel pleasant	1	2	3	4	5

General Information

1. **Other than today, have you ever participated in an experiment involving a driving simulator?**

   o Yes

   o No

2. **Do you regularly play driving-related video games?**
   o Yes

   o No

3. **In one word, how do you describe the driving environment in Lebanon:**

   _____

4. **In one word, how do you describe the driving environment in the simulator?**

   _____

5. **What Driver's Licenses do you hold? (check all that apply)**
   o Lebanese
   o Foreign
   o International
   o Not active

6. **How much driving experience do you have?**
   o Less than a year

   o 1-3 years

   o 3-6 years

   o More than 6 years

7. **How do you classify yourself as a driver?**
    o Novice

    o Advanced

    o Expert

8. **How many hours do you drive per week?**

    _____

9. **Have you ever driven in a country other than Lebanon for more than 6 months?**
    o Yes

    o No

10. **Have you been diagnosed with/treated for a psychological difficulty?**
    o No
    o Yes. Please Specify _____

11. **Are you taking medication for that psychological difficulty?**
    o Yes
    o No

12. **Are you currently experiencing tough circumstances?**
    o No problems
    o Financial problems
    o Dissatisfaction at work
    o Personal medical problems
    o Divorce
    o Medical problems in the family
    o Other family issues

13. **Do you have a diagnosed medical condition?**
    o No
    o Yes. Please Specify _____

14. **Do you practice meditation?**
    • Yes
    • No (if not, please skip the next page)

15. **How long have you been practicing meditation?**
    • Less than 1 year
    • 1-5 years

- 6-10 years
- More than 10 years

16. How many hours do you meditate per week?
- 1-2 per week
- 3-4 per week
- 5-6 per week
- 7 or more per week

17. What is the length of your typical meditation session?
- Less than 10 minutes
- 10-20 minutes
- 21-30 minutes
- 31-45 minutes
- 46-60 minutes
- Greater than 60 minutes