THE EFFECT OF DRIVING IN UNFAMILIAR TRAFFIC FLOW TO SIMULATED DRIVING PERFORMANCE

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ABSTRACT

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Being unfamiliar with foreign traffic environments is a known factor that has a negative impact on road safety. However, unlike route familiarity, traffic flow familiarity, that is being familiar with right-hand or left-hand traffic, is overlooked in road safety studies. Even though some studies reported safety concerns regarding being on the unfamiliar side of the traffic, the effect of driving on the unfamiliar side of the road on driving safety is under-explored. This study aims to explore the impact of driving in left-hand traffic by drivers who are familiar with right-hand traffic on their driving in simulated driving. In addition, this study aims to compare the visual attention of drivers in left-hand traffic and right-hand traffic using eye-tracking technology. Lastly, the current study aims to explore the difference in traffic climate evaluations of drivers in left-hand traffic and right-hand traffic scenarios using self-report measurements. The results demonstrated that drivers had overall lower driving performance in unfamiliar, left-hand traffic scenarios. Traffic climate evaluations also demonstrated that participants perceived unfamiliar traffic flow as more risky and demanding. Although visual attention parameters did not differ between different traffic flow scenarios, whether participants allocated visual attention to the correct side of the road or not is discussed. The examination of simulator outputs and traffic climate evaluations by driver skill evaluations are discussed.

Keywords: driving simulator, familiarity, traffic climate, eye tracker, traffic flow

ÖZ

AŞİNA OLUNMAYAN TRAFİK AKIŞINDA ARAÇ KULLANMANIN SİMÜLE EDİLEN SÜRÜŞ PERFORMANSINA ETKİSİ

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Aşinalığın yabancı trafik ortamlarında düşük olmasının trafik güvenliği üzerinde negatif etkilere sahip olduğu bilinmektedir. Öte yandan, rota aşinalığının aksine, sağdan akan ya da soldan akan trafikteki aşinalığı niteleyen yol akışı aşinalığı, trafik güvenliği çalışmalarında yeterince çalışılmamıştır. Bazı çalışmalar yolun aşina olunmayan tarafındaki trafik ortamlarında bulunmaya yönelik güvenlik endişelerinden bahsetse de yolun aşina olunmayan tarafında araç kullanmanın sürüş güvenliğine yönelik etkisi yeterince keşfedilmemiştir. Bu çalışma sağdan akan trafikte araç kullanmaya aşina olan sürücülerin soldan akan trafikte araç kullanmalarının sürüşlerine yönelik etkisini simüle edilmiş sürüş ortamında keşfetmeyi amaçlamaktadır. Çalışmanın bir diğer amacı, sürücülerin sağdan akan ve soldan akan trafik ortamlarındaki görsel dikkatlerini göz izleme teknolojisi kullanarak karşılaştırmaktır. Son olarak, bu çalışma sürücülerin sağdan akan ve soldan akan trafik ortamlarına yönelik trafik iklimi değerlendirmeleri arasındaki farkı öz-bildirim yöntemiyle keşfetmeyi amaçlamaktadır. Sonuçlar genel olarak sürücülerin aşina olmadıkları soldan akan trafikte daha düşük sürüş performansı sergilediklerini göstermiştir. Ayrıca katılımcılar soldan akan trafik senaryosunu daha riskli olarak algılamıştır. Görsel dikkat ölçümleri farklı trafik akışları arasında fark göstermese de görsel dikkatin yolun doğru kısımlarına verilip verilmediği tartışılmıştır. Simülatör

çıktıları ve trafik iklimi değerlendirmeleri sürücü becerileri değerlendirmeleriyle birlikte incelenmiş ve sonuçlar tartışılmıştır.

Anahtar Kelimeler: sürüş simülatörü, aşinalık, trafik iklimi, göz izleme, trafik akışı

To My Dear Mother

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LIST OF ABBREVIATIONS

RTA	Road Traffic Accident
DSI	Driver Skills Inventory
TCS	Traffic Climate Scale
MTC	Minimum Time to Collision
WHO	World Health Organization
GDP	Gross Domestic Product

CHAPTER 1

INTRODUCTION

Road traffic accidents (RTAs) are an ongoing road safety issue all around the globe. According to the report of the World Health Organization (WHO) in 2020, 1.35 million individuals lost their life and about 50 million individuals were injured as a result of RTAs. RTAs not only cause millions of deaths and injuries but also significant economic and social burdens. As a result of RTAs, many adults in their prime age when they are the most efficient in their work are removed from labor due to losing their life or being permanently injured and disabled. In addition, those who are injured require prolonged medical attention and rehabilitation, which has a financial impact on the person himself, the person's relatives, the institution the person has been working in, and the government. In their simulation study, World Bank (2018) predicted that a reduction in road traffic injuries and deaths might result in a 7.1% to 22% boost in the gross domestic product (GDP) of low-middle-income come countries over the years. Further reduction of road traffic injuries and deaths predicted a further increase in GDP. The social impact of RTA-induced injuries and deaths is another major concern. The passing away of loved ones and the permanent physical and psychological health impairments caused by RTAs can have a devastating impact on families and communities. Thus, preventing RTAs not only concerns having safer roads but also supporting the development of countries and preventing individual and family lives from being disrupted. Even though the health, economic, and societal impact of RTAs is evident, studies and practices to understand and prevent RTAs are not given adequate attention. Thus, the number of RTA-induced deaths and injuries continues to be a major public health problem (WHO, 2022).

1.1. The Elements of Road Safety

Accidents are defined as unanticipated incidents which lead to undesirable outcomes (Hollnagel, 2016, p.10). Although accidents in traffic settings were considered to be mainly caused by human errors, the contemporary view states that RTAs are dependent on the interaction of multiple factors (Larsson, Dekker & Tingvall, 2010). In essence, these interrelated factors can be stated as the human factor, the vehicle factor, and the environment factor (Haddon Jr, 1972, pp.193-207).

1.1.1. Human Factors

Factors that are directly related to the human component of traffic system are regarded as human factors. The human factors are said to be the most impactful factor in road safety (Evans, 1996; Petridou & Moustaki, 2000; Dingus et al., 2019). Human factors refer to the features, behaviors, and skills of road users. The place of drivers is especially significant within the scope of human factors. Driver-related factors that play an important role in accident causation can be exemplified as speeding, inattentiveness, lack of required driving skills to respond to the situation properly, being distracted, lack of driving experience, improper lookout, driving under the effect of substances, traffic rule violations, cognitive and psychomotor abilities, driving under fatigue, and so on (Treat, et al., 1977; Ferguson, 2003; De Winter, 2010; Bucsuházy et al., 2020). Up to 75% of all RTAs occur under the influence of driver errors (Salmon, Regan & Johnston, 2005). Similarly, driver errors were reported to be an important factor where it had some Influence in over 90% of all RTAs (Treat, et al., 1977). Thus, human factors, especially the driver related factors, is a major subject of interest in road safety literature.

Since studies regarding young male drivers and measures of driver skills yielded good predictive results of aberrant driver behaviors and RTA involvement, driver skills, age and sex have become widely studied components of various human factors in accident involvement. Driver skills are among the most studied and influential aspects of human factors. Driving skills refer to what a driver can do based on their capabilities unlike driver behaviors, which is defined as the way a driver prefers to use the vehicle (Elander et al., 1993). Another topic road safety studies focus on is the age and the sex of drivers. Especially the group of young male drivers is a driver-related factor frequently encountered in road safety studies (Erkuş & Özkan, 2019), as research suggests young male drivers as an important contributor to the occurrence of RTAs.

For the focus of the current study and practical reasons, driver skills and young male drivers are investigated in detail.

1.1.1.1. Driver Skills

Driving skills consist of two elements, which are perceptual-motor skills and safety skills (Lajunen & Summala, 1995). Perceptual-motor skills consist of skills such as having fast reactions to the requirements of the current traffic situation and having good control of the vehicle, whereas safety skills are motives towards road safety such as keeping adequate following distance with other vehicles and driving under the speed limits. Lajunen and Summala (1995) developed the Driver Skills Inventory (DSI) to measure driver skills. DSI is an easy-to-use self-report instrument in which participants evaluate their driver skills by choosing whether they are strong or weak on the specific statements regarding perceptual-motor skills and safety skills.

DSI has been validated and used in various countries such as Turkey, Iran, and Greece (Özkan, et al., 2006), Germany (Ostapczuk et al., 2017), Finland and Australia (Lajunen et al., 1998), and Denmark (Martinussen et al., 2014), and reported as a valid and reliable tool. Modified versions of DSI based on cultural properties of China are also utilized in studies (Xu et al., 2018; Liu et al., 2021). Consistently demonstrating its two-factor structure in various cultures, DSI has become a frequently utilized instrument for measuring self-reported driver skills in road safety studies.

Perceptions of the drivers regarding their own driver skills are predictive of the way they drive and their impact on the road safety. Research suggested that higher safety skills predicted lower RTA involvement, whereas higher perceptual-motor skills predicted higher RTA involvement and were associated with unsafe acts of driving such as speeding (Sümer et al., 2006). Higher perceptual-motor skills were found to be positively correlated with speed, engaging in secondary tasks such as using mobile phones while driving, and number of tickets received, whereas higher safety skills were negatively correlated with speed and number of tickets received (Ostapczuk et al., 2017). Drivers who reported higher perceptual-motor skills but lower safety skills had the highest number of violations and also reported higher number of driving errors, whereas drivers who reported higher perceptual-motor skills and higher safety skills reported lower unsafe driving behavior, accidents, and tickets (Martinussen et al., 2014). Drivers also reported their driving skills as better than the average drivers' driving skills, which indicates a tendency for drivers to overestimate their driving skills and increase the risk of accidents (Delhomme, 1991; Horswill et al., 2006). Thus, drivers' orientation towards possessing high driving skills and overestimation of actual driving skills might result in more violations of traffic rules and increased risk of RTAs, whereas drivers' orientation towards safety skills might result in lower violations of traffic rules and decreased risk of RTAs.

Driver skills have also been studied in terms of drivers' cognitive skills. Sümer and colleagues (2005) studied whether driving skills and aberrant driver behaviors are correlated with certain cognitive abilities such as reaction time, peripheral perception, selective attention, and visual pursuit. It was found that reaction time was negatively correlated with perceptual-motor skills, while peripheral perception was positively correlated with perceptual-motor skills and safety skills. Interestingly, selective attention was found to be negatively correlated with both perceptual-motor skills and safety skills, which the authors highlighted the possible effect of sensation seeking as previous research suggested individuals who scored better on selective attention tasks would also score higher in sensation seeking (Ball & Zuckerman, 1992). In their study, Andersson and Peters (2020) reported that individuals who suffer from visual field loss rated themselves superior in DSI as compared to drivers who have no visual impairments; however, drivers with visual field impairment performed worse than drivers without visual impairments in various cognitive tasks and had higher reaction times. However, even though individuals with visual field loss performed worse in cognitive tasks, their performance did not significantly differ from individuals without visual impairments in simulated driving performance (Andersson & Peters, 2020). It was stated that similar performance between visually impaired and not impaired groups could be explained by compensating lack of visual ability with other strategies and skills. Gehlert and colleagues (2014) stated that drivers might adjust their driving according to the amount of risk they perceive, highlighting the effect of risk homeostasis theory (see Wilde, 2001). Thus, even though cognitive and visual impairments would be expected to result in worse driving performance, individuals with cognitive and visual impairments might evaluate themselves better in driving skills as drivers without cognitive and visual impairments do, and might demonstrate similar driving performance with drivers without cognitive and visual impairments through adjusting their driving as their impairments require. However, the literature regarding how cognitive skills, driver skills, and actual driving performance are related is not yet saturated and more work is needed to draw firm conclusions. Furthermore, studies of driver skills demonstrated varying results in different cultures, suggesting the possible influence of different traffic cultures on assessments of driver skills (Warner et al., 2013; Özkan et al., 2006). All in all, self-assessed driving skills remain to be one of the most studied human factors related to road safety.

1.1.1.2. Age and Sex

Similar to driving skills, drivers' age and sex have become widely studied components of human factors in accident involvement due to having a strong impact on driving behavior and road safety. It is stated that RTAs as one of the leading causes of death for young drivers (WHO, 2013). There are multiple reasons why young drivers would be represented higher in the death toll of RTAs. Summala (1987) suggested that while young drivers' driver abilities increase shortly after starting to drive, their hazard control skills develop at a lower rate. When young drivers gain confidence in their driving skills while lacking the required skills to avoid potential hazards, the likelihood of young drivers being involved in RTAs increases. Similarly, overestimating the driving skills of self and underestimating the risks related to driving were stated as one of the factors that would contribute to the accident involvement rate of young drivers (Gregersen, 1996; Sümer et al., 2006). Huang et al. (2017) suggested that whether driving in familiar or unfamiliar conditions, young drivers who evaluated their driving skills higher would engage in more risky driving behaviors. Furthermore, Clarke et al., (2006) suggested that young drivers would drive to seek pleasure, which caused more involvement in accidents, especially driving during nighttime. As Summala (1987) stated, deliberate risk-taking and showing off constitute another reason why young drivers might get involved in RTAs more. Speeding and the use of mobile devices were also reported as the potential factors why young drivers are involved in RTAs more (Trivedi & Rawal, 2011). Drinking under the effect of alcohol was another factor that would contribute to the RTA involvement of young drivers (Jonah, 1990).

Similar to young age, the sex of the driver also has an effect on driving behavior and road safety. Young male drivers would underestimate the risk of being involved in

RTAs and accept risk as compared to older drivers (Deery, 1999). Oltedal and Rundmo (2006) suggested that male drivers would engage in more risky driving behaviors in comparison to female drivers. For instance, young male drivers would drive at increased speed when in a happy mood and having a friend as a passenger (Rhodes et al., 2015). Up to 70 percent of young male drivers who are fatally injured in RTAs were found to be under the effect of alcohol and other substances (Williams et al., 1985). Young male drivers who lack experience, engage in risky driving behaviors, and engage in drunk driving were reported as the driver group that has the highest risk of being involved in RTAs (Horwood & Fergusson, 2000). Furthermore, Özkan and Lajunen (2006) reported that being male was associated with a higher number of RTA involvement and higher ratings of perceptual-motor skills. In general, the lack of experience, the differing rate of the development of driving skills and safety skills, risk-taking behaviors and the reason to drive (e.g. seeking pleasure and showing off), and driving under the effect of substance were found as the reasons why young and male drivers are represented in RTA involvement more.

1.1.2. Vehicle Factors

The properties of the vehicles used in road travel are referred to as the vehicle factors of the traffic system. In a study, it was found that vehicle-related factors such as tire bursting, failure in the brake systems, and axle problems caused 16% of the total accidents (Hoque & Hasan, 2006). Similarly, it was reported that tire problems constituted the majority of vehicle-related factors that lead to RTAs, whereas faulty brakes and lights were also mentioned as possible vehicle-related factors (Moodley & Allopi, 2008). Other than faulty parts, certain vehicle properties can also create road safety hazards. For instance, the increasing prevalence of electric vehicles is said to bring potential road safety hazards as electric cars are significantly more silent than internal combustion engines, which makes detecting electric cars more difficult (Verheijen & Jabben, 2010). Another design-related vehicle factor is the position of the steering wheel. Roesel (2017) reported that wrong-hand drive vehicles (e.g. driving a left-hand drive vehicle in a left-hand traffic environment or a right-hand drive vehicle in a right-hand traffic environment), would increase RTA risk by up to 30%. In a literature review study, Yaacob and colleagues reported that vehicle factors lead to RTAs of up to 33% (2018). Although vehicle factors are not the focal point of the current study, vehicle factors such as the changing placement of the steering-wheel may also have an effect on road safety when driving in traffic environments with unfamiliar traffic flow setting. All in all, defective parts such as braking systems, or design features that do not match with the traffic system such as the position of the steering wheel are influential factors that may lead to RTAs.

1.1.3. Environment Factors

The physical, social, and cultural environment in which road travel occurs is referred to as the environmental element of the traffic system. Environmental factors refer to a broad spectrum of factors. The physical structure of the road that affects road safety includes factors such as the width of the road, the material of the road, the number of lanes, roadside elements such as trees that obstruct the view, roadside lighting, signage, road markings, and so on (Losurdo et al., 2017). For example, a narrow road where trees limit the visibility of a pedestrian crossing sign may increase the accident risk for pedestrians and vehicles. Similarly, time of the day or weather conditions such as rain and snow also limit the visibility of the road, while weather conditions may also reduce the traction of vehicles and further increase the risk of RTAs. Road designs that prevent road users' views from obstructing, preventing speeding, and protecting road users with safety barriers are among some interventions recommended in the scope of the environmental factors of the traffic system (Gichaga, 2017). Another environmental factor that may contribute to the occurrence of RTAs is which direction the traffic flows. The topic of traffic flow direction is examined in detail in *section 1.2*. Treat et al. reported that physical environment factors of traffic were reported to be influential in about 46% of all RTAs (1977). All in all, the physical characteristics of the environment play an important role in road safety studies.

1.1.4. Traffic Culture and Climate

As physical factors of the environment are inadequate to draw a complete picture of a safe road environment, the cultural component is suggested as another factor that affects road safety (Gehlert et al., 2014). In fact, traffic culture and traffic environment are said to be two complementary parts of the traffic system (Özkan & Lajunen, 2015). While the physical environment includes components of traffic such as the infrastructure of the road, culture includes intangible components such as norms and attitudes.

Traffic safety culture is a function of both the environment and road users. Traffic safety culture consists of shared beliefs regarding appropriate safety behaviors in a context (Gehlert et al., 2014). Traffic safety climate is a component of traffic safety culture, and it refers to the ’’road users’ attitudes and perceptions of the traffic in a context (e.g. country) at a given point in time’’ (Gehlert, Hagemeister & Özkan, 2014, p. 326). In their study, Gehlert, Hagemeister and Özkan (2014) specified the components of traffic climate as external affective demands, which correspond to the affective component of traffic, internal requirements, which correspond to the individual skills and cognitive components regarding participating in traffic, and functionality, which correspond to the features of a functional traffic system. As Chu et al. stated, attitudes and perceptions of road users towards a traffic context can change based on the characteristics of the environment, traffic culture, or other factors that can have influence on the attitude, skills, and behavior of the drivers (2019). Road users may adjust their behaviors based on the interactions of social and cultural environments, road users’ perceptions of other drivers’ driving styles, and their own capabilities. For example, if a traffic context is perceived as less demanding and safer, the drivers would engage in more secondary tasks and violate rules in a given cultural context, which indicates more risky driving (Gehlert, Hagemeister & Özkan, 2014), while drivers would report safer driving in another cultural context (Chu et al., 2019). These findings suggested that a safer traffic environment does not necessarily mean safer road user behaviors, and culture is a strong factor that influences road user behavior. In line with these studies, different cultures are expected to have different aberrant driver behavior problems. Several studies suggested that driver behaviors show variations between countries, hence cultures (Ersan et al., 2020; Özkan et al., 2006; Lajunen et al., 1998). Özkan and Lajunen (2015) reported that Greek and Turkish road users would evaluate their traffic climate as chaotic, fast, and dangerous, whereas Swedish and Finnish road users would evaluate their traffic climate as functional, planned, and safe. It was also reported that even though different traffic contexts would share similar perceptions of traffic climate, differing levels of enforcement might create different statistics in terms of RTAs and fatalities

(Üzümcüoğlu, 2020). Warner and colleagues (2011) suggested that road safety interventions should focus on each traffic culture and the problems specific to those traffic cultures differently. Based on these suggestions, it is said that different traffic contexts with different traffic safety culture parameters influence the traffic safety climate attitudes of drivers in a way that affects road users uniquely in line with their driving skills, behavior, and culture to which they are accustomed. However, even though the involvement of traffic safety culture and climate to road safety studies has made revealing remarkable findings possible, the influence and interactions of traffic safety culture, traffic safety climate, driver skills, and RTAs have not yet been thoroughly studied. Contemporary road safety research suggests that the environmental factor is not merely regarded as physical environment, but also regarded as a factor of traffic system with social and cultural components. Thus, the literature regarding the impact of the environmental factor on road safety is expected to expand in a framework of traffic safety culture and traffic safety climate in future studies.

1.1.5. Familiarity and Road Safety

Familiarity is another factor that has an impact on driver behaviors and road safety. Similar to the impact of attitudes regarding traffic (e.g., traffic climate) that varies in different traffic contexts and affects road user behaviors, familiarity with a traffic context also affects road user behavior and road safety. In the scope of road safety research, familiarity is frequently studied as route familiarity. Route familiarity is defined as the acquaintance of drivers with a route as a result of repeated exposure, or travel, and is said to have a significant impact on road safety as it has a direct impact on the task of driving (Intini, Colonna & Ryeng, 2019). As mentioned before, the task of driving is affected by numerous human, vehicle, and environment factors. In terms of familiarity, it is said that from being unfamiliar with a traffic context to being familiar with the traffic context, drivers will experience changes in their attention and driving behavior (Lu et al., 2020). For instance, as Yanko and Spalek (2013) demonstrated, increased familiarity with route may lead to decreased attention and slower response to potential hazards in traffic.

One reason for attentional processes might be disrupted as a result of increased familiarity is said to be going automatic from controlled driving. Automatic behaviors are said to be resource-efficient in terms of allocating attention as compared to controlled behaviors (Schneider & Shiffrin, 1977). Driving a vehicle becomes more effortless, automatic, and depletes less attentional resources with experience as compared to inexperienced drivers that consciously think about the moves they will make while driving. Similarly, as drivers are repeatedly exposed to the same route, they are also expected to develop familiarity with the route and perform an automatic driving rather than a controlled driving (Yanko, 2013). For instance, while a driver that is unfamiliar with a given route is expected to be more vigilant and scan for road elements such as traffic signs, traffic lights, and where potential hazards might come from, a driver that is familiar with a route will perform an automatic driving where the driver will pay much less attention to road elements and be less vigilant, which will allocate more attentional resources for other tasks. Allocation of more attentional resources due to increased familiarity with other tasks might be taken as a beneficial process as it allows the driver to pay attention to hazards instead of scanning the road to get familiarized with the road and roadside elements (Yanko, 2013).

On the other hand, as increased familiarity releases more attentional resources, familiarity might foster mind-wandering, which is shifting of attention from the primary task to task-unrelated thoughts that decrease the performance for the primary task (Smallwood & Schooler, 2006; Yanko & Spalek, 2013). When mind-wandering increases as a result of increased route familiarity, attention to the task of driving and dealing with potential hazards is expected to decrease, and crash risk increases (Yanko & Spalek, 2013). It was reported that mind-wandering was more likely in less demanding traffic situations as compared to more demanding traffic situations such as coming to a roundabout (Geden et al., 2018; Burdett et al., 2019). The increased confidence level of drivers and underestimation of hazards were also mentioned as other potential reasons why increased familiarity would predict more hazardous driving (Intini, Colonna & Ryeng, 2019). Numerous studies reported a negative effect of familiarity on driving performance. Rosenbloom and colleagues reported that drivers were involved in significantly more violations on familiar roads (2007). Wu and Xu reported that drivers would engage in distracting activities more frequently and longer on familiar routes (2018). Drivers would drive significantly faster on familiar roads (Colonna et al., 2016). Bertola and colleagues reported higher standard deviations of lateral position and higher speed with increased route familiarity (2012). However, the effect of familiarity is not solely negative. In fact, some studies reported that being unfamiliar with a road context might increase the risk of RTAs. For example, some studies suggest that foreign road users would be more likely to be involved in certain types of RTAs (Wilks et al., 1999; Yan et al., 2005), and be at fault in RTAs (Yannis et al., 2007). Furthermore, Yanko and Spalek (2013) reported that even when a few rides develop some familiarity with the route that fosters mind-wandering and hazardous driving, a further increase in familiarity might result in increased driving performance and safety, indicating a parabolic relationship between route familiarity and driving performance. Thus, the literature regarding the effect of familiarity on driving performance is expected to expand.

The concept of familiarity not only applies to route familiarity but many other factors in traffic. For instance, using different vehicles that are not previously experienced or driving in different traffic contexts also constitutes an effect of familiarity in road safety (Intini, Colonna & Ryeng, 2019). One type of familiarity that is understudied in the road safety literature is traffic flow familiarity. The two common traffic systems are known as left-hand traffic (LHT) and right-hand traffic (RHT) (Wen & Lee, 2022). Traffic flow familiarity refers to being familiar with a right-hand traffic flow or a left-hand traffic flow, and is regarded as another level of familiarity in road safety literature (Harms et al., 2021). The term traffic convention is also used to refer to the flow of traffic (Wen & Lee, 2022). The familiarity of road users with RHT or LHT systems is a momentous road safety concern because if the flow of the traffic in the traffic context the road users are in is different from the flow of the traffic the road users are familiar with, the risk of RTA occurrence may increase. For instance, there are numerous papers that emphasize the risk of RTAs for tourists, as tourists are often found in unfamiliar traffic contexts where they are exposed to unfamiliar traffic flow settings. Wilks et al. reported that RTAs as one of the most frequent causes of death for international tourists (1999). Choocharukul and Sriroongvikrai reported that the risk of violating traffic laws is higher for tourists that are in unfamiliar traffic contexts (2017). Castro-Nuño and Arévalo-Quijada reported a negative correlation between tourist activity and road safety (2018). Driving in an unfamiliar traffic flow setting was reported as one of the most important factors in tourists' involvement in RTAs

(Papakitsos et al., 2018; Malhotra et al., 2018). Wilks stated that the reason why tourists experience RTAs as the fact that tourists are often exposed to unfamiliar traffic flow and environment (1999). Ye et al. reported that pedestrians acted significantly less cautiously in the unfamiliar traffic flow context (2020). Further studies suggested that pedestrians would continue their habitual behaviors, behaviors that are appropriate in the traffic flow they are familiar with, in an unfamiliar traffic flow context, in which those behaviors are inappropriate (Ye et al., 2021). Jeon et al. reported that the driving performance of Korean drivers, who are familiar with RHT, decreased when they were asked to perform in an LHT context, where the side of the steering wheel was also the opposite (2004). Thompson and Sabik demonstrated that when participants were asked to evaluate whether it is safe to enter to roundabout or not in dash-cam videos including RHT and LHT scenarios, and found that the accuracy was higher and the reported task difficulty was lower for the videos of familiar traffic flow (2018). In addition, it was reported that participants would fixate more on the relevant side of the road for familiar traffic flow as compared to unfamiliar traffic flow scenarios (Thompson & Sabik, 2018). It was reported that drivers would engage in significantly more incorrect control manipulations for right turns and decelerating in the LHT scenario as compared to the RHT scenario (Xu et al., 2023).

All in all, whether due to tourism or other reasons that put road users in unfamiliar traffic flow contexts, being in an unfamiliar traffic flow constitutes a road safety concern for the many reasons that are stated above. On the other hand, adapting to different traffic contexts, especially to different traffic flow contexts (e.g., RHT and LHT traffic), is an understudied topic in the field of road safety studies (Thompson & Sabik, 2018).

1.2. Driving Simulators, Eye Tracking, and Road Safety Studies

1.2.1. Driving Simulators and Road Safety Studies

Simulating traffic to study how the interaction of human, vehicle, and environment factors affect road safety is a common practice in road safety studies. Roadside elements, road infrastructure, secondary tasks while driving such as the use of mobile devices, the effect of medical conditions on driver behavior, comparing different treatments, the effect of driving under the effect of various substances, the effect of fatigue and distraction are among the variables studied in driving simulation studies (Burns et al., 2002; Reimer et al., 2006; Carsten & Jamson, 2011; Wynne et al., 2019). Studying these variables (e.g. substance use, fatigue, distraction etc.) through on-road studies, where participants actually drive a real vehicle in real traffic, would put participants, researchers, and other road users in danger (Reimer et al., 2006; Helman & Reed, 2015).

As driving simulators provide ‘’practical, safe, and controlled’’ environments to study driver behavior under various experimental conditions, driving simulators are widely utilized in road safety research (Wynne et al., 2019, p.138). Other advantages that driving simulators provide can be stated as experimental control, cost-effectiveness, replication and the fact that collecting data is easy (Godley et al., 2002).

On the other hand, driving simulators also come with a few downsides to consider. One of the most focused problems in driving simulation studies is the simulation sickness (Carsten & Jamson, 2011). Simulation sickness is defined as the motion sickness that is caused by the lack of vestibular feedback of motion while the visual perception of motion is present (Carsten & Jamson, 2011). The symptoms of simulation sickness are reported as nausea, vomiting, and concentration problems, and it is recommended to control potential simulation sickness effect in experimental studies to obtain meaningful results (Bittner et al., 1997).

Another significant problem that is frequently mentioned in driving simulation studies is the validity of driving simulators. Two main types of validity in driving simulators are defined as behavioral validity and physical validity, which is also known as fidelity of the simulator (Blaauw, 1982; Godley et al., 2002). Behavioral validity concerns the extent a simulator elicits similar behavior in real driving condition (Blaauw, 1982). Although there is no consensus upon how to measure, behavioral validity is measured by comparing the driving performance of participants in simulated and real, i.e. on-road, driving (Blaauw, 1982; Reimer et al., 2006; Wynne et al., 2019). Physical validity concerns the extent a simulator’s physical properties and the experience of driving resemble the actual experience of driving (Blaauw, 1982; Godley et al., 2002; Reimer et al., 2006). For instance, a driving simulator that is equipped with a moving base, a 360° field of view, motion feedback, and full controls of the vehicle (Kaptein et al., 1996; Godley et al., 2002; Wynne et al., 2019) that provides the most similar experience of driving an actual vehicle will provide the greatest physical validity. Although physical validity, or physical fidelity, is important, unless a simulator establishes behavioral validity, it is stated that even the most physically valid simulation would not yield meaningful results (Triggs, 1996; Godley et al., 2002). Thus, a low physical fidelity simulator that uses a simple screen and controllers (e.g. a steering wheel, an accelerator, a brake pedal, a gear knob etc.) may also be useful in obtaining behavior similar to actual driving behavior, and obtaining meaningful results (Carsten & Jamson, 2011). Another measurement of validity distinction to consider in simulator studies is absolute validity and relative validity (Blaauw, 1982; Kaptein et al., 1996; Carsten & Jamson, 2011). Absolute validity refers to almost perfect correlation, or equal values, between values obtained from on-road field study and simulation study (Blaauw, 1982; Carsten & Jamson, 2011), whereas relative validity refers to similar values, or a correlation in the same direction, between values obtained from on-road field study and simulation study (Blaauw, 1982; Harms, 1996; Carsten & Jamson, 2011). The distinction between absolute validity and relative validity is important to have a comprehensive perspective in understanding the outcomes of driving simulator validation studies. For instance, in their validation study, Abdel-Aty and colleagues reported absolute validity in terms of mean speed outcomes between simulated driving and actual on-road driving (2006). Similarly, Bella (2005) reported no significant differences between mean speed values obtained from driving simulator and mean speed values obtained from field, demonstrating an absolute validity. Branzi and colleagues demonstrated absolute validity for mean speed measurements, whereas they demonstrated relative validity for speed variation (2017). Similarly, Blaauw reported relative validity for mean speed and speed variation (1982). Veldstra and colleagues (2015) demonstrated absolute validity for lane position variation, whereas Harms (1996) demonstrated relative validity for lateral position. Fors and colleagues (2013) demonstrated relative validity for the development of sleepiness during the course of driving, speed change, and absolute validity for lane crossings. Meuleners and Fraser (2015) demonstrated a relative validity for total number of errors, which consisted of errors of mirror checking, driving according to road signage, and maintaining the correct speed at intersections. Hoffman and colleagues (2002) demonstrated similarity for braking behavior between simulated driving and on-road driving, indicating a relative validity. Even though there were studies that failed to demonstrate an absolute or a relative validity for these outcomes, more studies were able to demonstrate an absolute or a relative validity for the study outcomes than the studies that failed to demonstrate validity (Wynne et al., 2019). In addition, the fidelity of the simulators in these studies varied from low to high, demonstrating that low-fidelity simulators can be as accurate as high-fidelity simulators in obtaining behavior similar to actual driving.

All in all, as many studies were able to demonstrate absolute and relative validities even though the fidelity of the simulators varied from low to high, driving simulators are accepted as reliable and valid tools of measuring driving behavior and performance in a controlled, replicable, and safe environment.

1.2.2. Eye Tracking and Road Safety

Another method used to study road safety is utilizing eye tracking devices in order to measure eye movements of drivers. Eye tracking devices operate by detecting the eyes of the participant through invasive technologies such as placing contact lenses and examining the alterations in electromagnetic field or non-invasive technologies such as sending infrared light beams to pupil and tracking the gaze point of the eyes of the participant in a momentarily, frame to frame manner (Khan & Lee, 2019; Carr & Grover, 2020; Vetturi et al., 2020). Two important variables of interest focused in eye tracking studies are fixations and saccades (Carr & Grover, 2020; Vetturi et al., 2020). Fixations are defined as the point of interest where participants direct their gaze (Hoffman & Subramaniam, 1995; Vetturi et al., 2020). Fixating to stimuli is said to be a conscious procedure (Nouzovský et al., 2022). It should be noted that even though fixations and the point of interest that an individual attends usually overlap, as eye movements and attention processes are separate processes, fixating on a point but not attending to that particular point is also possible (Shinar, 2008). Where to fixate the gaze depends on top-down processes, such as the knowledge, goals, and expectations of the individual, and bottom-up processes, such as the features of a scene in observational field (Hoffman & Subramaniam, 1995). Similarly, the duration of the fixations also depends on several factors such as the physical properties of the stimuli or cognitive load (Vetturi et al., 2020).

On the other hand, saccades, which are also called oscillating eye movements, are rapid eye movements between fixations (Hoffman & Subramaniam, 1995; Vetturi et al., 2020; Nouzovský et al., 2022). Saccades are also defined as the basic scanning movement (Sodhi et al., 2002). Saccadic eye movements are said to be affected by spatial attention processes in selectively determining where to fixate next in a selective and energy-efficient manner (Hoffman & Subramaniam, 1995; Nouzovský et al., 2022). It is stated that the eye movements do not occur in a straight trajectory during saccades, and most visual information is not perceived as certain cognitive abilities are not utilized during this movement (Sodhi et al., 2002; Vetturi et al., 2020). Filtering techniques and minimum duration of the eye movement events are often used as a method to distinguish between fixations and saccadic eye movements (Sodhi et al., 2002). In the context of driving, saccadic eye movements are said to last between 60-200ms, whereas for the fixations, a minimum duration of 200ms is accepted (Kapitaniak et al., 2015; Bıçaksız et al., 2019).

The use of eye-tracking technology has an increasing trend in the field of road safety research (Ojsteršek & Topolšek, 2019;Vetturi et al., 2020). Depending on the features of the eye-tracking device utilized or the aim of the study, the eye movements of drivers can be measured in on-road driving or simulated driving scenarios. However, eye-tracking devices are mostly used in simulated driving studies or other studies where participants are presented video recordings of driving, as compared to the studies conducted in on-road field studies (Ojsteršek & Topolšek, 2019). Eye-tracking studies are mostly interested in fixations in road safety studies. Eye tracking devices are used to examine the gaze data of drivers in various conditions such as the allocation of attention at intersections, curves, and pedestrian crossings, gaze behavior for road signs, the impact of distraction, experience, age, and so on (Hurtado & Chiasson, 2016; Vetturi et al., 2020; Carr & Grover, 2020). For instance, research suggested that experienced drivers would have fewer fixation durations and focus more on the potentially hazardous stimuli in the traffic setting (Underwoord et al., 2002). In contrast, research also suggested that there were no significant differences between fixation patterns of experienced and inexperienced drivers, whereas pointed out that inexperienced drivers had reduced and narrower horizontal scanning (Alberti et al., 2014; Robbins & Chapman, 2019). In a high-fidelity driving simulator study, drivers' eye movements indicated that novice and young drivers detected significantly fewer hazards as compared to older drivers (Pradhan et al., 2005). Hurtado and Chiasson demonstrated that road signage in different countries resulted in higher fixation durations, misreading of signs, and overall slower driving speeds to compensate for the mental load induced by being exposed to unfamiliar road signs (2016). Older drivers were found to have longer fixation durations and more fixations (Kunishige et al., 2019; Sun et al., 2018). In regards to distractions, cognitive distractions, use of mobile devices, presence of advertisement signs and roadside signage were the most studied distractions (Ojsteršek & Topolšek, 2019). Briggs et al. demonstrated that presenting an auditory message that induces mental imagery that drivers had to respond while demonstrating recordings of driving resulted in slower reaction times in reacting to hazards, and lesser mean variance of fixations which indicate a tunnel vision that prevents noticing hazards in peripheral vision, and engaged in significantly more errors even though they gazed on the relevant event, indicating ''looked but failed to see'' phenomenon (2016). Beijer and colleagues demonstrated in an on-road field driving that drivers would fixate more and longer for animated/moving advertisements (2004). The same effect was observed in a simulated driving study, where video advertisements received more and longer fixations as compared to static advertisements (Chattington et al., 2009). It was also reported that video advertisements caused higher lateral position variation and slower driving speeds, indicating compensatory behavior (Chattington et al., 2009). Thompson and Sabik demonstrated that presenting video recordings of unfamiliar traffic flow would cause participants to attend to the wrong side of the intersection as a result of habitual behavior, yet the effect was absent if participants were informed beforehand of the study about the rules of the traffic flow scenario they are unfamiliar with (2018). Brimley and colleagues created heatmaps based on the drivers' fixations in an on-road driving study and demonstrated that fixations of unfamiliar drivers were significantly more focused when coming to curves (2014). Nakayasu and colleagues demonstrated that when drivers were put in an unfamiliar traffic regulation scenario (i.e. USA and Japan), drivers were overshooting in right turns whereas undershooting in left turns, during which fixation durations and numbers of the drivers increased (2011). In another study regarding the effect of familiarity on fixations, Hu and colleagues demonstrated that drivers that are unfamiliar with the route had significantly longer fixation times, indicating a longer duration to process the information and a higher mental load (2022). Young and friends demonstrated that with increased route familiarity over repeated drives, fixations shifted towards driving irrelevant stimuli instead of the road, even with expert drivers (2018). All in all, eye-tracking studies in road safety research yielded promising results in studying visual attention in the traffic context. Thus, it is expected that eye-tracking devices will be utilized more frequently in future road safety research, and the literature regarding visual attention and road safety will be expanded (Ojsteršek & Topolšek, 2019).

1.3. Aim of the Study

When the road safety literature is examined, it is seen that many factors, such as human factors, vehicle factors, environmental factors, traffic culture and climate, and familiarity have an interrelated impact on driving performance and road safety. Even though there is a rich literature regarding road safety research, there are spots that remain underexplored, especially for the familiarity. As seen, most studies focus on route familiarity, whereas there is little emphasis on the effect of traffic flow familiarity (i.e. being familiar with RHT or LHT traffic). To the author's knowledge, even though data suggested that tourists or other individuals who are exposed to unfamiliar traffic flow have an increased risk of experiencing RTAs, no studies explored potential differences in driving performance and visual attention of drivers in unfamiliar traffic flow. To explore whether the driving performance and visual attention of drivers differ between the traffic flow they are familiar and unfamiliar with, the current study aims to utilize driving simulation and eye-tracking methods, and demonstrate potential differences between driving in familiar traffic (RHT) and unfamiliar traffic (LHT). In addition to laboratory measures, the current study also utilizes self-report measures and aims to explore the potential difference between how RHT and LHT road systems are perceived in terms of traffic climate, and how participants' evaluations of their own driving skills might have an impact on their driving performance is examined.

CHAPTER 2

METHOD

2.1. Participants

Participants were reached via social media, e-mail, and posters. Snowball and cluster sampling methods were used to obtain participants. Participants were given bonus points for their classes for their participation. The sample consisted of 34 undergraduate students. Participants that held their driving license for at least 3 years and that drove at least 3000 km in the last year were included in the study. 5 participants were removed from the sample for not complying with the 3000 km limit of minimum kilometers driven in the last year. The sample consisted of male drivers (*N* = 29). The age of the participants ranged between 20 and 27 (*M* = 22.17, *SD* = 1.71). The duration of having a driving license ranged between 3 and 6 years (*M* = 3.76, *SD* = .98). Total mileage of participants ranged between 6000 km and 50000 km (*M* = 21500, *SD* = 13548.85), whereas mileage in the last year ranged between 3000 km and 30000 km (*M* = 7325.86, *SD* = 5506.88).

2.2. Materials

2.2.1. Demographic Form

Participants were presented with a demographic information form to obtain information regarding sample characteristics and driving information. Participants were asked information about their age, sex, eye condition, use of eyeglasses, conditions that might interfere with driving, conditions that might interfere with using/spending time with a computer, whether they have previously visited an LHT country, whether they have previously driven in an LHT country, whether they use an automatic or manual transmission car, the duration of having a driving license, total mileage, mileage in the last year, accident history, ticket history, preferred driving speed in urban roads and inter-urban roads.

2.2.2. Driver Skill Inventory (DSI)

Self-reported driving skills of participants were obtained using the Turkish version of the driver skill inventory (DSI). Driver skill inventory was developed in 1995 by Lajunen and Summala, and the Turkish translation of the inventory was done by Sümer and Özkan in 2002. DSI consists of 20, 5-point Likert-type items (1 = very weak, 2 = weak, 3 = neither weak nor strong, 4 = strong, 5 = very strong). DSI consists of two subscales which are perceptual-motor skills and safety skills, and there are 10 items for each of the subscales. Perceptual-motor skills included items such as ‘’managing the car through a skid’’ and ‘’controlling the vehicle’’ whereas safety skills included items such as ‘’conforming to the speed limits’’ and ‘’keeping a sufficient following distance’’. In the current study, internal consistency reliability coefficients of .87 and .83 were obtained for the subscales of perceptual-motor skills and safety skills.

2.2.3. Traffic Climate Scale (TCS)

Self-reported attitudes and perceptions of participants regarding the RHT and LHT scenarios were collected using the traffic climate scale (TCS). TCS was developed in 2011 by Özkan and Lajunen. The short version of TCS that is utilized in the current study was developed by Üzümcüoğlu in 2020. The short version of the TCS consists of 16, 6-point Likert-type items (1 = does not describe it at all, 2 = does not describe it, 3 = describes a little, 4 = somewhat describes it, 5 = describes it, 6 = very much describes it). The short version of the TCS consists of three subscales, which are external affective demands, functionality, and internal requirements. External affective demands included items such as ‘’aggressive’’ and ‘’stressful’’, whereas functionality included items such as ‘’planned’’ and ‘’free=flowing’’, and internal requirements included items such as ‘’demands alertness’’ and ‘’demands cautiousness’’. As participants filled the Traffic Climate Scale twice for sthe RHT scenario and LHT scenario separately, the internal consistency reliability coefficients were calculated separately. In the current study, internal consistency reliability coefficients of .67, .65, and .86 were obtained for the subscales of external affective demands, functionality, and internal requirements for the TCS in evaluating the RHT scenario, whereas internal consistency reliability coefficients of .79, .65, and .79 were obtained for the subscales of external affective demands, functionality, and internal requirements for the TCS in evaluating the LHT scenario.

2.2.4. Driving Simulator

For the driving simulator, Stisim Drive M100W (STISIM Drive® Model 100 Wide Field-of-View Complete System) was utilized (See Figure 1.). The simulator was equipped with STISIM DRIVE-M100W-ASPT software, a 60 Hz 22" LCD display with 1280x1024 resolution, a Logitech G27 wheel and pedals, Logitech X-210 2.1 speakers, and a stationary chair. Participants received auditory feedback for throttle and brakes, as well as environment sounds. Only the middle display was utilized due to the restrictions of eye-tracker device. Although the simulator was also equipped with a shifter, participants were not required to use the shifter as manual transmission was not used in the current study.

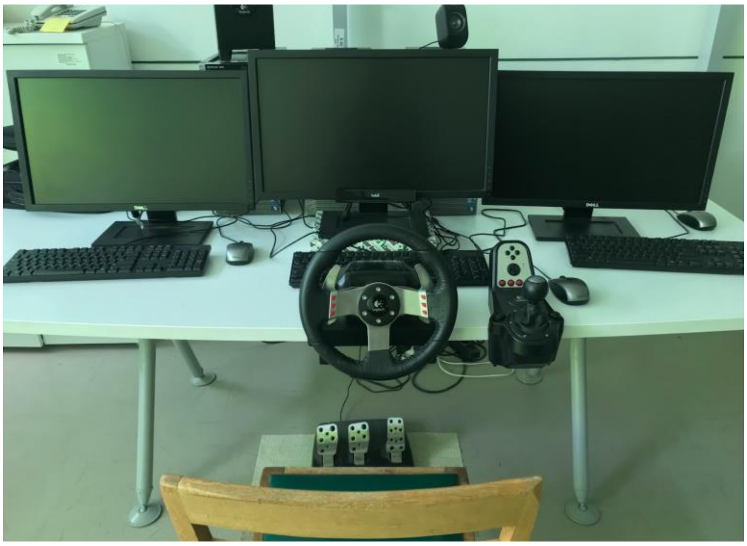


Figure 1. Stisim Drive M100W, Logitech G27 Wheel and Pedals, and Tobii Pro X2-60

2.2.4.1. Test Scenario

Participants were presented with a test drive scenario before driving in experimental scenarios. The aim of presenting a test drive scenario is to accustom participants to the controls and the display. Another aim for using a test drive scenario is to see if participants would experience simulation sickness. Upon finishing the test drive scenario, participants were asked about if they experienced simulation sickness (i.e. drowsiness, nausea etc.). Participants did not report any symptoms of simulation sickness. Participants were presented with the opportunity to drive the test drive scenario twice if they required. None of the participants demanded to took the test drive scenario twice.

The test drive scenario was a short, 2 km long, straight inter-urban road with a single lane for each direction. The standard lane width value of Turkey was used for the width of the each line. The test drive scenario did not require participants to take any turns or come to a stop (e.g. red traffic lights or stop signs), and had light traffic, and some roadside objects such trees and traffic signs. Because the participants were familiar with RHT system, the test drive scenario was created in RHT traffic configuration. It took approximately 2 minutes for each participant to complete the test drive scenario.

2.2.4.2. Experiment Scenario

After completing the test scenario, participants were assigned to experiment scenarios. The experiment scenario was a 2 km long, straight road with a single lane for each direction. The standard lane width value of Turkey was used for the width of the each line. The road was divided with yellow broken lines, and yellow solid lines in curves. The scenario began with a residential, urban area for 300 meters (See Figure 2). The residential area included parked cars, trees, and houses. There were no pedestrians or animals. The speed limit was 50 km/h in the residential section. Following the residential section, the inter-urban section began with a 90 km/h speed limit. The remaining part of the scenario was an inter-urban road with no residents nearby. Only trees and a few rural house models that are far to the road was used as roadside elements in inter-urban section. There were a total of three curves at 300, 900, and 1500 meters. Traffic signs that indicate the direction of the curves were present. There were two vehicles that approached at the beginning of the scenario and towards the end of the scenario with 50 and 60 km/h speeds. There were no vehicles that moved in the same direction as the participant. The vehicles did not interact with the participants' vehicle. There were no traffic lights or stop signs that required participants to come to a stop. The scenario also did not include roundabouts or intersections. The scenario had no weather events such as rain or wind. There were two experiment scenarios, which were the RHT scenario and the LHT scenario. As the aim of the study was to observe the difference in driver performance in unfamiliar traffic flow, the only difference between the RHT and the LHT scenarios was the flow of the traffic. There was a two-way traffic sign at the beginning of the scenario, specifically at 100 meters, to warn the drivers regarding the flow of the traffic. As the simulator software was not equipped with RHT and LHT versions of the two-way signs, the signs were created using Krita open source digital painting software and edited using a binary editor to integrate the signs to the simulator software (See Figure 3).

Figure 2. Beginning Section of the RHT Scenario

As the flow of the traffic change, the vehicles approaching were also driving in the corresponding lane. The aim of the use of approaching vehicles was to emphasize the change in the traffic flow. The traffic signs that are facing the participants' lane also changed to the corresponding lane in RHT and LHT scenarios. The vehicle of the participant was positioned in the corresponding lane for RHT and LHT scenarios at the beginning of the each scenario. In line with the recommendations of Intini and colleagues, an isolated road scenario with low traffic density was created in order to be able to measure "free flow characteristics" of speed and lateral lane position values (2016). The test drive scenario and experiment scenarios had different routes and objects (e.g. houses, trees etc.) in order to prevent a learning effect stemming from the test drive scenario over experimental scenarios (Intini et al., 2016). As the aim of the study was to observe the effect of familiarity, participants drove in both the RHT and

LHT scenarios 7 times repeatedly. Participants were told to imagine themselves using the same route just as everyday driving. Thus, the total length of a single scenario was 14 km. As the study utilized a repeated measures design, participants drove both in the RHT and LHT scenarios. Thus, every participant drove a total of 28 km. The order of presenting RHT and LHT scenarios after completing the test scenario was counterbalanced in order to prevent order effects. For every 5 meters traveled, simulator software collected the data of speed, lateral position, minimum time to collision between the driver and all vehicles opposing the driver's direction, and percentage of time and distance out of the lane. The data files provided by the simulator was separated for each 2000 meters in order to obtain results for each single drive in each of the RHT and LHT scenarios. Thus, a total of 14 data files (7 data files for each ride of the RHT and LHT scenarios) were obtained for each participant.

Figure 3. One Direction Signs for RHT and LHT Traffic Configurations

2.2.5. Eye Tracker

For the eye-tracking device, Tobii Pro X2-60 eye-tracker was utilized. Tobii Pro X2-60 is a screen-based, non-invasive eye tracking device that is mounted under the display screen (See Figure 4). Tobii Pro X2-60 is a compact eye tracking device that has an operating distance of 45-90 cm, a system latency of 48-67 ms, a sampling rate of 60 Hz, and a freedom of head movement width and length of 50 x 36 cm (Tobii, n.d.). The eye-tracker utilized in the current study works through sending infrared lights to the eye of the participants and then and picking up the reflected infrared lights from the eye of the participant, and calculating where the participant gaze on the single screen that is utilized to display the driving simulation. The official software of the eye-tracker, that is Tobii Pro Studio, was utilized to configure the eye-tracker, calibration, and data collection. A 9-point calibration points were applied using Tobii

Pro Studio. Gaze points that are not widely dispersed on the calibration points indicated good precision and good accuracy. Number of fixations and the duration of fixations were obtained as data of interest. Separate eye-tracking recordings were obtained for RHT and LHT scenarios. Similar to the data obtained from driving simulator, a total of 14 data files (7 data files for each ride of the RHT and LHT scenarios) were obtained for each participant.

Figure 4. Tobii Pro X2-60 (Tobii, 2015)

2.3. Procedure

The ethical approval for the research was obtained from Middle East Technical University Ethical Committee. Participants were obtained through social media posts, e-mails, and posters. Convenience and snowball sampling methods were used. The study is conducted in the Human Factor Lab located in ODTU-TSK MODSIMMER building. Participants were asked approve the consent form and fill the demographic information form. Following, the participants were asked to drive in the test drive scenario. Participants that provided consent and did not experience any symptoms of simulation sickness continued to study. None of the participants left the study at this stage. Following the completion of the test drive scenario, participants were assigned randomly to one of the RHT or LHT scenarios. Before beginning the drive, a calibration process is done in Tobii Pro Studio in order to calibrate the eye-tracker for each participant. For the calibration, 9-point calibration scheme is used. Participants were asked to focus on the center of the screen. Subsequently, articipants were required to follow a red dot that moved between each of the 9 calibration points. If poor results of precision and accuracy were obtained, the calibration process was redone. After obtaining good results for calibration, the driving simulation began. After finishing the first 14 km long run in either of the RHT or the LHT scenarios, participants were asked to fill in TCS and evaluate the traffic context they had just driven in. Subsequently, another calibration procedure was completed before beginning to drive in the remaining traffic flow scenario. After successfully completing the calibration process, the driving simulation began for the remaining traffic flow scenario. Upon finishing the scenario, the participants were asked to evaluate the traffic context they had just driven in through filling TCS again. Finally, participants were asked to fill in DSI. It took approximately 40 minutes for each participant to complete the study. The data collected from driving simulator and eye-tracker were processed using Microsoft Office Excel. The obtained data was analyzed using IBM SPSS Statistics 24 software.

CHAPTER 3

RESULTS

3.1. Descriptives

A descriptive analysis of the demographics were conducted (see Table 1). The mean for the age of the participants was found as 22.17 (SD = 1.71, Min = 20, Max = 27). The mean for the total duration of having driver license was found as 3.76 years (SD = .98, Min = 2, Max = 6). The mean for the total mileage of the participants was found as 21500 km (SD = 13548.85, Min = 6000, Max = 50000). The mean for the total mileage in the last year of participants was found as 6891.03 km (SD = 4192.64, Min = 3000, Max = 20000). The mean for the accidents in the last 3 years was found as .69 (SD = .93, Min = 0, Max =4). The mean for the accidents in which the participant was at fault was found as .45 (SD = .63, Min = 0, Max =2). None of the participants reported accidents that resulted in death or injury. The mean for the parking tickets participants received was found as .07 (SD = .25, Min = 0, Max =1). The mean for the overtaking tickets participants received was found as .07 (SD = .37, Min = 0, Max =2). The mean for the speeding tickets participants received was found as .31 (SD = .47, Min = 0, Max =1). The mean for the red light violation tickets participants received was found as .24 (SD = .68, Min = 0, Max =3). The mean for other tickets (broken signals, missing equipment etc.) was found as .10 (SD = .31, Min = 0, Max =1). The mean speed in urban roads reported by participants was 77.66 (SD = .14.07, Min = 40, Max =100). The mean speed in inter-urban roads reported by participants was 124.10 (SD = .16.66, Min =80, Max =150). In terms of eye conditions, 16 participants reported none (55.17%), 9 participants reported nearsightedness (31.03%), and 4 participants reported astigmatism (13.79%). A total of 11 participants reported using eyeglasses (37.93%). None of the participants reported a condition that might interfere with driving a vehicle. Two participants reported visiting a LHT country before (6.89%). The mean duration of residing in a LHT country was .48 days (SD = 1.97, Min =0, Max =10). None of the participants reported driving in a LHT country before.

13 Participants reported using an automatic transmission vehicle (44.82%), whereas 16 participants reported using a manual transmission vehicle (55.17%).

Table 1. *Descriptive Statistics of Demographics*

	N	Mean	SD	Min	Max	Percent
Age	29	22.17	1.71	20	27	100
Total duration of having driver license (years)	29	3.76	.98	2	6	100
Total mileage	29	21500	13548.85	6000	50000	100
Total mileage in the last year	29	6891.03	4192.64	3000	20000	100
Accidents in the last 3 years	29	.69	.93	0	4	100
Accidents at fault	29	.45	.63	0	2	100
Accidents with death or injury	29	0	0	0	0	100
Parking tickets	29	.07	.25	0	2	100
Overtaking tickets	29	.07	.37	0	2	100
Speeding tickets	29	.31	.47	0	1	100
Red light violation tickets	29	.24	.68	0	3	100
Other tickets	29	.10	.31	0	1	100
Mean speed in urban roads	29	77.66	14.07	40	100	100
Mean speed in inter-urban roads	29	124.10	16.66	80	150	100
Eye conditions	29	-	-	-	-	100
None	16	-	-	-	-	55.17
Nearsighted	9	-	-	-	-	31.03
Astigmatism	4	-	-	-	-	13.79
Use of eyeglasses	29	-	-	-	-	100
Not using	18	-	-	-	-	62.06
Using	11	-	-	-	-	37.93
Conditions that might interfere with driving a vehicle	29	-	-	-	-	100
Don’t have	29	-	-	-	-	100
Have	0	-	-	-	-	0
Visited a LHT country	29	-	-	-	-	100
Haven’t visited	27	-	-	-	-	93.10
Have visited	2	-	-	-	-	6.89
Duration of residing in a LHT country (days)	29	.48	1.97	0	10	100
Driving in a LHT country	29	-	-	-	-	100
Haven’t driven	29	-	-	-	-	100
Have driven	0	-	-	-	-	0
Transmission	29	-	-	-	-	100
Manual	16	-	-	-	-	55.17
Automatic	13	-	-	-	-	44.82

3.2. Correlations

Bivariate correlations was conducted for the relevant study variables (see Table 2). Although there were separate outcomes for the each of the 7 repeated drive in RHT and LHT scenarios for driving simulator data and eye-tracker data, mean of the total values for 7 repeated drives were calculated for the driving simulator data and eye-tracker data to provide a convenient correlations table. Results demonstrated that age was positively correlated with total duration of having a driver license ($r = .68$, $p < .001$), total mileage ($r = .68$, $p < .001$), total mileage in the last year ($r = .41$, $p < .05$), total variance of the vertical coordinate of the fixations in LHT ($r = .37$, $p < .05$). Total duration of having a driver license was positively correlated with total mileage ($r = .61$, $p < .001$), and total mileage in the last year ($r = .43$, $p < .05$). Total mileage was positively correlated with mean speed in inter-urban roads ($r = .50$, $p < .01$). Total mileage in the last year was positively correlated with parking tickets ($r = .43$, $p < .05$), speed in inter-urban roads ($r = .39$, $p < .05$), and negatively correlated with the total minimum time to collision between the driver and all vehicles opposing the driver's direction in LHT ($r = -.37$, $p < .05$). Accidents in the last 3 years was positively associated with accidents at fault ($r = .79$, $p < .001$), parking tickets ($r = .53$, $p < .01$), speeding tickets ($r = .47$, $p < .01$), red light violation tickets ($r = .56$, $p < .001$), and external affective demands of LHT ($r = .54$, $p < .01$). Accidents at fault was positively associated with accidents in the last 3 years ($r = .79$, $p < .001$), parking tickets ($r = .46$, $p < .01$), red light violation tickets ($r = .39$, $p < .05$), external affective demands in LHT ($r = .49$, $p < .01$), internal requirements in LHT ($r = .53$, $p < .01$), and negatively associated with mean fixation duration in RHT ($r = .-45$, $p < .05$), mean fixation duration in LHT ($r = .-47$, $p < .05$), and safety skills ($r = .-37$, $p < .05$). Parking tickets was associated with speeding tickets ($r = .40$, $p < .05$), external affective demands in LHT ($r = .48$, $p < .01$), internal requirements in LHT ($r = .49$, $p < .05$), and negatively associated with safety skills ($r = -.41$, $p < .05$). Overtaking tickets was associated with internal requirements in RHT ($r = .40$, $p < .05$). Speeding tickets was associated with speed in inter-urban roads ($r = .53$, $p < .01$). Red light violation tickets was associated with external affective demands in LHT ($r = .42$, $p < .05$). Other tickets was associated with total mean fixation duration in RHT ($r = .42$, $p < .05$), total percent time out of the lane in LHT ($r = .46$, $p < .01$), percent distance out of the lane in LHT ($r = .44$, $p < .05$), and negatively associated with functionality in LHT ($r = -.43$, $p < .05$).

Speed in inter-urban roads was associated with perceptual-motor skills ($r = .37, p < .05$). Total mean speed in RHT was associated with total mean speed in LHT ($r = .84, p < .001$), perceptual-motor skills ($r = .53, p < .01$), and negatively associated with minimum time to collision between the driver and all vehicles opposing the driver's direction in RHT ($r = -.42, p < .05$), and safety skills ($r = -.57, p < .001$). Total mean speed in LHT was associated with perceptual motor skills ($r = .62, p < .001$), and negatively associated with safety skills ($r = -.58, p < .001$).

Total standard deviation of the lateral lane position in RHT was associated with total standard deviation of the lateral lane position in LHT ($r = .57, p < .001$), total percent time out of the lane in RHT ($r = .59, p < .001$), total percent distance out of the lane in RHT ($r = .59, p < .001$), total percent time out of the lane in LHT ($r = .40, p < .05$), total percent distance out of the lane in LHT ($r = .41, p < .05$). Total standard deviation of the lateral lane position in LHT was associated with total percent time out of the lane in LHT ($r = .50, p < .01$) and total percent distance out of the lane in LHT ($r = .54, p < .01$). Minimum time to collision between the driver and all vehicles opposing the driver's direction in RHT was associated with total percent time out of lane in RHT ($r = .51, p < .01$), and total percent distance out of lane in RHT ($r = .50, p < .01$). Minimum time to collision between the driver and all vehicles opposing the driver's direction in LHT was negatively associated with external affective demands in LHT ($r = .37, p < .05$). Total percent time out of lane in RHT was perfectly associated with total percent distance out of lane in RHT ($r = .99, p < .001$), and associated with total percent time out of lane in LHT ($r = .43, p < .05$), and total percent distance out of lane in LHT ($r = .40, p < .05$). Total percent distance out of lane in RHT was associated with total percent time out of lane in LHT ($r = .44, p < .05$), and total percent distance out of lane in LHT ($r = .41, p < .05$). Total percent time out of lane in LHT was perfectly associated with total percent distance out of lane in LHT ($r = .99, p < .001$). Total number of fixations in RHT was associated with total number of fixations in LHT ($r = .61, p < .001$). Total number of fixations in LHT was negatively associated with perceptual-motor skills ($r = -.37, p < .05$). Total mean fixation duration in RHT was associated with total mean fixation duration in LHT ($r = .59, p < .001$), total percent time out of lane in RHT ($r = .65, p < .001$), total percent distance out of lane in RHT ($r = .65, p < .001$), total percent time out of lane in LHT ($r = .49, p < .01$), and total percent distance out of lane in LHT ($r = .45, p < .05$). Safety skills was negatively associated with perceptual-motor skills ($r = -.48, p < .01$). External affective demands in RHT was associated with external affective demands in LHT ($r = .47, p < .001$) and internal requirements in LHT ($r = .37, p < .05$). Internal requirements in RHT was associated with internal requirements in LHT ($r = .58, p < .001$). Functionality in RHT was associated with functionality in LHT ($r = .82, p < .001$). External affective demands in LHT was associated with internal requirements in LHT ($r = .62, p < .001$). Internal requirements in LHT was negatively associated with total percent time out of lane in RHT ($r = -.37, p < .05$), total percent distance out of lane in RHT ($r = -.38, p < .05$).

3.3. Comparison of Traffic Climate Scale (TCS) Subscales in RHT and LHT

Participants' evaluations of external affective demands, internal requirements, and functionality dimensions of TCS was compared with a series of paired samples t-test. The results indicated that there was a significant difference between external affective demands in RHT ($M = 1.54$, $SD = .47$) and LHT ($M = 1.81$, $SD = .71$), $t(28) = -2.36$, $p < .05$. Participants evaluated LHT scenario as higher in external affective demands. There was a significant difference between functionality in RHT ($M = 4.34$, $SD = .88$) and LHT ($M = 4.03$, $SD = .94$),), $t(28) = 3.14$, $p < .01$. Participants evaluated RHT scenario as higher in functionality. There was no significant difference between internal requirements in RHT ($M = 2.72$, $SD = 1.24$) and LHT ($M = 3.00$, $SD = 1.12$), $t(28) = -1.37$, $p = .18$. Participants evaluated RHT and LHT scenarios similarly in terms of internal requirements.

3.4. Comparison of Traffic Climate Scale (TCS) Subscales' interaction with Driver Skill Inventory (DSI) scores in RHT and LHT

To demonstrate how the participants' self-reported evaluations of their safety skills and perceptual-motor skills would interact with their comparison of external affective demands, functionality, and internal requirements scores in RHT and LHT scenarios, the subscales of DSI were split by their corresponding median value. Participants were separated into two groups with low scores or high scores based on the median value of safety skills (3.90) and perceptual-motor skills (4.00).

3.4.1. External Affective Demands and Safety Skills

A 2 x 2 mixed-design analysis of variance (ANOVA) was computed for external affective demands scores, with traffic flow (RHT vs. LHT) as within-subject factors and safety skills (Low vs. High) as between-subject factors. There was a significant main effect of traffic flow, $F(1, 27) = 5.08$, $p < .05$, $\eta_p^2 = .16$, on the evaluations of external affective demands. The main effect of safety skills, $F(1, 27) = .04$, $p = .83$, $\eta_p^2 = .00$, and the interaction effect of safety skills and traffic flow was not significant, $F(1, 27) = .43$, $p = .51$, $\eta_p^2 = .02$. Specifically, participants evaluated LHT scenario (*M* = 1.87, *SD* = .14) higher than RHT scenario (*M* = 1.55, *SD* = .09) in external affective demands (Figure 5).

3.4.2. Internal Requirements and Safety Skills

A 2 x 2 mixed-design analysis of variance (ANOVA) was computed for internal requirements scores, with traffic flow (RHT vs. LHT) as within-subject factors and safety skills (Low vs. High) as between-subject factors. There was a significant interaction effect of traffic flow and safety skills, $F(1, 27) = 5.36$, $p < .05$, $\eta_p^2 = .17$. The main effect of safety skills, $F(1, 27) = .08$, $p = .78$, $\eta_p^2 = .00$, and traffic flow, $F(1, 27) = 1.50$, $p = .23$, $\eta_p^2 = .05$, was not significant. Specifically, internal requirements scores was higher in RHT scenario for participants who scored higher in safety skills (*M* = 3.02, *SD* = .34), whereas internal requirements scores was higher in LHT scenario for participants who scored lower in safety skills (*M* = 3.14, *SD* = .28) (Figure 6).

3.4.3. Functionality and Safety Skills

A 2 x 2 mixed-design analysis of variance (ANOVA) was computed for functionality scores, with traffic flow (RHT vs. LHT) as within-subject factors and safety skills (Low vs. High) as between-subject factors. There was a significant main effect of traffic flow $F(1, 27) = 9.15$, $p < .01$, $\eta_p^2 = .25$. The main effect of safety skills $F(1, 27) = .06$, $p = .80$, $\eta_p^2 = .00$, and the interaction effect of safety skills and traffic flow $F(1, 27) = 1.28$, $p = .27$, $\eta_p^2 = .05$, was not significant. Specifically, participants evaluated RHT scenario (*M* = 4.34, *SD* = .17) higher in functionality than LHT scenario (*M* = 4.03, *SD* = .18) (Figure 7).

Table 2. *Correlations Table of Study Variables*

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Age	1	.680**	.684**	.413*	-.100	-.074	.c	-.190	-.019	-.246	-.127	.167	.275
2	Total duration of having a driver's license	.680**	1	.613**	.430*	-.240	-.278	.c	-.213	.047	-.217	-.121	.318	.247
3	Total mileage	.684**	.613**	1	.688**	.223	.071	.c	.153	-.192	.092	.151	.102	.506**
4	Total mileage in the last year	.413*	.430*	.688**	1	.216	.061	.c	.431*	-.151	.193	.144	.008	.396*
5	Accidents in the last 3 years	-.100	-.240	.223	.216	1	.793**	.c	.539**	-.143	.473**	.567**	.239	.348
6	Accidents at fault	-.074	-.278	.071	.061	.793**	1	.c	.461*	-.136	.116	.399*	.120	.172
7	Accidents with injury or death	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c
8	Parking tickets	-.190	-.213	.153	.431*	.539**	.461*	.c	1	-.051	.406*	.305	-.092	.347
9	Overtaking tickets	-.019	.047	-.192	-.151	-.143	-.136	.c	-.051	1	-.127	-.067	-.064	.010
10	Speeding tickets	-.246	-.217	.092	.193	.473**	.116	.c	.406*	-.127	1	.311	.017	.533**
11	Red light violation tickets	-.127	-.121	.151	.144	.567**	.399*	.c	.305	-.067	.311	1	-.121	.212
12	Other tickets	.167	.318	.102	.008	.239	.120	.c	-.092	-.064	.017	-.121	1	-.016
13	Speed in inter-urban roads	.275	.247	.506**	.396*	.348	.172	.c	.347	.010	.533**	.212	-.016	1

Table 2. *Continued*

		1	2	3	4	5	6	7	8	9	10	11	12	13
14	Speed in urban roads	.075	.058	-.153	.217	.106	.291	.[c]	.145	.305	-.183	.024	-.008	-.088
15	Total mean speed in RHT	.139	.053	.074	.149	-.145	-.019	.[c]	.143	.024	-.233	.100	-.215	.185
16	Total mean speed in LHT	.116	-.014	.073	.138	-.134	-.031	.[c]	.074	.059	-.239	.141	-.246	.132
17	Total standard deviation of the lateral lane position in RHT	.089	.077	.068	.239	-.054	-.282	.[c]	-.119	.333	.267	-.059	.075	.069
18	Total standard deviation of the lateral lane position in LHT	.069	.143	.100	.164	-.161	-.104	.[c]	-.045	.198	-.151	-.128	.040	-.025
19	Total time to collision between the driver and all vehicles opposing the driver's direction in RHT	-.009	-.130	.041	.219	.291	.118	.[c]	.065	-.016	.328	-.115	.015	.145
20	Total time to collision between the driver and all vehicles opposing the driver's direction in LHT	-.054	.074	-.243	-.387*	-.341	-.176	.[c]	-.338	-.029	-.007	-.225	-.053	-.056
21	Total mean fixation duration in RHT	.077	.237	.096	-.005	-.068	-.456*	.[c]	-.146	.240	.147	-.176	.429*	-.022
22	Total mean fixation duration in LHT	-.072	-.090	-.083	-.176	-.221	-.473*	.[c]	-.186	-.027	.124	-.272	.090	-.031
23	Total mean fixation number in RHT	-.283	-.048	-.118	.027	-.033	-.099	.[c]	.149	-.097	.245	.234	.148	.025
24	Total mean fixation number in LHT	-.059	-.002	.003	-.099	-.001	-.082	.[c]	-.023	-.179	.056	-.212	.272	-.003
25	Mean time of completing RHT scenario	-.148	-.079	-.079	-.171	.165	.021	.[c]	-.128	-.048	.280	-.100	.212	-.164
26	Mean time of completing LHT scenario	-.095	.022	-.050	-.137	.160	.058	.[c]	-.081	-.094	.255	-.111	.244	-.099

Table 2. *Continued*

		1	2	3	4	5	6	7	8	9	10	11	12	13
27	Safety skills	.028	.225	.014	-.081	-.361	-.379*	.[c]	-.408*	.110	-.118	-.294	.090	-.176
28	Perceptual-motor skills	.081	.138	.103	.240	-.019	-.068	.[c]	.160	.047	.165	.122	-.321	.378*
29	External affective demands in RHT	-.126	-.163	.211	.327	.214	.212	.[c]	.349	-.223	.004	-.044	-.122	-.242
30	Internal requirements in RHT	-.072	-.115	-.090	.000	-.025	.149	.[c]	.248	.405*	.009	-.087	-.326	.042
31	Functionality in RHT	-.076	-.095	-.010	.067	-.093	.065	.[c]	.049	-.075	-.137	.005	-.363	.213
32	External affective demands in LHT	-.153	.101	.331	.336	.546**	.495**	.[c]	.484**	-.221	.200	.429*	.149	.159
33	Internal requirements in LHT	-.229	-.139	.052	.166	.353	.537**	.[c]	.493**	-.057	.180	.246	-.103	.089
34	Functionality in LHT	-.092	-.224	-.161	-.173	-.225	-.095	.[c]	-.081	.046	-.160	-.120	-.438*	.055
35	Total percent time out of lane in RHT	.026	.042	-.029	.123	.067	-.329	.[c]	-.137	.272	.210	-.166	.309	-.108
36	Total distance time out of lane in RHT	.018	.038	-.032	.122	.071	-.331	.[c]	-.136	.254	.218	-.167	.311	-.107
37	Total percent time out of lane in LHT	-.066	.052	.104	.160	.146	-.162	.[c]	.035	.009	-.030	-.004	.466*	-.145
38	Total distance time out of lane in LHT	-.071	.059	.101	.172	.113	-.176	.[c]	.034	.013	-.054	.001	.440*	-.133

Table 2. *Continued*

		14	15	16	17	18	19	20	21	22	23	24	25	26
14	Speed in urban roads	1	.129	.162	.143	.173	-.007	-.225	-.109	-.053	-.302	-.298	-.161	-.147
15	Total mean speed in RHT	.129	1	.844**	.143	.206	-.425*	-.191	-.225	-.050	-.362	-.287	-.994**	-.847**
16	Total mean speed in LHT	.162	.844**	1	.187	.354	-.284	-.206	-.203	.052	-.300	-.254	-.865**	-.994**
17	Total standard deviation of the lateral lane position in RHT	.143	.143	.187	1	.577**	.200	-.017	.232	-.003	-.216	-.351	-.123	-.179
18	Total standard deviation of the lateral lane position in LHT	.173	.206	.354	.577**	1	-.051	.162	-.176	-.176	-.102	-.055	-.213	-.321
19	Total time to collision between the driver and all vehicles opposing the driver's direction in RHT	-.007	-.425*	-.284	.200	-.051	1	-.037	.212	.001	.341	.323	.445*	.279
20	Total time to collision between the driver and all vehicles opposing the driver's direction in LHT	-.225	-.191	-.206	-.017	.162	-.037	1	-.338	-.195	.035	.028	.190	.223
21	Total mean fixation duration in RHT	-.109	-.225	-.203	.232	-.176	.212	-.338	1	.592**	.238	.267	.245	.158
22	Total mean fixation duration in LHT	-.053	-.050	.052	-.003	-.176	.001	-.195	.592**	1	.043	.339	.065	-.078
23	Total mean fixation number in RHT	-.302	-.362	-.300	-.216	-.102	.341	.035	.238	.043	1	.618**	.364	.273
24	Total mean fixation number in LHT	-.298	-.287	-.254	-.351	-.055	.323	.028	.267	.339	.618**	1	.298	.236
25	Mean time of completing RHT scenario	-.161	-.994**	-.865**	-.123	-.213	.445*	.190	.245	.065	.364	.298	1	.869**
26	Mean time of completing LHT scenario	-.147	-.847**	-.994**	-.179	-.321	.279	.223	.158	-.078	.273	.236	.869**	1

Table 2. *Continued*

	14	15	16	17	18	19	20	21	22	23	24	25	26
27 Safety skills	-.305	-.570**	-.586**	-.095	-.116	-.031	.331	.176	-.068	.181	.126	.551**	.559**
28 Perceptual-motor skills	.139	.538**	.623**	.295	.207	-.005	-.257	-.018	.013	-.187	-.377*	-.525**	-.611**
29 External affective demands in RHT	.185	-.224	-.252	-.049	-.068	.050	-.317	-.036	-.158	-.184	-.196	.215	.257
30 Internal requirements in RHT	.307	-.158	-.250	-.037	-.129	.090	-.073	-.182	-.235	.063	-.176	.154	.241
31 Functionality in RHT	.001	.162	.000	.031	.047	-.117	.102	-.374	-.168	-.108	-.297	-.150	.006
32 External affective demands in LHT	.138	-.176	-.233	-.299	-.121	-.162	-.370*	-.115	-.134	.063	-.091	.165	.255
33 Internal requirements in LHT	.291	-.121	-.102	-.241	-.158	.074	-.249	-.347	-.253	.142	-.077	.109	.119
34 Functionality in LHT	.046	.054	-.021	.077	.111	-.198	.213	-.265	-.006	-.285	-.287	-.041	.027
35 Total percent time out of lane in RHT	-.062	-.190	-.229	.593**	-.017	.513**	-.175	.658**	.178	.046	.066	.216	.195
36 Total distance time out of lane in RHT	-.065	-.188	-.227	.599**	-.010	.508**	-.169	.652**	.180	.035	.059	.214	.195
37 Total percent time out of lane in LHT	-.074	-.128	.053	.401*	.507**	.171	-.322	.493*	.133	.187	.141	.127	-.049
38 Total distance time out of lane in LHT	-.060	-.084	.108	.410*	.541**	.148	-.315	.454*	.121	.207	.123	.079	-.102

Table 2. *Continued*

		27	28	29	30	31	32	33	34	35	36	37	38
27	Safety skills	1	-.481**	-.002	.054	.089	-.163	-.346	.180	.165	.159	-.041	-.068
28	Perceptual-motor skills	-.481**	1	-.233	-.083	.042	-.033	-.005	-.023	-.045	-.039	.011	.043
29	External affective demands in RHT	-.002	-.233	1	.226	.012	.474**	.379*	.008	.040	.050	.146	.131
30	Internal requirements in RHT	.054	-.083	.226	1	.133	.060	.582**	.185	-.065	-.080	-.294	-.280
31	Functionality in RHT	.089	.042	.012	.133	1	.053	.042	.823**	-.268	-.266	-.255	-.230
32	External affective demands in LHT	-.163	-.033	.474**	.060	.053	1	.626**	-.224	-.313	-.307	.059	.051
33	Internal requirements in LHT	-.346	-.005	.379*	.582**	.042	.626**	1	-.166	-.370*	-.376*	-.219	-.206
34	Functionality in LHT	.180	-.023	.008	.185	.823**	-.224	-.166	1	-.253	-.250	-.188	-.179
35	Total percent time out of lane in RHT	.165	-.045	.040	-.065	-.268	-.313	-.370*	-.253	1	.999**	.436*	.402*
36	Total distance time out of lane in RHT	.159	-.039	.050	-.080	-.266	-.307	-.376*	-.250	.999**	1	.445*	.411*
37	Total percent time out of lane in LHT	-.041	.011	.146	-.294	-.255	.059	-.219	-.188	.436*	.445*	1	.994**
38	Total distance time out of lane in LHT	-.068	.043	.131	-.280	-.230	.051	-.206	-.179	.402*	.411*	.994**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

.[c] Cannot be computed because at least one of the variables is constant.

3.4.4. External Affective Demands and Perceptual-Motor Skills

A 2 x 2 mixed-design analysis of variance (ANOVA) was computed for external affective demands scores, with traffic flow (RHT vs. LHT) as within-subject factors and perceptual-motor (Low vs. High) as between-subject factors. There was a significant main effect of traffic flow $F(1, 27) = 5.27$, $p < .05$, $\eta_p^2 = .16$. The main effect of perceptual-motor skills $F(1, 27) = .00$, $p = .98$, $\eta_p^2 = .00$ was not statistically significant. Similarly, the interaction effect of the traffic flow and perceptual-motor skills $F(1, 27) = .00$, $p = .94$, $\eta_p^2 = .00$, was not statistically significant. Specifically, participants evaluated LHT scenario (*M* = 1.82 *SD* = .14) higher in external affective demands than RHT scenario (*M* = 1.54, *SD* = .09) (Figure 8).

3.4.5. Internal Requirements and Perceptual-Motor Skills

A 2 x 2 mixed-design analysis of variance (ANOVA) was computed for external affective demands scores, with traffic flow (RHT vs. LHT) as within-subject factors and perceptual-motor (Low vs. High) as between-subject factors. The main effect of the traffic flow was not statistically significant, $F(1, 27) = 2.44$, $p = .13$, $\eta_p^2 = .08$. The main effect of perceptual motor skills was not statistically significant, $F(1, 27) = .06$, $p = .81$, $\eta_p^2 = .00$. Similarly, the interaction effect of the traffic flow and perceptual-motor skills was also not statistically significant $F(1, 27) = 1.38$, $p = .25$, $\eta_p^2 = .05$ (Figure 9).

3.4.6. Functionality and Perceptual-Motor Skills

A 2 x 2 mixed-design analysis of variance (ANOVA) was computed for functionality scores, with traffic flow (RHT vs. LHT) as within-subject factors and perceptual-motor (Low vs. High) as between-subject factors. There was a significant main effect of traffic flow $F(1, 27) = 9.37$, $p < .01$, $\eta_p^2 = .26$. The main effect of perceptual-motor skills $F(1, 27) = .00$, $p = .99$, $\eta_p^2 = .00$ was not statistically significant. Similarly, the interaction effect of traffic flow and perceptual-motor skills $F(1, 27) = .01$, $p = .91$, $\eta_p^2 = .00$, was not statistically significant. Specifically, participants evaluated RHT scenario (*M* = 4.34, *SD* = .17) higher in functionality than LHT scenario (*M* = 4.03, *SD* = .18) (Figure 10).

Figure 5. External affective demands by traffic flow and safety skills

Figure 6. Internal requirements by traffic flow and safety skills

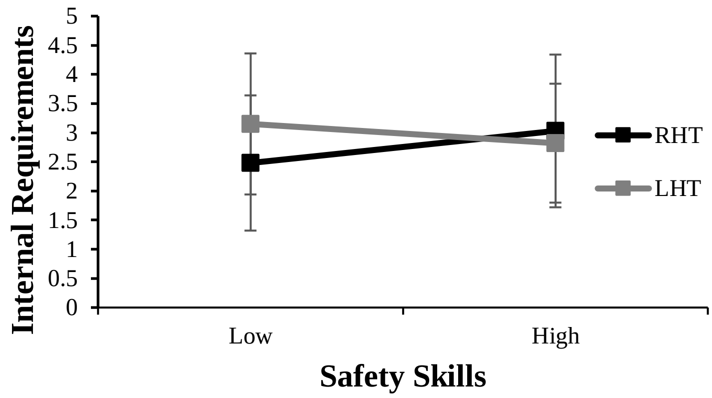


Figure 7. Functionality by traffic flow and safety skills

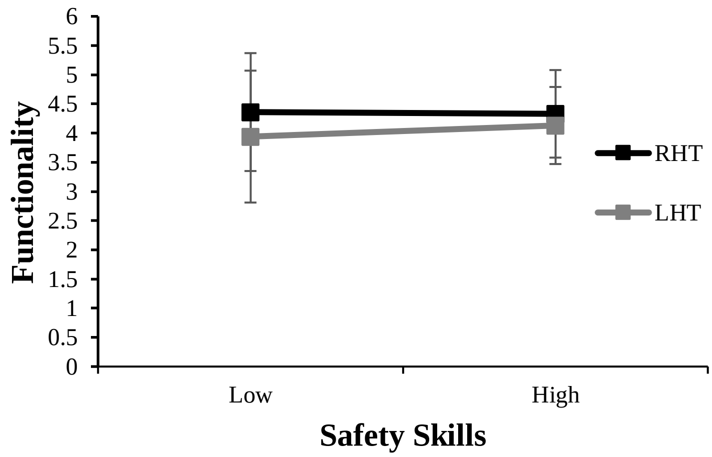


Figure 8. External affective demands by traffic flow and perceptual-motor skills

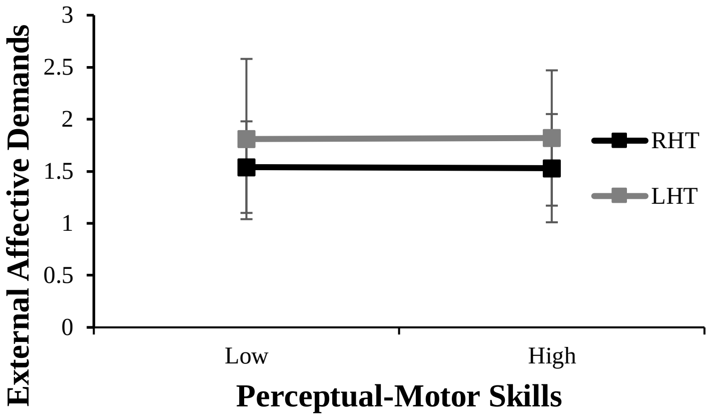


Figure 9. Internal requirements by traffic flow and perceptual-motor skills

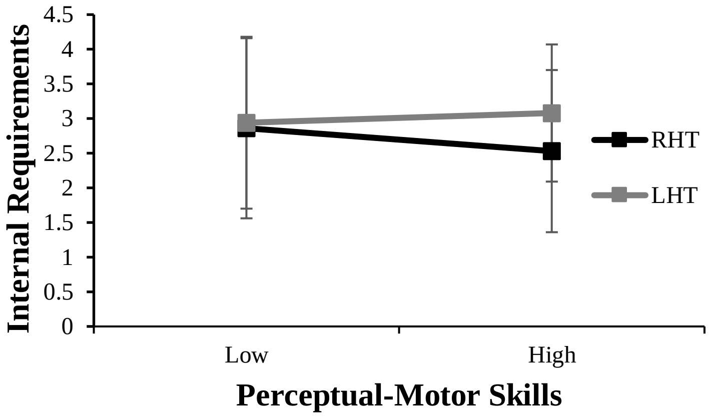
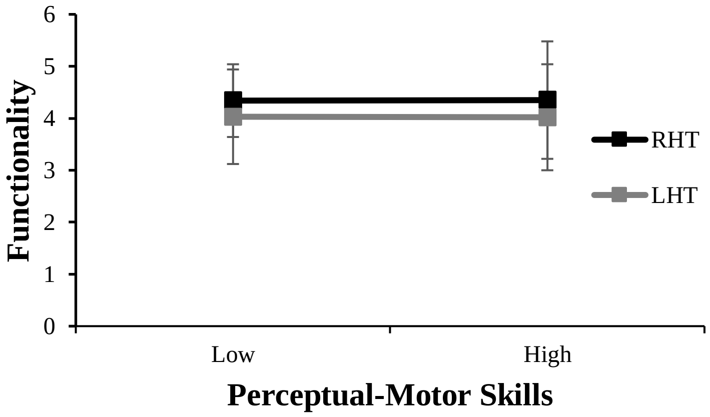


Figure 10. Functionality by traffic flow and perceptual-motor skills

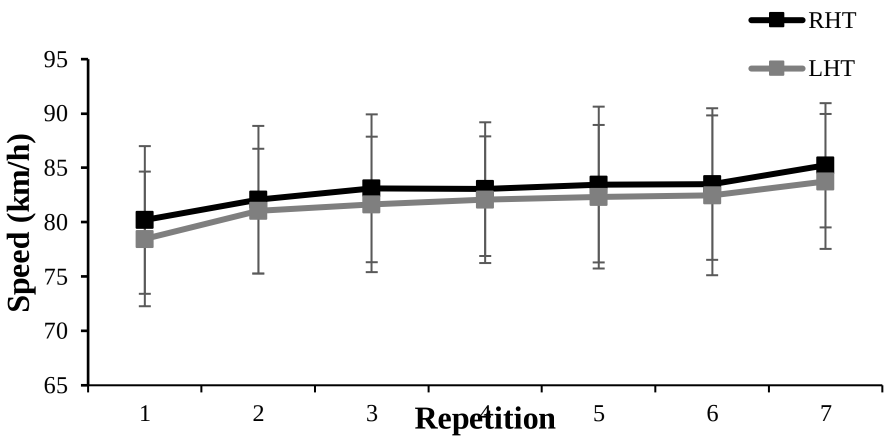


3.5. Driving Simulation

3.5.1. Speed

To demonstrate the effect of traffic flow and number of repetitions on the drivers' speed, a 2 x 7 repeated measures analysis of variance (ANOVA) was conducted, with traffic flow (RHT vs. LHT) and repetition (1 vs. 2 vs. 3 ….. vs. 7) as within-subject factors. There was a significant main effect of traffic flow $F(1, 28) = 4.19$, $p < .05$, $\eta_p^2 = .13$, and a significant main effect of repetition $F(2.25, 62.99) = 13.72$, $p < .001$, $\eta_p^2 = .33$. The interaction between traffic flow and repetition was not significant $F(3.98, 111.45) = .209$, $p = .93$, $\eta_p^2 = .01$. Since sphericity is violated, Greenhouse-Geisser corrected results are reported for repetition ($\varepsilon = 0.37$), and the interaction between repetition and traffic flow ($\varepsilon = 0.66$) (Figure 11).

Figure 11. Speed by traffic flow and repetition



3.5.1.1. Threshold of Familiarity for Speed

In order to see the threshold of becoming familiar with the routes in the scenarios, a series of analysis of variance (ANOVA) was conducted for RHT and LHT scenarios, with repetition (1 vs. 2 vs. 3 …. Vs. 7) as within-subject factors. It was aimed to see how many repetitions drivers required until the significant differences in speed values between each ride disappeared. There was a significant difference between repetitions in RHT scenario, $F(3.85, 107.92) = 9.61$, $p < .001$, ηp2 = .25, and in LHT scenario $F(2.25, 62.93) = 8.12$, $p < .001$, ηp2 = .23 (See Figure 12 and Figure 13). Since sphericity is violated, Greenhouse-Geisser corrected results are reported for repetition in RHT ($\varepsilon = .64$), and LHT ($\varepsilon = 0.38$).

Figure 12. Speed by repetition in RHT.

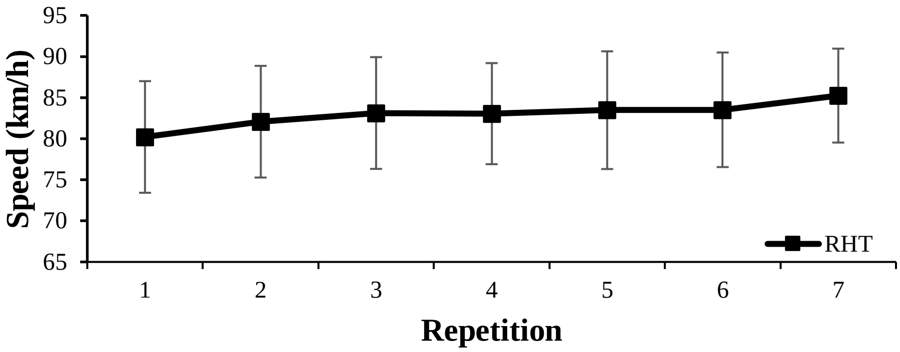
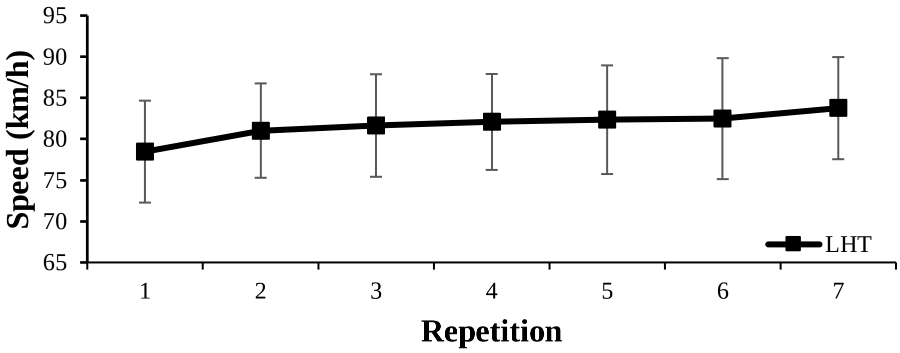


Figure 13. Speed by repetition in LHT.



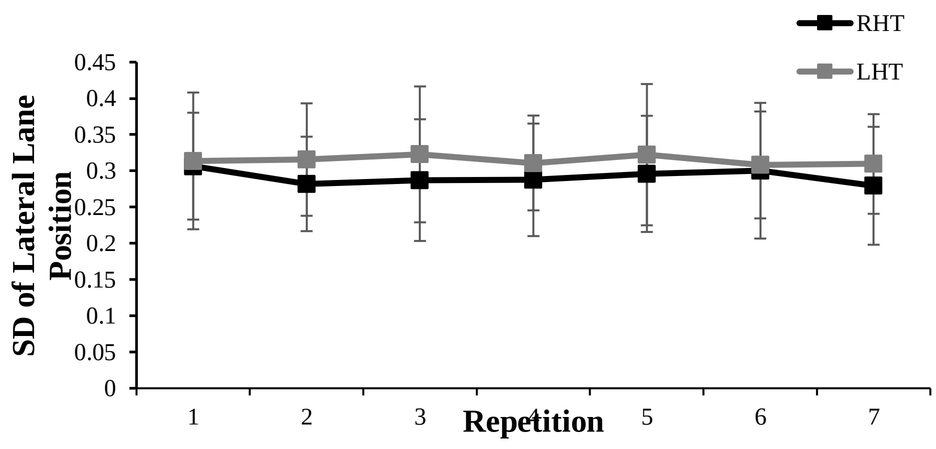
Post-hoc analyses for RHT scenario demonstrated that there was a significant difference between ride 1 (M = 80.21, SD = 1.26) and ride 2 (M = 82.07, SD = 1.26), ride 3 (M = 83.12, SD = 1.26), ride 4 (M = 83.04, SD = 1.14), ride 5 (M = 83.47, SD = 1.33), ride 6 (M = 83.51, SD = 1.29), and ride 7 (M = 85.24, SD = 1.06). Ride 2 (M = 82.07, SD = 1.26) significantly differed only with ride 6 (M = 83.51, SD = 1.29) and ride 7 (M = 85.24, SD = 1.06). Ride 3 (M = 83.12, SD = 1.26), ride 4 (M = 83.04, SD = 1.14), ride 5 (M = 83.47, SD = 1.33), and ride 6 (M = 83.51, SD = 1.29) significantly differed only with ride 7 (M = 85.24, SD = 1.06). The highest mean difference occurred between consecutive rides was between ride 1 (M = 80.21, SD = 1.26) and ride 2 (M = 82.07, SD = 1.26).

Post-hoc analyses for LHT scenario demonstrated that there was a significant difference between ride 1 (M = 78.46, SD = 1.15) and ride 2 (M = 81.03, SD = 1.07), ride 3 (M = 81.64, SD = 1.16), ride 4 (M = 82.07, SD = 1.08), ride 5 (M = 82.35, SD = 1.23), ride 6 (M = 82.48, SD = 1.37), and ride 7 (M = 83.75, SD = 1.15). Ride 2 (M = 81.03, SD = 1.07), Ride 3 (M = 81.64, SD = 1.16), ride 4 (M = 82.07, SD = 1.08), ride 5 (M = 82.35, SD = 1.23), and ride 6 (M = 82.48, SD = 1.37) significantly differed only with ride 7 (M = 83.75, SD = 1.15). Similar to RHT scenario, the highest mean difference occurred between consecutive rides was between ride 1 (M = 78.46, SD = 1.15) and ride 2 (M = 81.03, SD = 1.07). Specifically, for both the RHT and LHT scenarios, the threshold for disappearance of significant differences for consecutive rides in mean speed values was the second ride. The potential reasons for the difference of the last ride with previous rides is discussed.

3.5.2. Lateral Lane Position

To demonstrate the effect of traffic flow and number of repetitions on the drivers' standard deviation of the lateral lane position, a 2 x 7 repeated measures analysis of variance (ANOVA) was conducted, with traffic flow (RHT vs. LHT) and repetition (1 vs. 2 vs. 3 ….. vs. 7) as within-subject factors. There was a significant main effect of traffic flow $F(1, 28) = 4.28$, $p < .05$, $\eta_p^2 = .13$. The main effect of repetition $F(6, 168) = .71$, $p = .64$, $\eta_p^2 = .03$, and the interaction effect between traffic flow and repetition $F(6, 168) = .81$, $p = .56$, $\eta_p^2 = .03$, was not significant (See Figure 14).

Figure 14. Standard deviation of lateral lane position by traffic flow and repetition



3.5.2.1. Threshold of Familiarity for Lateral Lane Position

In order to see the threshold of becoming familiar with the routes in the scenarios, a series of analysis of variance (ANOVA) was conducted for RHT and LHT scenarios, with repetition (1 vs. 2 vs. 3 …. Vs. 7) as within-subject factors. It was aimed to see how many repetitions drivers required until the significant differences in standard deviation of the lateral lane position values between each ride disappeared. There was no significant difference between repetitions in RHT scenario, $F(6, 168) = 1.15$, $p = .33$, ηp2 = .04, and between repetitions in LHT scenario, $F(6, 168) = .38$, $p = .88$, ηp2 = .01. In specific, the standard deviation of the lateral lane position values did not significantly differ between repetitions. Thus, no separate figures for the ANOVA results of the difference between lateral lane position values of participants in consecutive rides was provided.

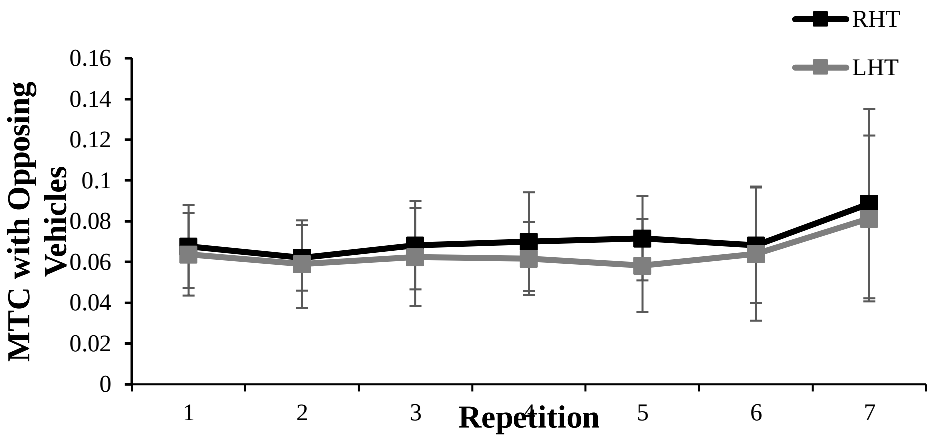
3.5.3. Minimum Time to Collision Between the Driver and All Vehicles Opposing the Driver's Direction

To demonstrate the effect of traffic flow and number of repetitions on the drivers' minimum time to collision () with all vehicles opposing the driver's direction, a 2 x 7 repeated measures analysis of variance (ANOVA) was conducted, with traffic flow (RHT vs. LHT) and repetition (1 vs. 2 vs. 3 ….. vs. 7) as within-subject factors. There was a significant main effect of traffic flow, $F(1, 28) = 5.26$, $p < .05$, $\eta_p^2 = .15$, and main effect of repetition $F(3.58, 100.27) = 4.54$, $p < .01$, $\eta_p^2 = .14$.

Since sphericity is violated, Greenhouse-Geisser corrected results are reported for repetition ($\varepsilon = .59$). The interaction effect of traffic flow and repetition $F(6, 168) = .29$, $p = .93$, $\eta_p^2 = .01$, was not significant. Specifically, minimum time to collision between the driver and all vehicles opposing the driver's direction was significantly lower in LHT scenario (*M* = .06, *SD* = .002) than RHT scenario (*M* = .07, *SD* = .002) (See Figure 15).

In terms of repetition, only the ride 7 (*M* = .09, *SD* = .006) differed from ride 1 (*M* = .07, *SD* = .002), ride 2 (*M* = .06, *SD* = .002), ride 3 (*M* = .07, *SD* = .003), ride 4 (*M* = .07, *SD* = .003), ride 5 (*M* = .07, *SD* = .003), and ride 6 (*M* = .07, *SD* = .004). The source of difference is explained by the fact that after the ride 7, the scenario stops repeating itself. Thus, there was no vehicle opposing the driver's direction in the last section of ride 7. As a result, no further ANOVA analyses were conducted to see the threshold of familiarity for the minimum time to collision between the driver and all vehicles opposing driver's direction.

Figure 15. Minimum Time to Collision Between the Driver and All Vehicles Opposing Driver's Direction by Traffic Flow and Repetition



3.5.4. Other Simulator Outputs

Total mean speed, total standard deviation of the lateral lane position, total percent of time out of the lane, and total percent of distance out of the lane outputs of RHT and LHT scenarios compared with a paired-sample t-test. There was a significant difference between total mean speed in RHT (M = 82.95, SD = 6.16) and LHT (M = 81.68, SD = 5.63), $t(28) = 2.05$, $p < .05$. There was a significant difference between total standard deviation of the lateral lane position in RHT (M = .29, SD = .07) and LHT (M = .32, SD = .07), $t(28) = -2.07$, $p < .05$. There was a significant difference between total percent of time out of lane in RHT (M = .49, SD = .99) and LHT (M = 1.47, SD = 1.88), $t(28) = -3.17$, $p < .01$. There was a significant difference between total percent of distance out of lane in RHT (M = .53, SD = 1.08) and LHT (M = 1.56, SD = 1.92), $t(28) = -3.09$, $p < .01$. Specifically, total mean speed was higher in RHT scenario, whereas total standard deviation of the lateral lane position was higher in LHT scenario. Total percent of time and distance out of lane in LHT scenario was higher than RHT scenario.

3.5.5. Other Simulator Outputs and DSI

Total mean speed, total standard deviation of the lateral lane position, total percent of time out of the lane, and total percent of distance out of the lane outputs of RHT and LHT scenarios are compared in a 2 x 2 mixed-design analysis of variance (ANOVA), including simulator outputs (RHT vs. LHT) as within-subject factors, and DSI subscales (High vs. Low) as between-subject factors. DSI subscales are dichotomized using median split.

3.5.5.1. Total Mean Speed and Safety Skills

For total mean speed, there was a significant main effect of safety skills $F(1, 27) = 16.49$, $p < .001$, $\eta_p^2 = .38$. There was no significant main effect of traffic flow, $F(1, 27) = 3.75$, $p = .06$, $\eta_p^2 = .12$, and an interaction effect of traffic flow and safety skills $F(1, 27) = .74$, $p = .39$, $\eta_p^2 = .03$. Specifically, participants with lower safety skills had higher total mean speeds (*M* = 85.41, *SD* = 1.14) than participants with higher safety skills (*M* = 78.51, *SD* = 1.26) (See Figure 16).

3.5.5.2. Total SD of Lateral Lane Position and Safety Skills

For total standard deviation of lateral lane position, there was a significant main effect of traffic flow $F(1, 27) = 4.06$, $p < .05$, $\eta_p^2 = .13$. There was no significant main effect of safety skills, $F(1, 27) = .15$, $p = .69$, $\eta_p^2 = .01$, and an interaction effect of traffic flow and safety skills $F(1, 27) = .00$, $p = .95$, $\eta_p^2 = .00$. Specifically, total standard deviation of lateral lane position was higher in LHT scenario (*M* = .31, *SD* = .01) than RHT scenario (*M* = .29, *SD* = .12) (See Figure 17).

3.5.5.3. Total Percent of Time out of Lane and Safety Skills

For total percent of time out of lane, there was a significant main effect of traffic flow $F(1, 27) = 9.77$, $p < .01$, $\eta_p^2 = .27$. There was no significant main effect of safety skills, $F(1, 27) = 1.56$, $p = .23$, $\eta_p^2 = .05$, and an interaction effect of traffic flow and safety skills $F(1, 27) = .05$, $p = .79$, $\eta_p^2 = .00$. Specifically, total percent of time out of lane was significantly higher in LHT scenario (*M* = 1.50, *SD* = .34) than RHT scenario (*M* = .51, *SD* = .18) (See Figure 18).

Figure 16. Total Mean Speed by Traffic Flow and Safety Skills

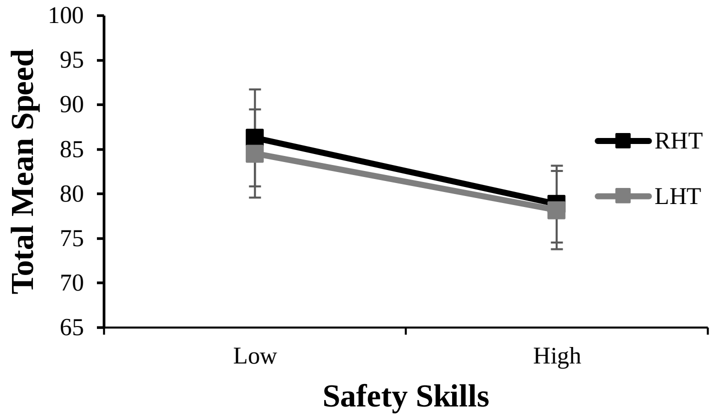
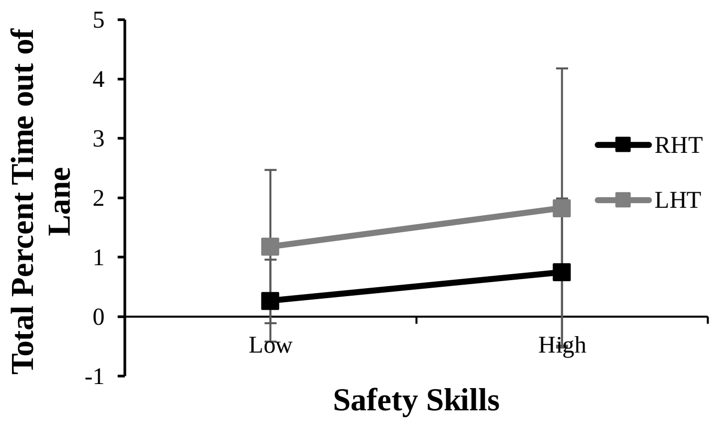


Figure 17. Total SD of Lateral Lane Position by Traffic Flow and Safety Skills

Figure 18. Total Percent of Time out of Lane by Traffic Flow and Safety Skills



3.5.5.4. Total Percent of Distance out of Lane and Safety Skills

For total percent of distance out of lane, there was a significant main effect of traffic flow $F(1, 27) = 9.22$, $p < .01$, $\eta_p^2 = .26$. There was no significant main effect of safety skills, $F(1, 27) = 1.36$, $p = .25$, $\eta_p^2 = .05$, and an interaction effect of traffic flow and safety skills $F(1, 27) = .02$, $p = .89$, $\eta_p^2 = .00$.

Specifically, total percent of distance out of lane was significantly higher in LHT scenario (*M* = 1.58, *SD* = .36) than RHT scenario (*M* = .56, *SD* = .20) (See Figure 19).

3.5.5.5. Total Mean Speed and Perceptual-Motor Skills

For total mean speed, there was a significant main effect of perceptual-motor skills $F(1, 27) = 12.35$, $p < .01$, $\eta_p^2 = .31$. There was no significant main effect of traffic flow, $F(1, 27) = 3.69$, $p = .06$, $\eta_p^2 = .12$, and an interaction effect of traffic flow and safety skills $F(1, 27) = .13$, $p = .72$, $\eta_p^2 = .01$.

Specifically, total mean speed was higher for participants with higher perceptual-motor skills (*M* = 86.03, *SD* = 1.38) than participants with lower perceptual-motor skills (*M* = 79.69, *SD* = 1.16) (See Figure 20).

3.5.5.6. Total SD of Lateral Lane Position and Perceptual-Motor Skills

For total standard deviation of lateral lane position, there was no significant main effect of traffic flow $F(1, 27) = 3.59$, $p = .06$, $\eta_p^2 = .12$, perceptual-motor skills $F(1, 27) = .61$, $p = .44$, $\eta_p^2 = .02$, or interaction effect of traffic flow and perceptual-motor skills $F(1, 27) = .52$, $p = .48$, $\eta_p^2 = .02$ (See Figure 21).

3.5.5.7. Total Percent Time out of Lane and Perceptual-Motor Skills

For total percent time out of lane, there was a significant main effect of traffic flow $F(1, 27) = 9.26$, $p < .01$, $\eta_p^2 = .25$. There was no significant main effect of perceptual-motor skills, $F(1, 27) = .62$, $p = .43$, $\eta_p^2 = .02$, and an interaction effect of traffic flow and perceptual-motor skills $F(1, 27) = .02$, $p = .89$, $\eta_p^2 = .00$.

Specifically, total percent time out of lane was higher in LHT scenario (*M* = 1.43, *SD* = .35) than RHT scenario (*M* = .46, *SD* = .19) (See Figure 22).

3.5.5.8. Total Percent Distance out of Lane and Perceptual-Motor Skills

For total percent distance out of lane, there was a significant main effect of traffic flow $F(1, 27) = 8.99$, $p < .01$, $\eta_p^2 = .25$. There was no significant main effect of perceptual-motor skills, $F(1, 27) = .43$, $p = .51$, $\eta_p^2 = .01$, and an interaction effect of traffic flow and perceptual-motor skills $F(1, 27) = .00$, $p = .96$, $\eta_p^2 = .00$. Specifically, total percent distance out of lane was higher in LHT scenario (*M* = 1.53, *SD* = .37) than RHT scenario (*M* = .51, *SD* = .21) (See Figure 23).

Figure 19. Total Percent of Distance out of Lane by Traffic Flow and Safety Skills

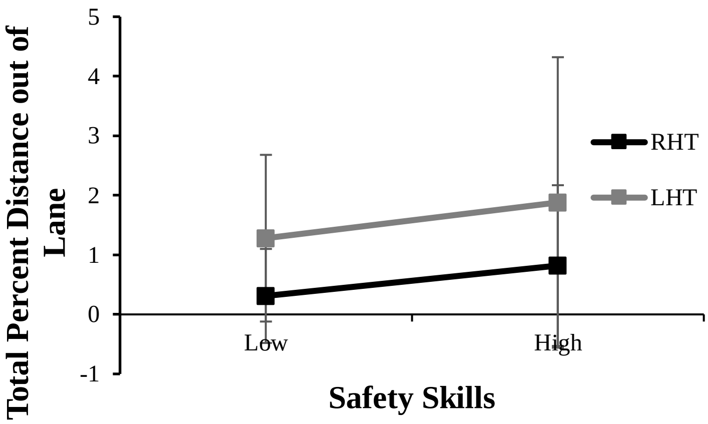


Figure 20. Total Mean Speed by Traffic Flow and Perceptual-Motor Skills

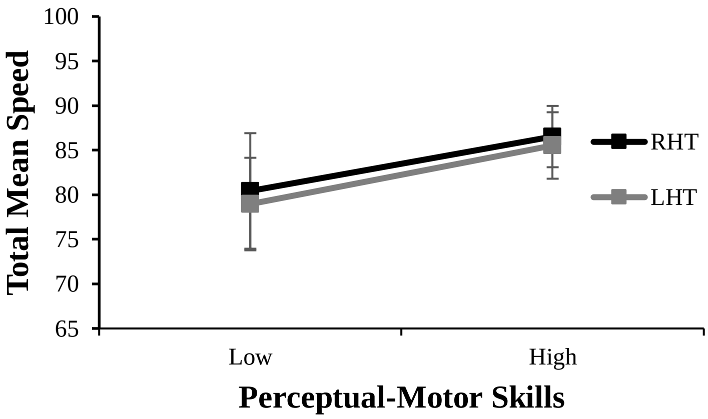


Figure 21. Total SD of Lateral Lane Position by Traffic Flow and Perceptual-Motor Skills

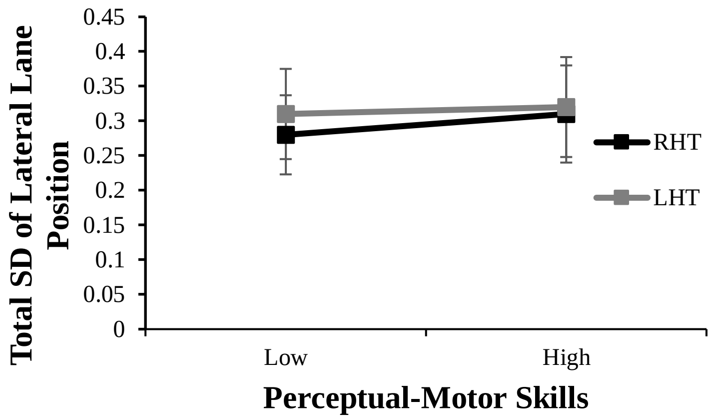


Figure 22. Total Percent Time out of Lane by Traffic Flow and Perceptual-Motor Skills

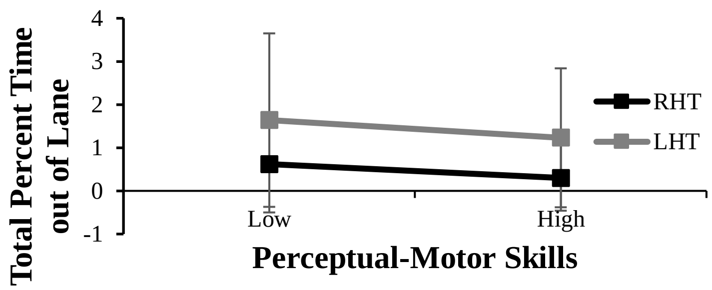
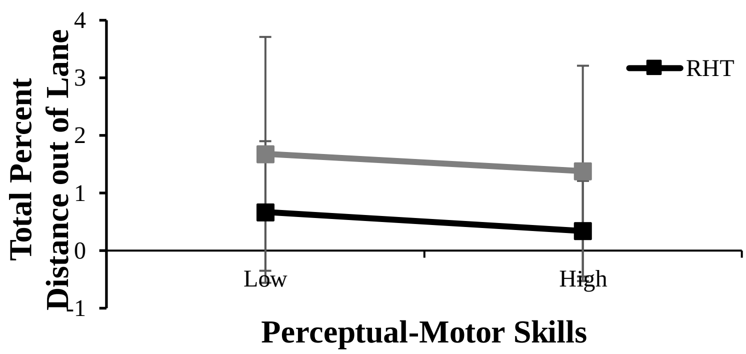


Figure 23. Total Percent Distance out of Lane by Traffic Flow and Perceptual-Motor Skills



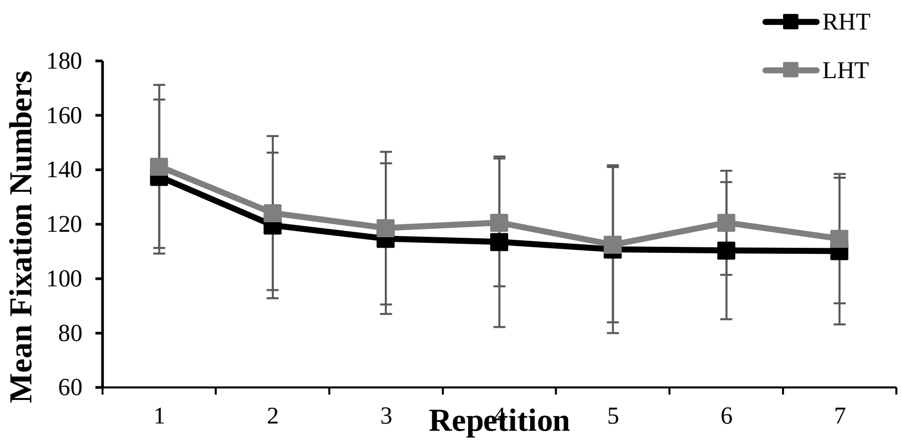
3.6. Eye-Tracker

3.6.1. Fixation Numbers

To demonstrate the effect of traffic flow and number of repetitions on the drivers' fixation numbers, a 2 x 7 repeated measures analysis of variance (ANOVA) was conducted, with traffic flow (RHT vs. LHT) and repetition (1 vs. 2 vs. 3 ….. vs. 7) as within-subject factors. there was a significant main effect of repetition $F(2.88, 80.83) = 19.99$, $p < .001$, $\eta_p^2 = .42$. The main effect of traffic flow $F(1, 28) = .28$, $p = .59$, $\eta_p^2 = .01$, and the interaction effect between traffic flow and repetition was not significant $F(3.77, 105.56) = .35$, $p = .83$, $\eta_p^2 = .01$, (See Figure 26).

Since sphericity is violated, Greenhouse-Geisser corrected results are reported for repetition ($\varepsilon = .48$), and interaction between traffic flow and repetition ($\varepsilon = 0.62$).

Figure 24. Fixation Numbers by Traffic Flow and Repetition



3.6.1.1. Threshold of Familiarity for Fixation Numbers

To see the threshold of becoming familiar with the routes in the scenarios, a series of analysis of variance (ANOVA) was conducted for RHT and LHT scenarios, with repetition (1 vs. 2 vs. 3 …. Vs. 7) as within-subject factors. It was aimed to see how many repetitions drivers required until the significant differences in fixation numbers between each ride disappeared. There was a significant effect of repetition in RHT scenario, $F(3.39, 95.18) = 10.89$, $p < .001$, $\eta_p^2 = .28$. Since sphericity is violated, Greenhouse-Geisser corrected results are reported ($\varepsilon = .57$).

The effect of repetition in LHT was also significant F(3.36, 94.14) = 13.89, $p < .001$, $\eta_p^2 = .33$. Since sphericity is violated, Greenhouse-Geisser corrected results are reported ($\varepsilon = .56$).

Post-hoc analyses for RHT scenario demonstrated that there was a significant difference between ride 1 (*M* = 137.50, *SD* = 4.97), ride 2 (*M* = 119.54, *SD* = 4.70), ride 3 (*M* = 114.69, *SD* = 4.86), ride 4 (*M* = 113.54, *SD* = 5.50), ride 5 (*M* = 110.81, *SD* = 5.41), ride 6 (*M* = 110.27, *SD* = 4.42), and ride 7 (*M* = 110.12, *SD* = 4.73). There was also a significant difference between ride 2 (*M* = 119.54, *SD* = 4.70) and ride 6 (*M* = 110.27, *SD* = 4.42) (See Figure 25).

Post-hoc analyses for LHT scenario demonstrated that there was a significant difference between ride 1 (*M* = 139.85, *SD* = 5.44), ride 2 (*M* = 122.07, *SD* = 5.42), ride 3 (*M* = 115.64, *SD* = 5.47), ride 4 (*M* = 117.14, *SD* = 4.82), ride 5 (*M* = 110.21, *SD* = 5.56), ride 6 (*M* = 116.14, *SD* = 4.49), and ride 7 (*M* = 111.11, *SD* = 5.11). Ride 2 was significantly different from ride 3 (*M* = 115.64, *SD* = 5.47), and ride 5 (*M* = 110.21, *SD* = 5.56). Ride 4 was significantly different from ride 5 (*M* = 110.21, *SD* = 5.56) (See Figure 26). Specifically, for the RHT scenario, the threshold for disappearance of significant differences for consecutive rides in fixation numbers was the second ride, whereas the threshold was the third ride in LHT scenario.

3.6.2. Fixation Durations

To demonstrate the effect of traffic flow and number of repetitions on the drivers' fixation durations, a 2 x 7 repeated measures analysis of variance (ANOVA) was conducted, with traffic flow (RHT vs. LHT) and repetition (1 vs. 2 vs. 3 ….. vs. 7) as within-subject factors. There was no significant main effect of traffic flow, F(1, 28) = 2.99, $p = .09$, $\eta_p^2 = .09$, and repetition F(2.59, 72.50) = 2.59, $p = .06$, $\eta_p^2 = .08$, or an interaction effect of traffic flow and repetition F(2.70, 75.66) = 1.62, $p = .19$, $\eta_p^2 = .05$.

As sphericity is violated, Greenhouse-Geisser corrected results are reported for repetition, ($\varepsilon = .43$), and interaction of repetition and traffic flow ($\varepsilon = .50$) (See Figure 27). As repetition did not yield significant results, no further ANOVA analyses were conducted to see the threshold of familiarity for fixation duration.

Figure 25. Fixation Numbers by Repetition in RHT

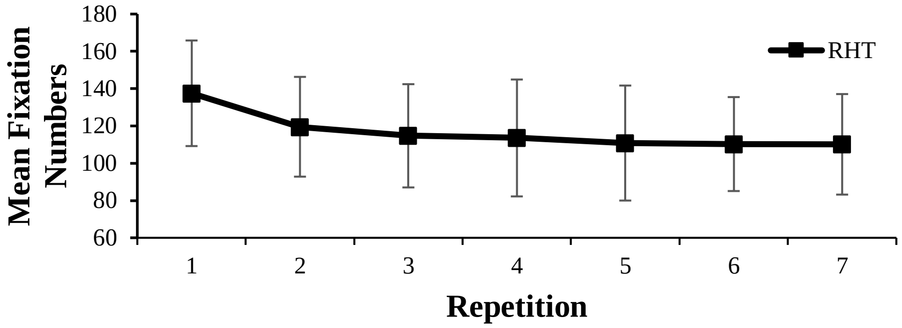


Figure 26. Fixation Numbers by Repetition in LHT

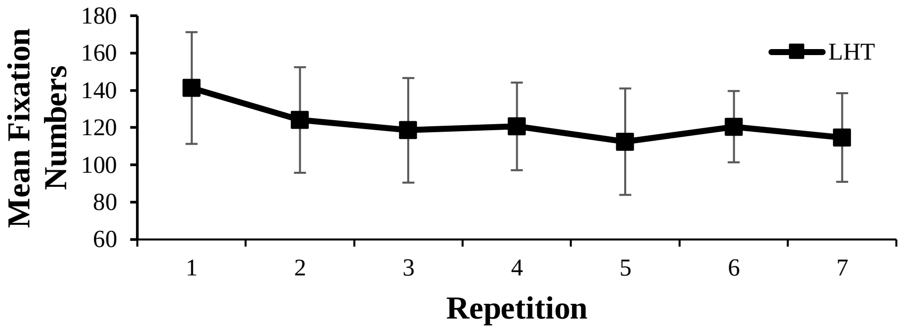
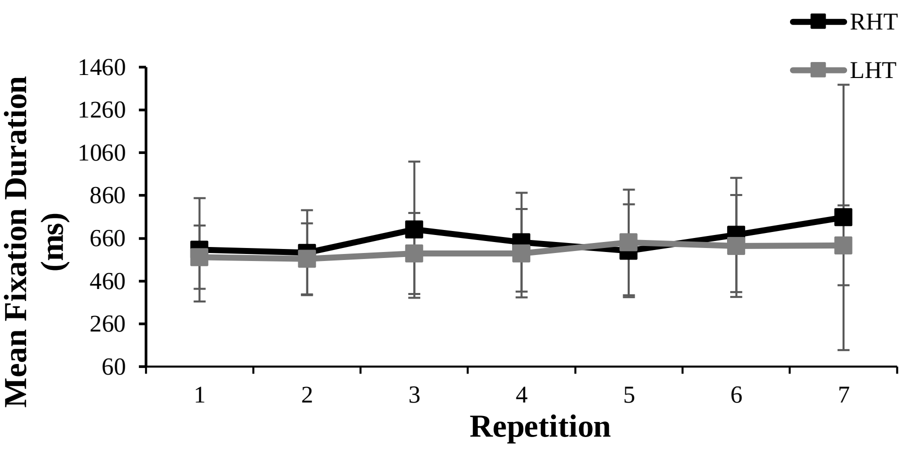


Figure 27. Fixation Duration by Traffic Flow and Repetition



CHAPTER 4

DISCUSSION

4.1. Discussion of Descriptives

After removing five participants for not complying with the minimum mileage in the last year criteria, the final sample was consisted of 29 drivers. In a review study, it was reported that the mean value of sample size for studies that utilized eye-tracker and driving simulators as 29 (Ojsteršek & Topolšek, 2019). Thus, the sample size was adequate for the current study. It was important not to mix extremely inexperienced and experienced drivers in research that aims to examine the effect of familiarity, as having a level of experience under certain limits may act as a confounding variable (Intini, Colonna, Berloco, & Ranieri, 2016). In line with the literature, participants that held their driving license for at least 3 years and that drove at least 3000 km in the last year were included in the current study in order to prevent experience to affect study outcomes (Intini et al., 2016; Özbozdağlı et al., 2018; Bıçaksız et al., 2019).

The sample was consisted of mainly young, male, university students. According to Druckman and Kam, use of college students might hinder the external validity, or generalizability, of a research (2011). Furthermore, the current study only had young male drivers. It is a known finding in the road safety literature that young male drivers are overrepresented in unsafe acts of driving and RTAs (Summala, 1987; Gregersen, 1996; Sümer et al., 2006, Clarke et al., 2006; Oltedal and Rundmo, 2006). Thus, the results of the current study should be evaluated considering the fact that due to practical reasons, university students, who are young male drivers, participated in the study.

None of the participants experienced an accident with injury or death. The mean values of speeding and red light violation tickets was higher than parking and overtaking tickets. As stated before, young male drivers are associated with more reckless driving behavior. Thus, the sample characteristics might had an influence on higher observations for the frequency of speeding and red light tickets.

37.93% of the participants was using eyeglasses. Dahlberg suggested that use of eyeglasses might increase the accuracy errors of eye-tracker devices up to 20% (2010). However, when the data was examined, no remarkable differences between participants who use eyeglasses and who do not use was found in terms of eye-tracker outputs. Furthermore, the current study only interested in exploring how fixation numbers and fixation durations are affected. It should be beneficial for researchers to consider accuracy of eye-tracker outputs when the sample includes participants with eyeglasses if the exact location of the gazes are the point of interest.

None of the participants had a condition that would prevent them from driving and using a computer. Only two participants visited a LHT country before, and their visit was for a brief amount of time. Thus, the sample did not had any significant experience with LHT system that might produce some familiarity with LHT traffic flow before the current study.

Although a slightly higher number of participants had manual transmission cars (55.17%), none of the participants reported any problem regarding the driving simulation, or the use of automatic transmission in the current study, after the test drive.

4.2. Discussion of Correlations

Age was positively correlated with total duration of having a driver license, total mileage, and total mileage in the last year. Outcomes for these variables were naturally expected to increase with age. Total mileage and total mileage in the last year was positively associated with speed in inter-urban roads, but not urban roads. Chipman and colleagues suggested that higher speeds indicate more exposure in a given period of time, which may also be associated with the severity of RTAs (1992). When the characteristics of young male drivers considered (Summala, 1987), higher speeds associated with higher mileage (exposure) might indicate a tendecy of reckless driving in the current sample. Total mileage, and total mileage in the last year was not associated with total mean speed in RHT and total mean speed in RHT scenarios, despite total mileage, and mileage in the last year, being associated with self-reported speed in inter-urban roads. This finding might indicate a difference between self-reported speed and speed in simulated driving. Although many studies reported absolute or relative validity for mean speed outcomes between actual driving and simulated driving (Wynne et al., 2019), self-reported speed and simulated driving speed values might have varied in the current study, which might have resulted in finding an association between self-reported speed and exposure, whereas there were no association between simulated driving speeds and exposure.

Accidents in the last 3 years was positively associated with accidents at fault, parking tickets, speeding tickets, and red light violation tickets. Speeding tickets was also positively associated with the speed in inter-urban roads. According to the literature, there is a strong positive association between the total number of accidents and tickets (fines) received (Lourens et al., 1999; Cellar et al., 2000). Number of speeding and parking tickets was also found to be positively associated with violations (Mesken et al., 2010). Thus, the findings of the current study was in line with the findings in other road safety research in regards to the positive relationship between accidents, speeding, and tickets received.

In contrary to findings from literature (Elander et al., 1993; Lourens et al., 1999), total mileage or mileage in the last year was not associated with accidents in the last three years or accidents at fault. However, the sample size was considerable small compared to studies that reported associations between mileage and accidents (Massie et al., 1997; Lourens et al., 1999). There were also no recordings of accidents with death or injury in the current study. In addition, Elander and colleagues suggested that subjective reports of mileage might include random or systematic error, accuracy issues, and mileage by itself may not be an adequate predictor of RTAs by itself, as other factors such as where and when drivers are exposed to traffic interacts with mileage (1993). Thus, failure to find an association between mileage and accidents might be explained by the limited sample size of simulation studies and limitations of mileage variable by itself.

Speed in inter-urban roads, total mean speed in RHT and total mean speed in LHT was positively associated with perceptual-motor skills, and negatively associated with safety-skills. Research regarding driver skills suggested that higher perceptual-motor skills would predict higher speeds and reckless driving, whereas safety skills was negatively correlated with speed and reckless driving (Sümer et al., 2006; Ostapczuk et al., 2017). Research (Lajunen et al., 1998; Lajunen et al., 2022) suggested that being male was associated positively with perceptual-motor skills. Thus, finding perceptual-motor skills associated with higher speeds in a sample consisted of male drivers was expected.

Safety skills was negatively correlated with perceptual-motor skills. Thus, as participants self-evaluated perceptual-motor skills increase, their safety skills tend to decrease. Perceptual-motor skills was found to be negatively associated with safety skills (Lajunen et. al, 2022). Research also suggested that drivers who overestimate their driving skills would be associated with more acts of reckless driving and more RTAs (Delhomme, 1991; Sümer et al., 2006; Horswill et al., 2006). Thus, the current study also demonstrated that higher perceptual-motor skills would be associated with lower safety skills, indicating a more unsafe driving.

In the current study, safety skills was negatively correlated with accidents at fault, and total accidents in the last three years, though the threshold of significance was almost met with total accidents in the last year. On the other hand, perceptual-motor skills was not positively associated with total accidents in the last three years or accidents at fault. Research suggested that safety skills would be negatively correlated with accidents, whereas perceptual-motor skills would be positively correlated with accidents (Lajunen, et al., 1998a; Özkan et al., 2006). However, Özkan and colleagues reported that the negative association between safety skills and accidents, and the positive association between perceptual-motor skills and accidents, was found in some countries but not others (2006). Thus, associations between safety-skills, perceptual-motor skills, and accidents also yielded mixed results in the current study. As Özkan and colleagues suggested, although DSI maintains it’s two factor structure, there may be differences in subscales of DSI depending on the context the study is conducted (2006). Furthermore, limited sample size of the current experimental study might also hindered detecting an association between perceptual-motor skills and accidents, as accidents are “rare events” (Elander et al., 1993, p. 281).

The total standard deviation of the lateral lane position in RHT was positively associated with total standard deviation of the lateral lane position in LHT, which indicated that participants who had higher outcomes for standard deviation of the lateral lane position in RHT also tend to have higher outcomes of the same variable in LHT traffic. Total standard deviation of the lateral lane position in RHT and LHT was also associated with total percent distance and time out of the lane in RHT and LHT. In other words, higher total standard deviation of the lateral lane position in RHT and LHT was associated with more time and distance out of lane while driving, indicating a risky driving. Failure in lane-keeping was associated with head-on and leaving the roadway RTAs (Blaschke et al., 2009). Standard deviation of lateral lane positioning was found to be higher using a phone while driving as compared to not using a phone, indicating worse lane keeping performance (Choudhary & Nagendra, 2017). Another study suggested that use of enhanced lane markings reduced the standard deviation of lateral lane position of drivers, which resulted in better lane keeping and an overall safer driving (Horberry et al., 2006). Thus, in line with the literature, current study also demonstrated that higher standard deviation of the lateral lane position values was associated with higher time and distance spent out of the lane, indicating a poorer lane keeping and unsafe driving. Bivariate correlations in the current study also demonstrated that total percent time and distance out of lane in RHT, but not in LHT, was positively associated with minimum time to collision between the driver and all vehicles opposing the driver's direction. It appears that driver's lane keeping performance was lower when there were no vehicles opposing the driver's direction in RHT scenario. He and McCarley suggested that increased cognitive load would result in higher lane keeping performance (2011). Identical results were obtained in another study (He et al., 2013). Drivers in RHT traffic flow might have demonstrated higher time out of lane, which indicates worse lane keeping performance, when there were no other vehicles in opposing direction was present, i.e. when the cognitive load was low due to the road setting (RHT) being familiar and the absence of other vehicles. This difference may not have been observed in the LHT scenario for LHT scenario inducing some levels of cognitive load simply through changing the flow of the traffic.

Total number and total duration of fixations in RHT and LHT was positively associated. That is, participants who yielded higher or lower number and duration of fixations in either one of the scenarios also demonstrated higher or lower number and duration of fixations in the other scenario. Total duration of fixations in RHT and LHT was negatively associated with accidents at fault. However, total fixation duration in RHT was positively associated with total percent time out of lane in RHT and LHT scenarios. Carr and Grover suggested that higher durations of fixations does not automatically mean a more attentive and safer driving (2020). Mental load inducing stimuli was also found to increase fixation durations (Hu et al., 2022). The relationship between familiar and non-familiar, i.e. mental load inducing, traffic contexts, fixation numbers and durations, self-reported accidents, and lane keeping behavior is complex relationship to make firm conclusions through bivariate correlations. These associations are examined discussed in “Discussion of eye-tracker outputs” section.

In terms of TCS subscales, there was a positive association between external affective demands in RHT and LHT scenarios, between internal requirements in RHT and LHT scenarios, and between functionality in RHT and LHT scenarios. The changing traffic flow did not change the direction of the correlations in the subscales of TCS. External affective demands in LHT and external affective demands in RHT was positively associated with internal requirements in LHT, similar to the literature findings (Öztürk et al., 2021). However, external affective demands in RHT was not significantly associated with internal requirements in RHT, although there was a positive association. Unlike the study conducted by Öztürk and colleagues (2021), there were no significant correlations between internal requirements and fucntionality. Öztürk and colleagues (2021) also reported correlations in opposite ways for Turkey and Sweden in between internal requirements and functionality. Although some significant correlations between TCS subscales are found, the limited sample size of the current study might hinder the power of the correlation analysis in detecting such correlations between subscales of TCS.

4.3. Discussion of TCS

4.3.1. Difference of TCS Subscales between RHT and LHT

Results demonstrated that participants evaluated LHT scenario significantly higher in external affective demands subscale of TCS. As stated in Gehlert et al., external affective demands indicate the “emotional engagement” of drivers regarding a traffic context (2014). Aggressive, stressful, pressuring, and chaotic are some of the items that belong to evaluate this emotional engagement in TCS. Gehlert et al. suggested that drivers who score higher on external affective demands perceive the traffic context less safe (2014). Similar findings were also reported by Chu et al., which indicated that higher external affective demands perceptions are associated with less safe traffic, and more accidents and violations (2019). In their study, Öztürk and colleagues suggested that the traffic context in Turkey was perceived higher in external affective demands as compared to Sweden, which indicated a safer perception of traffic in Sweden (2021). In a similar fashion, as participants in the current study evaluated LHT scenario higher in external affective demands, LHT traffic context was perceived overall less safe as compared to the RHT traffic context. When a traffic context is perceived riskier, driver behaviors might also change. When the perceived risk while driving is lower, unsafe acts of driving tends to increase, whereas when the perceived risk is higher in a traffic context, drivers are likely to be extra cautious (Cohn et al., 1995; Ram and Chand, 2016). As Ram and Chand suggested, as drivers perceived the LHT scenario less safe, they might adopt their driving behavior in order to minimize the risks (2016). However, although participants evaluated LHT scenario less safe and riskier and drove slower in LHT scenario, standard deviation of the lateral lane position, and the time and distance spent out of lane in LHT scenario was significantly higher than RHT scenario. These results might indicate that although participants identified LHT context less safe, they failed to adopt their driving behavior. However, it should be noted that the sample of the current study was consisted of young drivers, who are associated with overall lower risk perceptions (Moen & Rundmo, 2006). Thus, the failure of young drivers to adequately perceive the risks in traffic might have also contributed to these results. In contrary to external affective demands, participants evaluated RHT scenario higher in functionality subscale of TCS as compared to LHT scenario. As opposed to external affective demands, functionality subscale includes items such as “Safe” and “Forgives mistakes”. As suggested in Gehlert et al., roads that are perceived higher in functionality are perceived as safer and less risky traffic contexts (2014). Although drivers feel more confident and relaxed in safer and less risky traffic contexts, low perceptions of risk are associated with higher speeds and other risky behaviors (Cohn et al., 1995; Renge, 1998; Ulleberg & Rundmo, 2003). It was observed that participants in RHT scenario had overall higher speeds as compared to LHT scenario, which might indicate an effect of low-risk perception and higher perceptions of functionality. It is an interesting finding that even though the driving scenarios and the behavior of other vehicles in the driving scenarios were identical in RHT and LHT, functionality, which is mostly related to the perception of others' driving, and external affective demands, which is also mostly related to the perception of others' driving (Gehlert et al., 2014), yielded opposite results in RHT and LHT scenarios. Sole change of traffic flow might have impacted drivers' perceptions of functionality and external affective demands of the traffic context.

For the internal requirements, there was no difference between perceptions of LHT and RHT scenarios. Internal requirements include items such as "Demands alertness" and "Requires vigilance", which are mostly related to own driving, rather than the others' driving (Gehlert et al., 2014). Although the mean value of internal requirements in LHT scenario was higher than RHT scenario, the difference was not significant. It is assumed that that there were no significant differences between LHT and RHT in terms of internal requirements as it was the traffic flow, an external factor, that changed between LHT and RHT scenarios, rather than perceptions regarding own driving.

4.3.2. Difference of TCS Subscales by DSI Subscales in RHT and LHT

Driver's perception of own driving skills are related to risk taking behaviors, unsafe acts, RTAs, and tickets (Lajunen et al., 1998; Sümer et al., 2006; Martinussen et al., 2014). Üzümcüoğlu and colleagues investigated Turkey and China to examine the interaction of driving skills and traffic climate and possible cross-cultural differences (2020). In the current study, it was aimed to demonstrate how evaluations of own driving skills might interact with evaluations of traffic climate in countries with different traffic flow, i.e. RHT and LHT.

4.3.2.1. Safety Skills

Results demonstrated that external affective demands evaluations and functionality evaluations was only significantly affected by the traffic flow, i.e. RHT and LHT, and not by safety skills or an interaction between safety skills and traffic flow. However, it was found that there was a significant interaction effect of traffic flow and safety skills in evaluations of internal requirements. Drivers who scored higher in safety skills evaluated RHT scenario as higher in internal requirements, whereas drivers who scored lower in safety skills evaluated LHT scenario higher in internal requirements.

It was demonstrated that participants who evaluate internal requirements higher would demonstrate more safe driving behaviors (Gehlert et al., 2014). Whereas Üzümcüoğlu and colleagues suggested violations would increase for drivers with low safety skills and higher evaluations of internal requirements in Turkey, whereas the violations would decrease in China, demonstrating opposite results in two countries (2020). Similar to these findings, findings of the current study also suggests different results in two different traffic configurations. In the familiar traffic flow, participants who scored higher in safety skills reported higher internal requirements about the traffic climate, whereas in unfamiliar traffic flow, participants who scored lower in safety skills reported higher internal requirements about the traffic climate. In other words, participants with higher safety skills evaluated the familiar RHT scenario as higher in cognitive demands, whereas participants with lower safety skills evaluated unfamiliar LHT scenario as higher in cognitive demands. Üzümcüoğlu and colleagues (2020) also reported that there was a positive relationship between safety skills and internal requirements only in Turkey, but not China. In line with the literature, evaluations of internal requirements was found to differ by safety skills and between different traffic contexts. Similar to the findings of Üzümcüoğlu and colleagues (2020), in the familiar RHT scenario, higher safety skills indicated higher evaluations of internal requirements. To the author's knowledge, the current study was the first to demonstrate the interaction between familiar and unfamiliar traffic flow and safety skills in evaluations of internal requirements. It is suggested that road safety and perceptions of traffic safety climate might show a relationship in the opposite directions due to risk compensation (Wilde, 2001; Gehlert et al., 2014). As Üzümcüoğlu and colleagues (2020) suggested, individuals with low safety skills might act extra cautious in obeying the traffic rules and showing less violations. Participants who consider their safety skills as lower might be evaluating unfamiliar LHT scenario higher in internal requirements (cognitive demands), and might demonstrate safer driving to compensate, which might also have been affected by the possibly higher cognitive load in LHT scenario due to unfamiliarity (Hu et al., 2022). Thus, it can be referred that participants with high safety skills were more prone to a safer driving in the familiar RHT scenario but not in the LHT scenario, whereas participants with lower safety skills were more prone to demonstrate a safer driving in the unfamiliar LHT scenario but not in RHT scenario, demonstrating an interesting effect of safety skills in familiar and unfamiliar traffic flow contexts. Further studies with driver behaviors are required to observe how iteractions of safety skills, traffic flow, and traffic climate might affect violations and errors.

4.3.2.2. Perceptual-Motor Skills

Results demonstrated that external affective demands evaluations and functionality evaluations was only significantly affected by the traffic flow, i.e. RHT and LHT, and not by perceptual-motor skills or an interaction between perceptual-motor skills and traffic flow. As opposed to safety skills, no interaction effect between perceptual-motor skills and internal requirements was found. As opposed to safety skills, participants evaluations of own perceptual-motor skills did not interact with traffic flow in influencing perceptions of traffic climate. Traffic climate evaluations were affected by traffic flow, and perceptual-motor skills had no influence on these evaluations.

Perceptual-motor skills are concerned with the self-evaluated ability to control the vehicle, whereas safety skills are concerned with attitudes regarding safe driving. Safety skills might have a special interaction in regards to evaluations of traffic climate in traffic contexts with different traffic flows, whereas perceptual-motor skills does not have an impact on these evaluations. As Üzümcüoğlu and colleagues (2020) stated, there are differences between driver skills evaluations and the relationship between driver skills and traffic climate evaluations, and these relationships may also differ by countries. Furthermore, the traffic context of the current study was a simple one with very low traffic density, no intersections, no traffic lights or stop signs, or no pedestrians. As Öztürk and colleagues suggested, TCS evaluations might be influenced by the specific properties of the traffic the road users are exposed (2021).

Thus, another variation of the same RHT and LHT scenarios, such as including higher traffic density, roundabouts, pedestrians etc. might have a different impact on the evaluations of TCS subscales, for which DSI parameters might also have varying influences.

4.4. Discussion of Driving Simulation

4.4.1. Speed

Participants had significantly higher speed values in RHT scenario, the traffic flow configuration for which the participants were familiar. In terms of route familiarity, it is known that familiar routes are assocaited with higher mean speeds. Angioi and Bassani demonstrated that drivers had a lower average speed in unfamiliar routes in a simulated driving scenario (2022). Similarly, Bertola and colleagues reported that average speed was higher in drivers familiar with the route in a simulated driving scenario (2012). Colonna and colleagues demonstrated that with repeated exposure to the same route, average speed of drivers increased in an on-road driving study (2016). Intini and friends suggested that driving with a speed the participants considered high speed, and driving with free speed choice had a similar pattern of increases in the mean values of speed over repeated drives (2016). Martens, using a high fidelity driving simulator, demonstrated that with repeated drives, average speed increased rapidly during the initial sections of the scenario, whereas the increase slowed down for the further sections (2018). Intini and friends suggested that accidents occurred frequently in familiar routes, indicating a negative relationship between road safety and route familiarity (2020). Wu and Xu (2018) suggested that speeding was observed in familiar roads as compared to unfamiliar roads in an on-road driving study.

Although there are plenty of simulated driving and on-road driving studies that demonstrated the effect of route familiarity on speed values, no studies were conducted to observe the effect of traffic flow familiarity on speed outcomes. To the author's knowledge, the current study was the first to demonstrate that drivers demonstrated higher mean speed values in traffic flow they are familiar (RHT) as compared to the traffic flow they are unfamiliar (LHT). Similar to route familiarity, traffic flow familiarity results in overall higher preferences for speed in simulated driving. Furthermore, the current study also provided participants seven repeated exposures to the RHT and LHT scenarios to observe the development of route familiarity. Again, for the author’s knowledge, the current study was the first to observe how route familiarity develops through repeated exposure in different traffic flow configurations (i.e. RHT vs. LHT). The results demonstrated an identical pattern of speed increases in familiar (RHT) and unfamiliar (LHT) traffic flow scenarios.

Intini and friends suggested that it is difficult to determine a precise threshold of familiarity, that is when an unfamiliar driver said to be familiar (2019). However, familiarity and driver behavior studies suggest that on average, the very first repeated exposures to the same route results in a larger impact on developing familiarity, which slows down on further exposures. For instance, Intini and friends demonstrated that speed increases was higher in the first four consecutive drives (2016). Similarly, Colonna and colleagues also demonstrated that speed increases was the highest for the first four trials (2016). Increase in average speed values was rapid in the initial drives, whereas the increase slowed down on later trials (Harms & Brookhuis, 2016). Although as Intini and friends suggested in 2019 that it is difficult to give a precise number of trials to determine the threshold of developing familiarity, or developing habituation (Rankin et al., 2009; Intini et al., 2019), the findings of the current study suggested that in both RHT and LHT traffic flow scenarios, increase of average speed due to being familiarized is highest for the initial drives, and this increase of average speed later slowed down.

Although drivers demonstrated higher overall mean speed values in RHT scenario, demonstrating an effect of traffic flow familiarity, drivers had similar patterns of increases in speed values in both RHT and LHT scenarios, demonstrating that rapid increases in speed followed by a decreased speed of increase also observable in familiar and unfamiliar traffic flow scenarios.

The impact of driving in familiar and unfamiliar traffic flow settings, and the impact of repeated exposure to the same road within these traffic environments on speed also have considerable safety implications. As the data demonstrated, average speed was overall higher in the familiar setting (RHT) as compared to (LHT) setting. One reason why drivers might had slower speeds in LHT might be explained through risk perception, which is affected by the familiarity (Tarko & Figueroa Medina, 2006;

Colonna et al., 2016). When drivers use familiar roads, they might perceive the traffic context less risky, and might engage in more unsafe acts of driving such as violations or speeding (Rosenbloom et al., 2007). As stated by Wilde's risk homeostasis theory, drivers may put a less emphasis on safety when driving in familiar roads, which they perceive as less risky (1982). Furthermore, it is suggested by Martens and Fox that familiarity might give rise to mind wandering, that is experiencing cognitions regarding driving unrelated things, and result in a more distracted driving (2007). Overall, speed is found to be positively relateed with RTA involvement, and the severity of RTAs (Aarts & Schagen, 2006). When RHT setting is perceived as less risky and mind wandering occurs, risk of RTAs might increase. Thus, solely based on the factor of speeding, driving in familiar traffic flow, that is RHT, might be evaluated as more risky.

On the other hand, there might be other parameters that might affect the risk of crashes in familiar and unfamiliar traffic flow setting. It is demonstrated by the current study that although overall mean speed is higher in familiar traffic (RHT), the pattern of habituation (gaining familiarity) was similar with unfamiliar traffic (LHT). Although it may seem that driving slower in unfamiliar traffic (LHT) is safer, the reason for driving slower in unfamiliar traffic (LHT) might be due to increased mental load. As stated in Lee and friends, driving in unfamiliar traffic convention (i.e. LHT) may increase mental load, and decrease driving performance (2023). When mental load increases and driving performance decreases, the risk of RTA involvement increases (Elvik, 2006; Lee et al., 2023). İntini and friends also suggested that unsafe acts such as curve-cutting was higher when the attention capacity was lower (2016). Lee and colleagues reported highest mental workload values for drivers who drive in unfamiliar traffic flow as compared to familiar (2023). Unfamiliar drivers are found to have higher involvement in RTAs in junctions (Yannis et al., 2007), higher occurrences of driving in wrong way (Kim et al., 2012), and higher violations (Yoh et al., 2017). Tourists that are familiar with RHT convention was found to experience more RTAs in countries with LHT convention (Thompson & Sabik, 2018). As Lee and colleagues stated, increased mental load might increase risk of RTAs in some specific situations, such as curves or roundabouts, when the mental load is high (2023). Although the current study utilized driving scenarios that has no roundabouts, sharp curves, or high traffic density, participants had overall lower speed in unfamiliar (LHT) scenario. Thus, the overall lower mean speed values in unfamiliar traffic (LHT) in the current study might be explained by participants' efforts in order to compensate with increased mental load, and also risk perception (see Wilde, 1982; Hurtado & Chiasson, 2016).

Thus, although it might seem that higher speeds obtained in familiar (RHT) setting might indicate a higher risk for RTA involvement, lower speeds in unfamiliar (LHT) setting might also indicate higher risk for RTA involvement, especially in in situations such as roundabouts or sharp curves, due to increased mental load.

4.4.2. Standard Deviation of Lateral Lane Position

Although the standard deviation of lateral lane positioning did not reveal a significant effect within scenarios, the findings was similar to the findings of Charlton and Starkey (2013), in which there was no significant differences between repeated drives in standard deviation of the lateral lane position, although there were fluctuations similar to the findings of the current study. On the other hand, participants had significantly higher standard deviation of lateral lane position values between scenarios. In particular, participants' standard deviation of lateral lane position values was higher in unfamiliar (LHT) scenario.

In terms of route familiarity, it was suggested that standard deviation of lateral lane position was higher in familiar routes in simulated driving (Bertola et al., 2012). Correspondingly, Intini and friends suggested hat that with increased route familiarity, out-of-road and head-on crashes might increase due to behaviors such as curve-cutting, which may result from increased confidence due to familiarity. Intini and friends suggested that with familiarity, curve-cutting, which might cause out-of-road and head-on crashes, increased (2016). On the other hand, driving in unfamiliar traffic flow was also reported to increase overshooting or undershooting in turns, and creating a riskier driving (Nakayasu et al., 2011). Thus, lane position seems to have different safety impacts on familiar and unfamiliar roads and traffic flow settings depending on the situation. In general, higher values of standard deviation of lateral lane position indicated higher time spent outside the lane, an impaired driving, and a riskier driving (Verster & Roth, 2014; Verster et al., 2017). Higher values of standard deviation of lateral lane position indicates the lane-keeping performance of drivers, which is used as a measure of driving effectiveness and safety (Taylor et al., 2005; Hallmark et al., 2013). Increased lane-keeping performance through supportive technologies suggested increased safety (Blaschke et al., 2009). Thus, a worse lane-keeping performance, or an increased standard deviation of lateral lane position, in unfamiliar scenario (LHT) indicated a less safe driving performance. Unlike the decreased speed values in unfamiliar (LHT) scenario, an increase in standard deviation of lateral lane position in unfamiliar (LHT) scenario might not be explained by cognitive or mental load, as increased mental load should have resulted in decreased variability of lane position rather than increased. Cognitive distractions are found to decrease standard deviation of lateral lane position, resulting in a safer driving (Li et al., 2018). Similarly, He and friends also reported that increased mental load would result in lower standard deviation of lateral lane position (2013). It is said that drivers show an extra effort to keep their lane position when the mental workload increases (He et al., 2013). Thus, lane keeping performance in unfamiliar traffic flow might have been affected by other factors such as being on the opposite side of the road, driving through curves on the opposite side of the road, curve-cutting due to decreased curve performance, showing of extra effort to avoid crashes with other vehicles and so on. As Thompson and Sabik suggested, habits and expectancies developed in a traffic system (RHT) might influence road users' safety on unfamiliar traffic systems (LHT) (2018).

Although the findings clearly suggested that lane keeping performance was lower in unfamiliar (LHT) scenario, which indicates higher risk of RTAs, further research is required to examine the reason for increased variability of lateral lane position in unfamiliar (LHT) scenario.

4.4.3. Minimum Time to Collision Between the Driver and All Vehicles Opposing the Driver's Direction

Minimum time to collision between the driver and all vehicles opposing driver's direction was overall significantly lower in LHT scenario. In terms of repetitions, there were no significant differences between the first repetition to sixth repetition both in LHT and RHT scenario. The increase in MTC in the seventh (last) ride was explained by the fact that the scenario did not repeat itself and there were no further vehicles approaching through the end of the scenario.

The significantly lower value of MTC in LHT scenario indicates higher risk of RTAs between the participants' vehicle and other vehicles approaching (Angioi & Bassani, 2022). Considering that the age range of the participants indicated a young driver population, overall lower MTC values were expected (Angioi & Bassani, 2022). However, Angioi and Bassani also suggested that MTC values were lower for route-familiar drivers (2022). The findings of the current study failed to replicate this result, as between 7 repeated exposure to the same route did not had a decreasing effect on MTC values neither on the RHT and LHT scenarios. Furthermore, to the author's knowledge, the current study was the first one to demonstrate that MTC values was lower for unfamliar (LHT) traffic flow, indicating higher risk of experiencing RTAs. Route-familiarity was associated with delayed response times and reduced levels of attention (Young & Stanton, 2002; Yanko & Spalek, 2013). Unfamiliarity with traffic flow was associated with higher mental load (Lee et al., 2023). The mental load and pressure created by unfamiliar traffic flow might be differing from the mental load created by unfamiliar routes, and might result in lower MTC values for unfamiliar traffic flow, but not unfamiliar route. Other factors such as measuring situation familiarity (such as specific interactions with pedestrians, vehicles, road etc.), the simulation scenario, speed of other vehicles, road infrastructure, simulation configurations etc. might also have an impact on MTC values. Angioi suggested that increased route familiarity might result in a riskier driving, whereas increased situational familiarity might result in a safer driving (2021). Angioi and Bassani also suggested that familiarity studies to consider effects resulting from the baggage, e.g. prior knowledge, regarding a road and the knowledge gained after repeated exposure to the road (2022). Thompson and Sabik suggested that habitual behavior as a result of being familiar with a traffic system might influence road safety (2018).

Unlike route familiarity, traffic flow familiarity and prior knowledge, habits, behaviors etc. that are based on the familiar traffic flow develops through years, and might have an unique impact on drivers' driving performance and safety in unfamiliar traffic flow contexts. Further research is required to have a comprehensive understanding of MTC in unfamiliar traffic flow scenarios.

4.4.4. Total Percent Time and Distance Out of Lane

Total percent time and distance out of lane was overall significantly higher in unfamiliar (LHT) scenario. Lane keeping is vital in avoiding running out of the lane and road (Wiacek et al., 2017). Running out of lane crashes were defined as the most frequently occurring RTAs in two-way roads (Kutela et al., 2021). Abnormal lane switching and lane departure was reported as one of the highest causes of RTAs (Sharma & Shah, 2013). As Liu and Subramanian (2009) reported, running out of road crashes have a high rate of fatalities and injuries. Higher variability of lane position observed in unfamiliar (LHT) traffic flow with higher values of total percentages of time and distance out of lane observed in unfamiliar (LHT) traffic flow indicates a high risk of RTAs in unfamiliar traffic flow contexts as a result of worse lane keeping performance. In line with the literature, higher values for time spent out of the lane and higher values of variability of lateral lane position indicated a riskier driving (Verster & Roth, 2014; Verster et al., 2017). There might be a unique effect of unfamiliar traffic flow on mental load as a cognitive distractor. Failure to attend might have an impact on increased percentages of out of lane time and distances and worse lane keeping performance (Peng et al., 2013). Habits and expectancies resulting from being familiar with RHT system might also have an impact on impaired lane keeping performance in unfamiliar LHT system (Thompson & Sabik, 2018).

4.4.5. Total Simulator Outputs and DSI

Overall, participants with lower self-evaluated safety skills had significantly higher total speeds both in familiar (RHT) and unfamiliar (LHT) systems. Safety skills had no effect on the total standard deviation of lateral lane position. Similarly, there was no significant effect of safety skills on total percent of time and distance out of lane. Participants with higher self-evaluated perceptual-motor skills had significantly higher total speeds both in familiar (RHT) and unfamiliar (LHT) systems. There was no significant effect of perceptual-motor skills on total standard deviation of lateral lane position. Similarly, there was no difference between participants who had higher and lower perceptual-motor skills on total percent of time and distance out of lane measurements. As suggested in the literature, it was found that drivers who evaluated themselves higher in perceptual-motor skills had higher speeds, despite being in an unfamiliar (LHT) traffic context (Delhomme, 1991; Sümer et al., 2006; Horswill et al., 2006). In the current study, there was a negative correlation between safety skills and accidents at fault, and total accidents in the last three years. Thus, the results are in line with studies such as Özkan and colleagues, participants with lower safety skills and participants with higher perceptual-motor skills had a more risky driving in terms of speed (2006). On the other hand, no interactions of safety skills and perceptual-motor skills in standard deviation of the lateral lane position, total percent of time out of lane, and total percent of distance out of lane was observed.

4.4.6. Discussion of Eye-Tracker

There was no significant effect of traffic flow or repetitions on fixation durations. However, the current study reported Greenhouse-Geisser corrected results for the statistical results of ANOVA analysis for the fixation durations. Thus, although the threshold of significance was almost met, not being able to ensure sphericity resulted in failure to demonstrate the effect of repetitions, hence familiarity. On the other hand, the graphs demonstrated similar results to the literature, as both in familiar (RHT) and unfamiliar (LHT) scenarios, there was a increase on fixation durations with repetitions (Young et al., 2017). The duration of fixations also seem to be higher in RHT scenario, although the difference was not significant.

There was no significant difference between unfamiliar (LHT) and familiar (RHT) scenarios in terms of total number of fixations. However, the effect of repetition was significant. Both in RHT and LHT scenarios, the number of fixations decreased. For the familiar (RHT) scenario, the significant difference between consecutive rides disappeared after the second ride, whereas the significant difference between consecutive rides disappeared after the third ride for the unfamiliar (LHT) scenario. It appeared that the threshold of familiarity was reached slower in unfamiliar (LHT) scenario in terms of number of fixations. However, as Intini and friends suggested, determining a clear threshold of familiarity, that is, when it is appropriate to say that drivers gained familiarity, is difficult (2019). Thus, further research is required to see how the effect of unfamiliar traffic flow have an impact on gaining familiarity with visual attention.

Furthermore, although the number and duration of fixations did not differ between familiar (RHT) and unfamiliar (LHT) scenarios, it does not mean that participants were able to process same amount of information in both scenarios. As Carr and Grover suggested, looking at the same point might not mean a successful cognitively processing of the relevant information regarding that specific area (2020). Thus, it is possible for participants to have the same fixation durations in familiar (RHT) and unfamiliar (LHT) scenarios, but be able to process different quality and quantity of important information in each of the scenarios. For example, participants might experience “look but not see” phenomenon in RHT scenario as high familiarity might lead to mind wandering, and focusing on irrelevant stimuli (Young et al., 2018; Carr & Grover 2020). On The other hand, participants might experience lower driving performance such as worse lane-keeping, increased standard deviation of lateral lane position, and time and distance spent out of the lane, because they were not focusing on the relevant side or information on the road in the unfamiliar (LHT) scenario (Thompson & Sabik, 2018). Young and colleagues suggested that with increased familiarity, fixation durations on off-road stimuli would increase, whereas fixation durations on driving and safety-related stimuli would decrease (2017). The duration of glances on safety-related stimuli such as road signs was also found to decrease with familiarity, and the performance on change detection would decrease (Martens & Fox, 2007). When participants were presented video recordings of intersections in familiar and unfamiliar traffic flow contexts, and were asked about to evaluate the safety to enter the roundabout, participants who were familiar with the traffic flow had higher accuracy of correct answers (Thompson & Sabik, 2018). Furthermore, Thompson and Sabik also reported that participants who were unfamiliar with the traffic flow made more fixations on the wrong side of the road (Thompson & Sabik, 2018). Thus, even though the number and duration of fixations did not differ between familiar (RHT) and unfamiliar (LHT) traffic flow settings, the exact location of fixations might give a different picture regarding allocation of visual attention in unfamiliar (LHT) scenario. Thus, other than the number and duration of fixations, the exact locations on the field of view that drivers facus also have important road safety implications. As Peng and friends suggested, gazing off the road was found to be associated with higher values of standard deviation of lateral lane position (2013). Thus, it is beneficial to consider the use of area of interest function of eye-trackers, which are separately created areas that define the boundaries for most relevant areas the researchers are interested in (Hessels et al., 2016), to see whether participants looking off the road or on the road more in familiar (RHT) and unfamiliar (LHT) scenarios, and how the gazes on these areas of interests (AOIs) change through repeated exposure to the same route. The current study aimed to explore how fixation durations and numbers change depending on being in a familiar (RHT) and unfamiliar (LHT) traffic contexts, through repeated exposures. The results indicated that there is a trend of increasing fixation durations through increased familiarity, and familiar (RHT) traffic scenario had higher fixation durations, although the data did not yield significant statistical outputs despite being closer to the limit of being significant. In terms of fixation numbers, there was a sharp decrease at the beginning of each of the familiar (RHT) and unfamiliar (LHT) scenarios, which was followed by a slow but steady decrease on further repetitions. Overall fixation numbers did not differ between familiar (RHT) and unfamiliar (LHT) scenarios. Further studies are required to explore how fixation numbers, fixation durations, and especially the locations where drivers fixate, change through repeated exposures in unfamiliar (LHT) and familiar (RHT) scenarios.

4.5. Conclusion and Implications of the Study

Although there are some research regarding how unfamiliarity with traffic flow might affect road safety (Nakayasu et al., 2011; Thompson & Sabik, 2018; Lee et al., 2023), and many research regarding how route familiarity affect driver performance and safety (Martens & Fox, 2007; Bertola et al., 2012; Peng et al., 2013; Colonna et al., 2016; Young et al., 2017; Angioni & Bassani, 2022), to the author's knowledge, the current study was the first to examine traffic flow familiarity and route familiarity together in examining driving performance.

Overall, it was observed that driver performance decreased in regards to lane keeping in unfamiliar (LHT) traffic setting, as indicated by higher standard deviation of lateral lane position, higher percent of time spent out of lane, higher percent of distance spent out of lane, and lower minimum time to collision with vehicles opposing driver's direction. Although speed was higher in familiar (RHT) traffic setting, the reason why speed is low in unfamiliar (LHT) traffic setting might be explained by increased cognitive load or perceived risk. Being slower in unfamiliar (LHT) traffic does not directly mean a safer driving, as increased cognitive load might result in worse driving performance, as indicated by lane position variability, lower minimum time to collision, and higher out of lane time and distance observed in unfamiliar (LHT) traffic setting. In terms of route familiarity, speed demonstrated a similar pattern in both familiar (RHT) and unfamiliar (LHT) scenarios, despite the mean speed being higher in familiar (RHT) scenario. In terms of speed, the course of the development of familiarity appeared to be similar in familiar both traffic settings. No significant differences between repeated rides in regards to standard deviation of the lateral lane position was observed. The course. Minimum time to collision between the driver and all vehicles opposing driver's direction was lower in unfamiliar (LHT) scenario, indicating increased risk for head-on crashes. In sum, the driving performance was worse in unfamiliar (LHT) scenario, especially for lane keeping ability.

Furthermore, the current study aimed to examine how perceptions of traffic climate change between unfamiliar and familiar traffic flow context. It was demonstrated that participants perceived unfamiliar (LHT) scenario as higher in external affective demands, and familiar (RHT) scenario as higher in functionality. Specifically, participants perceived unfamiliar (LHT) traffic setting as more aggressive and stressful, whereas they perceived familiar (RHT) traffic setting as more planned and free-flowing. Drivers might adjust their driving behavior according to their perceptions of a traffic environment. For example, the reason why familiar (RHT) traffic had higher mean speed values might be partly explained by the participants' evaluations of familiar (RHT) scenario as more functional.

The current study also examined simulator outputs and traffic climate evaluations by participants' self-evaluated driver skills. An interesting result was found for internal requirements subscale of TCS. While participants who had higher self-evaluated safety skills had higher mean scores of internal requirements for familiar (RHT) scenario, participants who had lower safety skills had higher mean scores of internal requirements for unfamiliar (LHT) scenario. It appeared that participants who consider themselves as lower in safety-skills evaluated unfamiliar (LHT) scenario as being more cognitively demanding and requires more cautiousness. In line with the literature, participants who had higher self-evaluated safety skills had lower mean speed values, whereas participants who had higher perceptual-motor skills had higher mean speed values. Interestingly, whether in RHT or LHT setting, higher perceptual-motor skills and lower safety skills lead to higher speed. Self-evaluated driving skills have more impact on driving speed than being in familiar or unfamiliar traffic flow.

Lastly, the current study aimed to explore changes in visual attention in regards to traffic flow and route familiarities. In line with the literature, number of fixations decreased, whereas duration of fixations increased (although for the duration the results was not significant), with repetition. No significant difference between familiar (RHT) and unfamiliar (LHT) traffic settings in terms of fixation numbers and durations was found, although the duration of fixations had a higher trend in familiar (RHT) scenario. However, it should be noted that similar numbers and durations of fixations does not mean processing of similar safety-related information. When the simulator outputs and eye-tracker outputs are melted in a pot, it may be said that lower lane keeping performance in unfamiliar (LHT) scenario might suggest fixations on safety-irrelevant stimuli on the road in unfamiliar (LHT) scenario. Further and more detailed analyses in regards to exact fixation points of participants in familiar (RHT) and unfamiliar (LHT) traffic settings are required to explore viusal attention in both traffic flow settings.

4.6. Contributions

The main contribution of the current study was to demonstrate the effect of traffic flow familiarity and route familiarity in the same study using simulated driving and eye-tracking. Another contribution of the current study was to demonstrate how driver’s perceptions of familiar (RHT) and unfamiliar (LHT) traffic contexts differed.

To the author’s knowledge, the current study was the first in the literature to make a comprehensive comparison between familiar (RHT) and unfamiliar (LHT) traffic settings in regards to driving performance, visual attention, self-reported driver skills, and evaluations of traffic climate. The findings are important to understand the increased RTA risk for tourists, especially those who are exposed to unfamiliar traffic flow, and develop interventions and take precautions to increase road safety for road users who will be exposed to unfamiliar traffic flow contexts.

4.7. Limitations and Suggestions

The first limitation of the study was the sample characteristics. The sample was consisted mainly by young, male, university students. The replication of the study with a mixed sample of males and females, or only females, will be beneficial as the driving performance and evaluations of traffic climate between familiar (RHT) and unfamiliar (LHT) traffic settings of female drivers might offer gender differences. Furthermore, replication of the study with professional drivers or drivers with higher exposure might yield different results due to higher exposure and familiarity with a specific traffic flow.

The driving scenario consisted of a simple, low-traffic density, two-way road. Although the way scenario designed was appropriate to study familiarity, a traffic setting with roundabouts, intersections, traffic lights, and higher-density traffic might elicit different driving behaviors, and yield important differences in driving performance and road safety between unfamiliar (LHT) and familiar (RHT) traffic settings. Furthermore, measurements of cognitive load or mental workload will be beneficial to observe the remaining cognitive capacities of participants in unfamiliar (LHT) and familiar (RHT) scenarios.

Another limitation of the current study was the fidelity of the driving simulator utilized. The driving simulator used in the current study was a low-fidelity driving simulator. Although the findings from low and high-fidelity simulators are found to be successful in eliciting actual driving behavior, use of a high fidelity simulator may represent the actual driving behavior and performance better. Furthermore, it might be beneficial to measure the driving performance and behavior in familiar (RHT) and unfamiliar (LHT) settings through an on-road actual driving study, as simulator studies may offer low external validity. Use of an eye-tracker device that can measure visual attention on broad displays is also recommended, as in the current study, only a single display could be utilized when using eye-tracker.

The sample size of the current study, although similar with other simulation studies, was also inadequate in taking measurements of self-reported traffic climate evaluations and driver skills evaluations and utilizing analysis techniques such as regressions. It is proposed to conduct the study with a higher sample size to obtain more reliable self-report evaluations.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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28 ŞUBAT 2023

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof. Dr. Türker ÖZKAN

Danışmanlığını yürüttüğünüz Batıkan ÖZKAN'ın **"Aşina Olunmayan Trafik Akışında Araç Kullanmanın Simüle Edilen Sürüş Performansına Etkisi: Tekrarın Rolü"** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek **0102-ODTUİAEK-2023** protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

B. INFORMED CONSENT FORM

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu çalışma ODTÜ Psikoloji Bölümü araştırma görevlilerinden Psk. Batıkan Özkan tarafından, ODTÜ Psikoloji Bölümü öğretim üyelerinden Prof. Dr. Türker Özkan danışmanlığında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Bu çalışmanın amacı, trafik akışının sürücülerin araç kullanmalarına yönelik etkisini incelemektedir.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırma ODTÜ-TSK Modsimmer Binası İnsan Faktörü Laboratuvarı'nda yapılacaktır. Çalışmaya 18 yaşını doldurmuş ehliyet sahibi araç kullanıcıları katılımcı olarak davet edilecektir. Çalışma kapsamında sizden sürüş simülatöründe yaklaşık 40 dakika kadar araç sürmeniz istenecektir.

Katılımınızla ilgili bilmeniz gerekenler:

Çalışmaya katılım tamamen gönüllülük esasına dayanmaktadır. Hiçbir yaptırıma maruz kalmadan çalışmadan çekilebilir ya da elde edilen verilerinizin geri çekilmesini talep edebilirsiniz. Çalışma dahilinde cevaplamak istemediğiniz soruları boş bırakabilirsiniz.

Toplanan bilgilere sadece yukarıda bahsi geçen araştırmacıların erişimi olacaktır. Katılımcıların kimlikleri gizli tutulacaktır. Katılımcı isimleri ve toplanan veriler ayrı toplanıp, bu veriler birbiriyle eşleştirilmeyecektir. Bilgiler sadece bilimsel yayım yapma amacı ile istatistiksek veri analizinde kullanılacaktır.

Çalışma sonrasında katılımcılar araştırmacılardan çalışma hakkında daha detaylı bilgi alabileceklerdir.

Riskler:

Sürüş simülasyonu kullanılarak gerçekleştirilecek sanal sürüş, nadir de olsa bazı katılımcılar içim mide bulantısı, göz ağrısı, baş dönmesi gibi fizyolojik tepkilere yol açabilmektedir. Bu nedenle daha önceden teknolojik cihazların (bilgisayar, televizyon, tablet vs.) kullanımında benzer semptomlar gösterdiyseniz araştırmaya katılımınız uygun değildir.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Çalışmayla ilgili soru ve yorumlarınızı araştırmacıya adresinden iletebilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyad Tarih İmza

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C. DEMOGRAPHICS FORM

Demografik Bilgiler Formu

Bu kısım demografik bilgileriniz hakkındadır. Lütfen ilgili kısımları sizin için doğru olduğu şekilde doldurunuz.

1) Yaşınız:______
2) Cinsiyetiniz:
- o Erkek
- o Kadın
- o Diğer:______

3) Eğitim durumunuz:______
4) Trafikte araç kullanıyor musunuz?
- o Evet
- o Hayır

5) Ne kadar süredir ehliyet sahibisiniz? (Yıl):______
6) Toplam kaç kilometre araç kullandınız?:______
7) Son bir yılda toplam kaç kilometre araç kullandınız?: ______
8) Son üç yıl içerisinde küçük ya da büyüklüğüne bakmazsızın, nedeni ne olursa olsun, başınızdan geçen kaza sayısı kaçtır?: ______
9) Bu kazaların kaç tanesinde hatalı taraftınız?: ______
10) Bu kazaların kaç tanesi yaralanma veya can kaybıyla sonuçlandı?: ______
11) Son üç yıl içerisinde, aşağıda belirtilen trafik cezalarını kaç kere aldığınızı belirtiniz.
- o Yanlış park etme ____
- o Hatalı sollama ____
- o Aşırı hız ____
- o Kırmızı ışıkta geçme ____
- o Diğer (eksik ekipman, kırık far vb.) ____

12) Hava ve yol koşulları uygun olduğunda şehirlerarası yollarda yaklaşık ortalama kaç kilometre hızla gidersiniz? (km/saat): ______
13) Hava ve yol koşulları uygun olduğunda şehir içi yollarda yaklaşık ortalama kaç kilometre hızla gidersiniz? (km/saat): ______
14) Mevcut bir göz rahatsızlığınız (miyop, hipermetrop, göz tansiyonu, renk körlüğü vs.) bulunuyor mu? Bulunuyorsa nedir? ______
15) Gözlük kullanıyor musunuz? ______
16) Araç kullanımınızı etkileyebilecek bir rahatsızlığınız veya düzenli kullandığınız bir ilaç bulunuyor mu? Var ise belirtiniz. ______
17) Bilgisayar kullanmanızı etkileyebilecek bir rahatsızlığınız (epilepsi vs.) bulunuyor mu? Var ise belirtiniz. ______
18) Daha önce trafiğin soldan aktığı bir ülkede bulundunuz mu? ______
- o Yanıtınız evet ise, ne kadar süreyle bulundunuz? ______

19) Daha önce trafiğin soldan aktığı bir ülkede araç kullandınız mı? ______
20) Kullandığınız araçta ne tür vites mevcuttur? ______
- o Manuel vites
- o Otomatik vites

D. DRIVER SKILLS INVENTORY

Araç kullanırken güçlü ve zayıf yönleriniz nelerdir?

Lütfen sizin, bir sürücü olarak güçlü ve zayıf yönlerinizin neler olduğunu her bir madde için aşağıdaki uygun seçeneği işaretleyerek belirtiniz

1= ÇOK ZAYIF 2= ZAYIF 3= NE ZAYIF NE GÜÇLÜ 4=GÜÇLÜ 5= ÇOK GÜÇLÜ

		Çok zayıf	**Zayıf**	**Ne zayıf ne güçlü**	**Güçlü**	**Çok güçlü**
1	Seri araç kullanma	1	2	3	4	5
2	Trafikte tehlikeleri görme	1	2	3	4	5
3	Sabırsızlanmadan yavaş bir aracın arkasından sürme	1	2	3	4	5
4	Kaygan yolda araç kullanma	1	2	3	4	5
5	İlerideki trafik durumlarını önceden kestirme	1	2	3	4	5
6	Belirli trafik ortamlarında nasıl hareket edileceğini bilme	1	2	3	4	5
7	Yoğun trafikte sürekli şerit değiştirme	1	2	3	4	5
8	Hızlı karar alma	1	2	3	4	5
9	Sinir bozucu durumlarda sakin davranma	1	2	3	4	5
10	Aracı kontrol etme	1	2	3	4	5
11	Yeterli takip mesafesi bırakma	1	2	3	4	5
12	Koşullara göre hızı ayarlama	1	2	3	4	5
13	Geriye kaçırmadan aracı yokuşta kaldırma	1	2	3	4	5
14	Sollama	1	2	3	4	5
15	Gerektiğinde kazadan kaçınmak için yol hakkından vazgeçme	1	2	3	4	5
16	Hız sınırlarına uyma	1	2	3	4	5
17	Gereksiz risklerden kaçınma	1	2	3	4	5
18	Diğer sürücülerin hatalarını telafi edebilme	1	2	3	4	5
19	Trafik ışıklarına dikkatle uyma	1	2	3	4	5
20	Dar bir yere geri geri park edebilme	1	2	3	4	5

E. TRAFFIC CLIMATE SCALE

Sürüş yaptığınız bu senaryoda trafik nasıldı?

Aşağıda, simülasyonda sürüş yaptığınız trafik sistemini, ortamını ve atmosferini tanımlamak için bazı kelimeler verilmiştir. Bu kelimelerin, sürüş yaptığınız trafik ortamındaki trafik durumunu yansıtıp yansıtmadığı hakkındaki düşüncenizi size göre doğru olan seçeneği işaretleyerek belirtiniz. Her bir soru için cevap seçenekleri:

1= Hiç tanımlamıyor

2= Tanımlamıyor

3= Pek az tanımlıyor

4= Biraz tanımlıyor

5= Tanımlıyor

6= Çok tanımlıyor

	1	**2**	**3**	**4**	**5**	**6**
1. Saldırgan	**O**	**O**	**O**	**O**	**O**	**O**
2. Stresli	**O**	**O**	**O**	**O**	**O**	**O**
3. Şansa bağlı	**O**	**O**	**O**	**O**	**O**	**O**
4. Tetikte olmanızı gerektiren	**O**	**O**	**O**	**O**	**O**	**O**
5. Tedbirli olunmasını gerektiren	**O**	**O**	**O**	**O**	**O**	**O**
6. Planlı	**O**	**O**	**O**	**O**	**O**	**O**
7. Üzerinizde baskı yapıcı	**O**	**O**	**O**	**O**	**O**	**O**
8. Kaotik	**O**	**O**	**O**	**O**	**O**	**O**
9. Tedirgin edici	**O**	**O**	**O**	**O**	**O**	**O**
10. Uyanık olmayı gerektiren	**O**	**O**	**O**	**O**	**O**	**O**
11. Ahenkli	**O**	**O**	**O**	**O**	**O**	**O**
12. Zaman kaybettiren	**O**	**O**	**O**	**O**	**O**	**O**
13. Sinir bozucu	**O**	**O**	**O**	**O**	**O**	**O**
14. Güvenli	**O**	**O**	**O**	**O**	**O**	**O**
15. İşlevsel	**O**	**O**	**O**	**O**	**O**	**O**
16. Akışkan	**O**	**O**	**O**	**O**	**O**	**O**

F. DEBRIEFING FORM

Katılım Sonrası Bilgi Formu

Bu çalışma, ODTÜ Psikoloji Bölümü araştırma görevlisi Psk. Batıkan Özkan tarafından, ODTÜ Psikoloji Bölümü öğretim üyelerinden Prof. Dr. Türker Özkan danışmanlığında yürütülmektedir. Araştırma, trafik akışı ve rota aşinalıklarının simüle edilen trafik ortamındaki sürüş performansına ve sürücü dikkatine yönelik etkisini incelemektedir.

Çalışma verilerinin toplanmasının Haziran 2023 içerisinde tamamlanması beklenmektedir. Çalışmada elde edilen verilen yalnızca bilimsel yayım amaçlı kullanılacaktır. Çalışmada elde edilecek verilerin güvenilirliğinin korunabilmesi için lütfen çalışmaya katılabilecek diğer katılımcılar ile çalışma hakkında bilgi paylaşımında bulunmayınız. Çalışmamıza katılım gösterdiğiniz için teşekkür ederiz.

Çalışma sonuçları hakkında veya çalışma ile ilgili daha detaylı bilgi almak için araştırmacılara başvurabilirsiniz.

Arş. Gör. Batıkan Özkan

Prof. Dr. Türker Özkan

Bu çalışma ile ilgili olarak katılımcı haklarınız veya etik ilkeler hakkında soru ve görüşlerinizi ODTÜ Uygulamalı Etik Araştırma Merkezi’ne iletebilirsiniz

G. SIMULATION SCENARIO (RHT, ONE REPETITION)

METRIC

0, ROAD, 3.75, 2, 1, 1, 0.1, 3.05, 3.05, 0.12, 0.12, 0, 0, 0, -1, 1, -1, 1, -1, 2, -1, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

300, ROAD, 3.75, 2, 1, 6, 0.1, 3.05, 3.05, 0.12, 0.12, 1, 0, 0, -1, 1, -1, 1, -1, 2, -1, 2, 0, 0, 0, 0, 0, 0, 0,

900, ROAD, 3.75, 2, 1, 6, 0.1, 3.05, 3.05, 0.12, 0.12, 1, 0, 0, -1, 1, -1, 1, -1, 2, -1, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

900, ROAD, 3.75, 2, 1, 6, 0.1, 3.05, 3.05, 0.12, 0.12, 5, 0, 0, -1, 1, 1, 1, -35, 10, -35, 10, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

1200, ROAD, 3.75, 2, 1, 1, 0.1, 3.05, 3.05, 0.12, 0.12, 5, 0, 0, -1, 1, -1, 1, -1, 2, -1, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

1500, ROAD, 3.75, 2, 1, 6, 0.1, 3.05, 3.05, 0.12, 0.12, 1, 0, 0, -1, 1, -1, 1, -1, 2, -1, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

1800, ROAD, 3.75, 2, 1, 1, 0.1, 3.05, 3.05, 0.12, 0.12, 5, 0, 0, -1, 1, -1, 1, -1, 2, -1, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

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0, sign, 100, 275, C:\STISIM\Data\EuroSigns\Speed_90.3ds

0, sign, 100, 275, C:\STISIM\Data\EuroSigns\Speed_90.3ds

0, sign, 100, 330, C:\STISIM\Data\EuroSigns\E_LCurve.3ds

0, sign, 100, 1480, C:\STISIM\Data\EuroSigns\E_LCurve.3ds

0, sign, 100, 880, C:\STISIM\Data\EuroSigns\E_Rcurve.3ds

0, sign, 100, 100, C:\STISIM\Data\Signs\T_WayRHT.3ds

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900, c, 0, 50, 200, 50, .0035

1500, c, 0, 50, 200, 50, -.0035

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1600, A, 60, 600, -2 {0}, 33,

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0, BLDG, 170, 10, H6, 0

0, BLDG, 200, 14, H5, 0

0, BLDG, 165, 35, H3, 0

0, BLDG, 120, -15, H6, 0

0, BLDG, 245, -45, U3, 0

0, BLDG, 270, 25, U3, 0

0, BLDG, 245, 50, U3, 0

0, BLDG, 240, 15, B15, 0

0, BLDG, 120, 15, B15, 0

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0, V, 0, 120, -10, 0, 2

1500, V, 0, 720, 10, 0, 33

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0, TBox, 719, -35, 1, 1, 1

0, TBox, 822, -45, 1, 1, 1

0, TBox, 753, -15, 1, 1, 1

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0, TBox, 726, -50, 1, 1, 1

0, TBox, 878, -35, 1, 1, 1

0, TBox, 767, -45, 1, 1, 1

0, TBox, 873, -25, 1, 1, 1

0, TBox, 745, -45, 1, 1, 1

0, TBox, 1805, 25, 1, 1, 1

0, TBox, 1710, -15, 1, 1, 1

0, TBox, 1813, 20, 1, 1, 1

0, TBox, 1728, -15, 1, 1, 1

0, TBox, 1816, 25, 1, 1, 1

0, TBox, 1768, -45, 1, 1, 1

0, TBox, 1833, 35, 1, 1, 1

0, TBox, 1729, -28, 1, 1, 1

0, TBox, 1839, 65, 1, 1, 1

0, TBox, 1719, -35, 1, 1, 1

0, TBox, 1822, 45, 1, 1, 1

0, TBox, 1753, -15, 1, 1, 1

0, TBox, 1848, 35, 1, 1, 1

0, TBox, 1726, -50, 1, 1, 1

0, TBox, 1878, 35, 1, 1, 1

0, TBox, 1767, -45, 1, 1, 1

0, TBox, 1873, 25, 1, 1, 1

0, TBox, 1745, -45, 1, 1, 1

0, BSAV, 0, 5, RHTDATA, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 18, 23, 26, 27, 28, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 50

2000, ESAV

2000, ES

H. TURKISH SUMMARY / TÜRKÇE ÖZET

Giriş

Trafik kazaları, global ölçekte insanların hayatlarını yaralanmalarına ve ölmelerine yol açan en önemli güvenlik sorunlarından birisidir. Trafik kazalarının milyonlarca insanın hayatlarını kaybetmesine veya insanların kalıcı fiziksel hasarlar almasına yol açmasının yanı sıra, iş gücü kaybı, uzun süren tedavi süreçlerinin maddi yükü ve psikolojik travmalar gibi farklı olumsuz sonuçları da mevcuttur (Dünya Bankası, 2018; Dünya Sağlık Örgütü, 2020). Bu nedenle trafik kazalarının önlenmesi yalnızca daha güvenli yollara sahip olmak açısından değil, aynı zamanda da ülkelerin ekonomik kalkınmalarının desteklenmesi ve kazaların yol açacağı birey, aile ve toplum seviyesindeki travmaların önüne geçilmesi açısından önemlidir. Bu nedenle, trafik kazalarının yol açtığı ölüm ve yaralanmaların önlenmesi günümüzde çözülmesi gereken önemli bir sorun olmaya devam etmektedir (Dünya Sağlık Örgütü, 2022).

Yol Güvenliğinde Önemli Faktörler

Kazalar istenmeyen sonuçlara yol açan beklenmedik olaylar şeklinde tanımlanmıştır (Hollnagel, 2016). Geçmişte kazaların nedeni olarak genellikle insan faktörü ortaya atılmış olsa da, günümüzde trafik kazalarının insan, araç ve çevre faktörlerinin etkileşimi doğrultusunda oluştuğu görüşü hakimdir (Haddon Jr, 1972; Larsson, Dekker ve Tingvall, 2010).

İnsan faktörleri kazalarda rol oynayan en etkili faktör olarak nitelendirilebilir (Evans, 1996; Petridou ve Moustaki, 2000; Dingus ve ark., 2019). İnsan faktörleri kapsamında davranışlar, beceriler, fiziksel özellikler, kişilik özellikleri, sağlık sorunları, yaş ve cinsiyet gibi faktörler bulunur. Bu faktörler içerisinde yaş, cinsiyet ve sürücü becerileri gibi bazı faktörlerin anormal sürücü davranışlarını yordayıcı niteliğe sahip olması sürüş güvenliği literatüründe sık sık karşılaşılan bir bulgudur. Sürücü becerileri algı-motor beceriler ve güvenlik becerileri olarak ikiye ayrılmaktadır (Lajunen ve Summala, 1995). Algı-motor beceriler araç kontrolünü sağlayabilmeye yönelik yetenekleri içerirken, güvenlik becerileri kişilerin trafik ortamındaki güvenlik motivasyonlarını etkileyen yetenekleri içermektedir. Sürücü becerileri, Lajunen ve Summala (1995) tarafından geliştirilen Sürücü Becerileri Ölçeği kullanılarak ölçülmektedir ve bu ölçek çeşitli çalışmalar ve çeşitli ülkelerde tutarlı sonuçlar ortaya koymasıyla sürücü becerileri ölçümünde en sık kullanılan araçlardan birisi olmuştur (Lajunen ve ark., 1998; Özkan ve ark., 2006; Martinussen ve ark., 2014; Ostapczuk ve ark., 2017; Xu ve ark., 2018; Liu ve ark., 2021). Sürücü becerilerinin öz beyana dayalı ölçülmesi, bu ölçümlerin araç kullanıcılarının araç kullanma stillerini ve bunun yol güvenliğine olan etkisini yordayıcı nitelikte bulunduğundan ötürü önemlidir. Örneğin, algı-motor becerilerini yüksek olarak değerlendiren araç kullanıcılarının daha yüksek hızda araç kullandığı ve araç kullanırken ikincil uğraşlar ile (telefon kullanmak, radyo ile uğraşmak vb.) meşgul olduğu bilinirken, güvenlik becerilerini yüksek olarak değerlendiren araç kullanıcılarının daha düşük hızda araç kullandığı ve daha az sayıda trafik cezası aldığı bilinmektedir (Sümer ve ark., 2006; Martinussen ve ark., 2014; Ostapczuk ve ark., 2017). Yaş ve cinsiyet de sürüş davranışları ve trafik güvenliği üzerinde önemli bir etkiye sahiptir. Araştırmalar genç sürücülerin trafik kazası yaşama risklerini düşük algıladıklarını, daha fazla riskli sürüş davranışları sergilediklerini gösterirken benzer şekilde erkek sürücülerin trafik kazalarına daha sık karıştıkları, erkeklerin algı-motor becerilerini daha yüksek değerlendirdikleri, daha hızlı araç kullandıklarınıgöstermiştir (Williams et al., 1985; Deery, 1999; Horwood & Fergusson, 2000; Oltedal ve Rundmo, 2006; Özkan ve Lajunen, 2006; Rhodes et al., 2015). Özetle, genç erkek sürücüler, yol güvenliğini etkileyen insan faktörleri arasında önemli bir yer tutmaktadır. Araç faktörleri, yol güvenliğinde etkisi insan faktörleri düzeyinde olmayan fakat aracın frenleri, ışıkları, lastikleri gibi parçalarındaki hataları ve bakımsızlıkları veya aracın direksiyonunun bulunduğu taraf ya da aracın elektrikli motor kullanması gibi fiziksel özelliklerinden kaynaklanabilecek sorunları kapsamaktadır (Hoque ve Hasan, 2006; Moodley ve Allopi, 2008; Verheijen ve Jabben, 2010; Roesel, 2017).

Öte yandan çevre faktörleri, bir noktadan diğerine varmak için kullanılan rotada bulunan fiziksel, sosyal ve kültürel çevreyi barındıran, yol güvenliğinde etkisi oldukça geniş olabilen bir faktördür. Yolun yapıldığı materyal, şerit sayısı, şerit genişliği, görüşü etkileyen ağaç, tabela vb. gibi faktörler, trafik işaret ve levhaları gibi yolun fiziksel özelliklerinin yanı sıra, trafik kültürü ve trafik iklimi gibi faktörler de çevre faktörleri kapsamında değerlendirilebilir (Gehlert, Hagemeister ve Özkan, 2014; Özkan & Lajunen, 2015; Losurdo ve ark., 2017; Gichaga, 2017). Trafik güvenliği kültürü, bir trafik bağlamına yönelik uygun güvenlik davranışlarını kapsayan ve o trafik bağlamında bulunan yol kullanıcıları tarafından paylaşılan algı ve inançları kapsamaktadır (Gehlert, Hagemeister ve Özkan, 2014). Trafik güvenliği iklimi ise belirli bir zamanda belirli bir trafik bağlamındaki yol kullanıcılarının o trafik bağlamına yönelik algı ve tutumları olarak tanımlanabilir (Gehlert, Hagemeister ve Özkan, 2014). Trafik ikliminin bileşenleri dışsal duygu talepleri, iç gereksinimler, ve işlevselliktir (Gehlert, Hagemeister ve Özkan, 2014). Kişilerin trafik iklimine yönelik tutum ve algıları farklılaşabilirken, bu algı ve tutumlar bireylerin sürüş davranışlarını ve dolaylı olarak trafik güvenliğini etkileyebilmektedir (Lajunen et al., 1998; Özkan et al., 2006; Gehlert, Hagemeister & Özkan, 2014; Chu ve ark., 2019). Örneğin güvenli olarak algılanan trafik ortamlarında yol kullanıcıları daha riskli davranışlar sergilerken, daha az güvenli olarak algılanan trafik ortamlarında yol kullanıcıları daha temkinli davranabilmektedir (Gehlert, Hagemeister & Özkan, 2014; Chu ve ark., 2019). Trafik ikliminin trafik güvenliği üzerindeki etkisi üzerine çarpıcı sonuçlar ortaya koyan çalışmalar olsa da, trafik iklimine yönelik değerlendirmeler ve trafik güvenliği arasındaki ilişkiyi aydınlatmak adına daha fazla çalışma yapılması gerekmektedir.

Yol kullanıcılarının davranışlarını ve yol güvenliğini etkileyen bir başka faktör ise aşinalıktır. Bir trafik bağlamına yönelik aşinalık genellikle rota aşinalığı üzerinden çalışılmıştır. Bir rotaya tekrarlı maruz kalma sonucunda gelişen rota aşinalığının sürüş eylemi üzerinde doğrudan etkisi olduğu belirtilmiştir (Intini, Colonna ve Ryeng, 2019). Bir trafik bağlamına yönelik aşinalığın artmasıyla birlikte sürücülerin dikkat, tepki süresi, tehlikeleri fark etme gibi davranış ve yeteneklerinin de değişim gösterdiği çeşitli çalışmalar tarafından raporlanmıştır (Yanko ve Spalek 2013; Lu et al., 2020). Aşinalığın artmasıyla dikkat süreçlerinin sekteye uğraması, kontrollü sürüşten otomatik sürüşe geçişle açıklanmaya çalışılmıştır (Schneider & Shiffrin, 1977; Yanko, 2013). Yani bir rotaya tekrar tekrar maruz kalmak, o rotada araç kullanırken daha dikkatsiz davranmaya, daha hızlı araç kullanmaya, azalan bilişsek yük nedeniyle ikincil uğraşlar ile meşgul olmaya, zihin gezinmesi olarak tanımlanan ve dikkatin araç kullanmanın haricindeki düşüncelere dalması olarak tanımlanabilecek fenomenin artışına ve kazalara daha açık hale gelmeye yol açabilir (Smallwood ve Schooler, 2006; Yanko ve Spalek, 2013). Öte yandan, aşinalığın etkisi yalnızca negatif değildir. Bir yol bağlamına yabancı yol kullanıcılarının bazı kaza tiplerine karışma olasılıklarının daha yüksek olduğu bilinmektedir (Wilks ve ark., 1999; Yan ve ark., 2005). Belirli bir miktarın ötesinde edinilecek bir aşinalığın ise parabolik bir ilişki çizerek daha güvenli sürüş davranışları ve daha güvenli trafik ortamıyla sonuçlanabileceği belirtilmiştir (Yanko ve Spalek, 2013).

Aşinalık faktörü ise yalnızca rota aşinalığı ile sınırlı değildir. Yol akışı aşinalığı, yol güvenliğinde önemli etkisi olduğu düşünülen bir başka aşinalık faktörüdür. Dünyada kullanılan en yaygın iki trafik akış sistemi, soldan akan trafik ve sağdan akan trafik sistemleridir (Wen ve Lee, 2022). Yol akışı aşinalığı ise, sağdan akan trafik sistemi veya soldan akan trafik sistemi ile aşina olmak olarak tanımlanabilir (Harms et al., 2021). Aşina olunmayan trafik akışlı trafik ortamlarında bulunmak kaza riskini artırabilir. Örneğin, aşina olunmayan trafik ortamlarında bulunan turistlerin trafik kazası yaşama ortanları ve risklerinin fazla olduğu araştırmalarca raporlanmıştır (Wilks ve ark., 1999; Choocharukul ve Sriroongvikrai, 2017; Castro-Nuño ve Arévalo-Quijada, 2018). Aşina olunmayan yol akışında araç kullanmanın ya da yaya olarak bulunmanın, bu yol kullanıcılarının kaza risklerini artıran ve sürüş performanslarını etkileyen en önemli faktörlerden birisi olduğu vurgulanmıştır (Wilks ve ark., 1999; Jeon ve ark., 2004; Papakitsos ve ark., 2018; Malhotra ve ark., 2018; Ye ve ark., 2021). Aşina olunmayan yol akışı ortamlarında sürücülerin araç kontrolüne yönelik manipülasyonlarında yanlış müdahalelerin fazlalığı ve sürüş performanslarının belirgin şekilde daha düşük olduğu belirtilmiştir (Jeon ve ark., 2004; Xu ve ark., 2023). Benzer şekilde araç kullanıcılarının görsel dikkatlerinin yolun aşina oldukları tarafında yoğunlaştığını ve aşina olunmayan yol ortamlarında bu alışkanlıklarının kazalara yol açabileceği belirtilmiştir (Thompson ve Sabik, 2018).

Sonuç olarak, turizm veya başka nedenlerden ötürü aşina olunmayan yol akışı ortamlarında bulunmanın yol güvenliği açısından önemli bir yeri olduğu aşikardır. Öte yandan aşina olunmayan yol akışlarına adapte olma ve aşinalık geliştirme süreçlerinin ve bu süreç içerisinde sürücülerin sürüş davranışlarının, yeteneklerinin ve performanslarının nasıl bir değişim geçirdiği yeterince çalışılmamış bir faktördür.

Sürüş Simülatörleri, Göz İzleme Cihazları ve Yol Güvenliği Araştırmaları

Sürüş Simülatörleri ve Yol Güvenliği Araştırmaları

Öz beyana dayalı ölçüm yöntemlerinin yanı sıra, trafik psikolojisi ve yol güvenliği araştırmalarında sıklıkla kullanılan bir başka ölçüm aracı sürüş simülatörleridir. Sürücülerin tehlikeye atılmadan, simüle edilen trafik ortamlarında yaş, cinsiyet, rota aşinalığı, yorgunluk, dikkat vb. pek çok faktöre dayalı sürüş performanslarında oluşabilecek değişimlerin gözlemlenmesi için sürüş simülatörleri, yol güvenliği araştırmalarında önemli bir yere sahiptir (Burns ve ark., 2002; Reimer ve ark., 2006; Carsten ve Jamson, 2011; Wynne ve ark., 2019). Kısacası, sürüş simülatörleri, yol güvenliği araştırmaları için pratik, güvenli, kontrol edilebilen ve tekrarlanabilen bir çalışma imkanı sunmaktadır (Wynne ve ark., 2019).

Sürüş simülatörleri kullanılrıken dikkat edilmesi gereken önemli bir husus, harekete dair görsel bir uyaran bulunduğu halde vestibüler sistemden kaynaklanan bir geribildirim olmamasından ötürü ortaya çıkan simülatör hastalığıdır (Carsten & Jamson, 2011). Simülatör hastalığı, mide bulantısı ve konsantrasyon zorluğu gibi belirtiler barındırmaktadır (Bittner ve ark., 1997).

Sürüş simülatörleri ile çalışırken dikkat edilmesi gereken bir başka husus ise sürüş simülatörlerinin geçerliliğidir. Sürüş simülatörlerinde bulunan iki önemli geçerlilik türü ise davranışsal geçerlilik ve fiziksel geçerlilik olarak tanımlanabilir (Blaauw, 1982; Godley ve ark., 2002). Davranışsal geçerlilik bir sürüş simülatörünün gerçek sürüş ortamıyla kıyaslandığında ne kadar benzer davranışları ortaya çıkarabildiğidir (Blaauw, 1982). Fiziksel geçerlilik ise bir sürüş simülatörünün gerçek bir araç sürme deneyimini ne kadar iyi yansıtabildiğidir (Blaauw, 1982; Godley ve ark., 2002; Reimer ve ark., 2006). Sürüş simülatörlerinde fiziksel geçerlilik yüksek olsa bile, davranışsal geçerlilik düşük ise sağlıklı veri almak zorlaşacaktır (Triggs, 1996; Godley ve ark., 2002). Yani düşük fiziksel geçerliliğe sahip olan fakat davranışsal geçerliliği yüksek olan bir sürüş simülatörüyle anlamlı sonuçlar elde etmek mümkündür (Carsten ve Jamson, 2011).

Sürüş simülatörlerini ilgilendiren bir diğer geçerlilik türü ise mutlak geçerlilik ve göreceli geçerliliktir (Blaauw, 1982; Kaptein ve ark., 1996; Carsten ve Jamson, 2011). Mutlak geçerlilik gerçek sürüş ile elde edilen verilen ile sürüş simülatöründe elde edilen veriler arasında hemen hemen birebir ilişki bulunmasını gerektirirken, göreceli geçerlilik gerçek sürüş ile elde edilen veriler ile sürüş simülatöründe elde edilen veriler arasında benzer bir ilişki bulunmasını gerektirmektedir (Blaauw, 1982; Harms, 1996; Carsten & Jamson, 2011). Pek çok çalışmada, düşük ve yüksek fiziksel geçerliliği olan sürüş simülatörleri ile, hız, şerit pozisyonu, hız varyansı, şerit ihlali, hata sayısı gibi verilerde mutlak ve göreceli geçerlilikler elde edilmiştir (Blaauw, 1982; Harms, 1996; Bella, 2005; Abdel-Aty ve ark., 2006; Fors ve ark., 2013; Veldstra ve ark., 2015).

Sonuç olarak, düşük ya da yüksek fiziksel geçerlilikleri olmasına rağmen pek çok çalışmada sürüş simülatörlerinin mutlak ve göreceli geçerlilikleri sağlaması nedeniyle sürüş simülatörlerinin trafik psikolojisi ve yol güvenliği çalışmalarında oldukça kullanışlı, ekonomik, pratik, güvenli ve faydalı ölçüm araçları olduğu sonucuna varılmıştır.

Göz İzleme Cihazları ve Yol Güvenliği Çalışmaları

Sürüş simülatörlerinin yanı sıra yol güvenliği ve trafik psikolojisi çalışmalarında kullanınal bir başka ölçüm yöntemi görsel dikkat ölçen göz izleme cihazlarının kullanılmasıdır. Göze kızıl ötesi ışınlar göndererek kişinin baktığı noktaları anlık olarak ölçebilen ve vücuda yerleştirilmesi gerekmeyen daha pratik ve yaygın kullanılan göz izleme cihazları yaygın kullanılmaktadır (Khan ve Lee, 2019; Carr ve Grover, 2020; Vetturi ve ark., 2020). Göz izleme çalışmalarında üzerinde en sık durulan değişkenler göz sabitleme ve gözün hızlı ve kısa hareketlerini tanımlayan sekme ya da seğirme hareketleridir (Carr ve Grover, 2020; Vetturi ve ark., 2020). Göz sabitleme hareketi, kişinin bakışını bir noktaya bilinçli şekilde odaklaması olarak tanımlanabilir (Hoffman ve Subramaniam, 1995; Vetturi ve ark., 2020; Nouzovský ve ark., 2022). Göz sabitleme hareketleri bilinçli olsa da, bakışın sabitlendiği noktaya dikkatin tamamen yönlendirildiği çıkarımı yapılmamalıdır, zira bakılan nokta ile dikkat verildiği şey aynı olmayabilir (Shinar, 2008). Çalışmaların genellikle odak noktası olan göz sabitlemeler, sekme davranışlarından minimum süre belirleme gibi çeşitli filtreleme yöntemleriyle ayrılmaktadırlar (Sodhi ve ark., 2002). Genel olarak, 60-200 milisaniye aralığındaki bakışlar sekme, 200 milisaniye üzeri bakışlar ise göz sabitleme olarak adlandırılabilir (Kapitaniak ve ark., 2015; Bıçaksız ve ark., 2019).

Göz izleme cihazlarının yol güvenliği araştırmalarındaki önemi ve yeri gün geçtikçe artmaktadır (Ojsteršek ve Topolšek, 2019;Vetturi ve ark., 2020). Örneğin deneyimli sürücülerin göz sabitleme süreleri daha kısa bulunurken, tehlike oluşturabilecek uyaranlar üzerindeki göz sabitleme süreleri daha yüksek bulunmuştur (Underwoord ve ark., 2002). Aşina olunmayan trafik ortamında araç kullanmaya bağlı olarak yükselen bilişsek yük dolayısıyla sürücülerin tabelalara daha uzun süre baktığı, tabelaları yanlış okuyabildiği, ve daha düşük hızlarda araç kullandıkları belirtilmiştir (Hurtadı ve Chiasson, 2016). Benzer şekilde, artan bilişsel yüke bağlı olarak tünel görüşü sergileyen sürücülerin çevresel görüşlerinin zayıfladığı ve bazı tehlikeleri görseler bile bu tehlikelere gerekli cevabı vermekte başarısız oldukları raporlanmıştır (Briggs ve ark., 2016). Dikkat dağıtan reklam panolarının ise sürücülerin şerit pozisyonlarını koruma performanslarını belirgin ölçüde azalttığı raporlanmıştır (Chattington ve ark., 2009). Aşina olunmayan yol akışında bir kavşak üzerinde kaydedilen videolar izletildiğinde katılımcıların yolun yanlış tarafında bakışlarını yoğunlaştırdıkları ve tehlikeleri tespit etme performanslarının azalması ise dikkat çeken bir başka bulgu olmuştur (Thompson ve Sabik, 2018). Aşina olunmayan yol akışında araç kullanması istenen katılımcıların benzer şekilde yüksek göz sabitleme sürelerine sahip olmalarına karşın dönüşlerde araca gereğinden fazla müdahalede bulunarak güvensiz bir sürüş ortaya koydukları raporlanmıştır (Nakayasu ve ark., 2011). Artan rota aşinalığına bağlı olarak ise sürücülerin göz sabitleme noktalarının yol, sürüş ve tehlike oluşturabilecek uyaranlardan sürüş eylemiyle ilgisi olmayan uyaranlara kaydığı görülmüştür (Young ve ark., 2018). Yani göz sabitleme sayıları ve süreleri benzer olsa bile, sürücülerin dikkatlerini verdikleri nokta farklı olabilmektedir. Bu nedenle göz izleme çalışmalarında göz sabitleme sayı ve süreleri, çalışmadaki diğer değişkenler bağlamında tartışılmalıdır. Sonuç olarak göz izleme cihazları trafik psikolojisi ve yol güvenliği çalışmaları açısından faydalı sonuçlar ortaya koymaktadır. Bu nedenle göz izleme cihazlarının ve görsel dikkatin yol güvenliği çalışmalarında sürüş simülatörlerine benzer şekilde kullanım yoğunluğunun gelecekte artması beklenmektedir.

Çalışmanın Amacı

Mevcut çalışma, aşina olunmayan yol akışında araç kullanmanın sürücülerin sürüş performansına ve görsel dikkat ölçümlerine etkisini incelemeyi amaçlamaktadır. Simülasyon ve göz izleme çıktılarına ek olarak, farklı trafik akışlarında trafik iklimine yönelik değerlendirmeler ve sürücülerin sürüş becerilerine yönelik değerlendirmelerin simülasyon çıktılarıyla ilişkisi de incelenmiştir. Mevcut çalışma, literatürde ilk defa aşina olunan ve aşina olunmayan trafik akışlarında tekrarlı araç kullanımına bağlı olarak gelişen aşinalık doğrultusunda sürüş performansının nasıl değiştiğini ortaya koyması açısından önemlidir.

Yöntem

Minimum ehliyet sahibi olma süresini ve son bir yıl içerisinde araç kullanılması gereken minimum kilometre miktarını sağlamayan beş katılımcı çıkarıldıktan sonra çalışmaya 29 katılımcı dahil olmuştur. Katılımcıların en az üç yıl ehliyet sahibi olması, son bir yıl içerisinde en az 3000 kilometre araç kullanmış olması şartları sağlanmıştır. Katılımcılar 20-27 yaş aralığında erkek sürücülerden oluşmaktadır.

Materyaller

Örnekleme ilişkin genel bilgi sahibi olmak adına katılımcılara yaş, toplam araç kullanılan kilometre, geçmişteki kaza bilgileri, bilgisayar ya da araç kullanmalarını etkileyebilecek bir sağlık sorunları olup olmadığı, göz rahatsızlıkları ve gözlük kullandıklarına dair bilgiler, daha önceden trafiğin soldan aktığı bir ülkede bulunup bulunmadıkları gibi sorular sorulmuştur. Sürücü becerileri ölçümü için 5’li Likert tipte 20 maddelik Sürücü Becerileri Ölçeği kısa versiyonu kullanılmıştır (Lajunen ve Summala, 1996; Sümer ve Özkan, 2002). Sürücü Becerileri Ölçeği’nde algı-motor beceriler ve güvenlik becerileri için 10 adet madde bulunmaktadır. Trafik iklimine yönelik algıların ölçülmesi için hem sağdan akan hem de soldan akan trafik senaryoları için 6’lı Likert tipte 16 maddeden oluşan Trafik İklimi Ölçeği kısa versiyonu kullanılmıştır (Özkan ve Lajunen, 2011). Sürüş performansına yönelik ölçümler Stisim Drive M100W sürüş simülatörü ve STISIM DRIVE-M100W-ASPT yazılımı kullanılarak alınmıştır. Görsel dikkat ölçümlerri için ekrana sabitlenen Tobii Pro X2-60 göz izleme cihazı kullanılmıştır.

Sürüş Senaryoları

Katılımcılar, bir test sürüşü senaryosu, bir sağdan akan trafik senaryosu ve bir soldan akan trafik senaryosu olmak üzere üç senaryoda araç kullanmışlardır. Test sürüşünün amacı katılımcıların simülasyon ortamına aşina olmasını ve simülasyon hastalığı yaşamadıklarından emin olmaktır. Sağdan akan ve soldan akan trafik senaryoları arasındaki tek fark trafiğin akış yönü, trafik tabelalarının yolun hangi tarafında bulunduğu ve karşıdan gelen araçların bulundukları şerit olmuştur. Bu farklılıkların haricinde her iki senaryoda 2 kilometre uzunluğunda gidiş-geliş şeklinde standart yol genişliğine sahip, ilk 300 metrelik kısmı şehir içi, sonraki kısmı şehirlerarası yoldan oluşan, trafik yoğunluğu düşük, yayaların ve başka canlıların olmadığı, yalnızca ağaçların ve bazı binaların olduğu, belirli metre aralıklarında virajların bulunduğu, kavşak veya dönüşlerin olmadığı sade bir yol yapısına sahiptir. Sade bir yol yapısı seçilmesinin nedeni, aşinalık çalışmalarında aşinalığın artışına bağlı olarak değişim gösteren sürüş davranışlarına ilişkin sağlıklı ve net veri alabilmektir (Intini ve ark., 2016). Mevcut çalışma tekrarlı sürüşe bağlı olarak gelişen aşinalığı gözlemlemek istediğinden, sağdan akan ve soldan akan trafik senaryolarında bu 2 kilometrelik yol 7 defa tekrar edecek şekilde ayarlanmıştır.

Prosedür

Araştırmanın etik izni ODTÜ İnsan Araştırmaları Etik Kurulu'ndan alınmıştır. Katılımcılara uygunluk ve kartopu örneklem yöntemleriyle ulaşılmıştır. Çalışma ODTÜ-TSK MODSIMMER binasında İnsan Faktörü Laboratuvarı'nda gerçekleştirilmiştir. Katılımcılar dersleri için ek puan almışlardır. Onam formunu ve demografik bilgiler formunu dolduran katılımcılar test sürüşü ardından karşıt dengeleme yöntemi ile sağdan akan trafik senaryosuna ya da soldan akan trafik senaryosuna atanmıştır. Araç kullanmaya başlamadan önce göz izleme cihazı her katılımcı ve senaryo için ayrı ayrı kalibre edilmiştir. İlk senaryoyu tamamlayan katılımcılar Trafik İklimi Ölçeği'ni doldurup araç kullandıkları senaryoyu değerlendirdikten sonra, diğer senaryoya atanmış ve bu senaryoyu tamamladıktan sonra da Trafik İklimi Ölçeği'ni doldurmuşlardır. Katılımcılar, sağdan akan trafik senaryosunda 7 ve soldan akan trafik senaryosunda 7 defa olmak üzere toplam 14 defa deney senaryosunu tamamlamıştır. Son olarak katılımcılar Sürücü Becerileri Ölçeği'ni doldurmuş ve çalışma hakkında bilgilendirilmişlerdir. Katılımcıların çalışmayı tamamlası ortalama 40 dakika civarı sürmüştür. Elde edilen veriler Microsof Office Excel ve IBM SPSS Statistics 24 yazılımları kullanılarak analiz edilmiştir.

Sonuçlar ve Tartışma

Katılımcıların sağ ve sol akışlı trafiğe yönelik iklim değerlendirmelerini karşılaştırmak için bağımlı gruplar t Testi analizi yapılmıştır. Katılımcılar soldan akan trafik ortamını dışsal duygu talepleri açısından daha yüksek algılamıştır. Yani soldan akan trafik ortamı daha agresif, stresli, ve daha az güvenli algılanmıştır (Gehlert ve ark., 2014). Sağdan akan trafik ortamı ise işlevsellik açısından daha yüksek algılanmıştır. Yani sağdan akan ve aşina olunan trafik ortamı daha güvenli ve daha az riskli algılanmıştır (Gehlert ve ark., 2014). Trafik ortamının güvenli algılanması halinde sürücüler daha fazla riskli davranış sergilerken, güvensiz algılanması halinde daha temkinli davranabilmektedirler (Cohn et al., 1995; Renge, 1998; Ulleberg & Rundmo, 2003; Ram and Chand, 2016). Öte yandan mevcut çalışmada daha riskli algılanan soldan akan trafik senaryosunda sürücüler şerit takibi, şerit dışında geçirilen süre ve karşıdan gelen araçlarla çarpışmaya kalan minimum mesafe ölçümlerinde daha güvensiz sonuçlar ortaya koymuştur. Sonuçlar, örneklem grubunun genç erkek sürücülerden oluşmasıyla ilişkili ya da aşina olunmayan trafik akışında trafik ortamı riskli algılansa bile bu güvenlik davranışlarının başarılı bir şekilde sergilenememesiyle ilgili olabilir. Sürücü Becerileri Ölçeği ve Trafik İklimi Ölçeği faktörleri arasındaki ilişki 2 x 2 karışık desen ANOVA ile incelenmiş fakat iç gereksinimler ve güvenlik becerileri arasında bulunan etkileşim etkisi haricinde önemli bulgulara rastlanmamıştır. Güvenlik becerileri düşük sürücüler soldan akan trafiğin iç gereksinimlerini daha yüksek değerlendirirken, güvenlik becerileri yüksek sürücüler sağdan akan trafiğin iç gereksinimlerini daha yüksek değerlendirmiştir.

Aşinalığın etkisini görmek adına hız, şerit pozisyonu standard sapması, ve karşıdan gelen araçlarla çarpışmaya kalan minimum süre ölçümleri 2 x 7 tekrarlı ölçümler ANOVA analiziyle karşılaştırılmıştır. Sağdan akan ve soldan akan trafik bir bağımsız değişkeni oluştururken, 7 adet tekrar bir diğer bağımsız değişkeni oluşturmuştur. Katılımcılar genel olarak sağdan akan ve aşina olunan yol senaryosunda literature uygun şekilde daha yüksek hızda araç kullanmışlardır (Angioi ve Bassani, 2022; Bertola ve ark., 2012). Tekrarlı ölçümlere bağlı hız ölçümlerinde ise sağdan akan ve soldan akan yol akışı senaryolarında benzer bir örüntü görülmüş ve sürüşleri arası hız farkı 2. Sürüşten sonra ortadan kalkmıştır. Aşinalığın ne zaman oluştuğunu kesin olarak anlamak zordur (Intini ve ark., 2019), fakat literatürle uygun şekilde mevcut çalışma genel olarak ilk sürüşlerde aşinalığın ve buna bağlı olarak hızın hızlı bir şekilde arttığını, daha sonradan bu artışın yavaşladığını ortaya koymuştur (Colonna ve ark., 2016; Harms ve Brookhius, 2016). Katılımcılar aşina olmadıkları soldan akan senaryoda daha yavaş araç kullanmış olsalar da, bu yavaşlığın nedeni güvenli sürüşten öte, yüksek bilişsel yük olabilir. Artan bilişsel yüke bağlı olarak ise sürüş performansının azaldığı ve kaza riskinin arttığı raporlanmıştır (Elvik, 2006; Lee ve ark., 2023). Şerit pozisyonu standart sapması, karşıdan gelen araçlar ile çarpışmaya kalan minimum süre ve şerit dışında geçirilen süre ve mesafe ölçümleri göz önüne alındığında, aşina olunmayan soldan akan trafik senaryolarında sürüş performansının düştüğü ve kaza riskinin arttığını söylemek mümkündür. Şerit pozisyonu standart sapması ölçümlerinde lüteratüre uygun şekilde sürüşler arası fark bulunamazken (Charlton ve Starkey, 2014), aşina olunmayan soldan akan trafik senaryosunda sürüş pozisyonu standart sapması daha yüksek bulunmuştur. Aşina olunmayan yol akışında bulunmanın virajlarda daha tehlikeli dönüşlere yol açabileceği (Nakayasu ve ark., 2011) belirtilirken, yüksek şerit pozisyonu standart sapması da şerit pozisyonunu koruyamama, şeritten çıkma ve genel olarak daha riskli bir sürüş ile ilişkili bulunmuştur (Verster ve Roth, 2014; Verster ve ark., 2017). Sonuç olarak, aşina olunmayan ve soldan akan trafik senaryosunda katılımcılar şerit pozisyonlarını korumakta güçlük yaşamışlardır ve bu durum trafik güvenliğini tehlikeye atabilmektedir. Benzer şekilde, karşıdan gelen araçlarla çarpışmaya kalan minimum süre ölçümlerinde, tekrarlı sürüşler arasında belirgin fark bulunamazken, soldan akan trafik senaryosunda bu süre daha düşük bulunmuştur. Çarpışmaya kalan minimum sürenin düşük olması, kaza riskini artıran bir faktördür (Angioi ve Bassani, 2022). Yüksek bilişsel yük, durumsal aşinalık, rota aşinalığı, bir trafik akışına yönelik bilgi birkimi ve alışkanlıklar gibi faktörler aşina olunan ve aşina olunmayan trafik akışı ortamlarında farklı etkilere neden olarak karşıdan gelen araçlar ile çarpışma riskinin artmasına neden olmuş olabilir (Young ve Stanton, 2002; Yanko ve Spalek, 2013; Thompson ve Sabik, 2018; Angioi, 2021; Lee ve ark., 2023). Yol dışında geçirilen süre ve mesafenin toplam yüzdeleri sağdan ve soldan akan trafik senaryolarında tekrar sayısına bakılmaksızın toplam ortalama değerler alınarak bağımlı gruplar t Testi ile analiz edilmiştir. Şerit dışında geçirilen toplam süre ve mesafe yüzdeleri soldan akan trafik senaryosunda daha yüksek bulunmuştur. Şerit takibi performansının soldan akan trafik senaryosunda daha düşük olduğu göz önüne alındığında, şerit dışında geçirilen süre ve mesafenin soldan akan trafik senaryosunda daha fazla olması beklenen bir sonuçtur. Sürücüler aşina olmadıkları yol akışında araç kullanırken daha yavaş araç kullanmış olsalar da şerit pozisyonlarını koruyamamış, şeritleri dışına daha sık çıkmış, ve genel olarak daha güvensiz ve riskli bir sürüş ortaya koymuşlardır. Son olarak, toplam hız, toplam şerit pozisyonu standard sapması, şerit dışında geçirilen süre ve mesafe yüzdeleri, 2 x 2 karışık desen ANOVA analizi kullanılarak Sürücü Becerileri Ölçeği ile birlikte incelenmiştir. Sürücü Becerileri Ölçeği faktörleri yüksek ve düşük şeklinde ikiye ayrılarak bir bağımsız değişkeni oluştururken, sağ ve sol trafik akışı bir diğer bağımsız değişkeni oluşturmuştur. Literatüre uygun şekilde, algı-motor becerilerini yüksek puanlayan sürücüler daha yüksek hızda araç kullanırken, güvenlik becerilerini yüksek puanlayan sürücüler daha düşük hızda araç kullanmıştır (Delhomme, 1991; Sümer ve al., 2006; Horswill ve al., 2006; Özkan ve ark., 2006). Mevcut çalışma, aşina olunmayan trafik akışı ortamlarında da bu etkinin devam ettiğini göstermesi açısından önemlidir. Son olarak, simülasyon çıktılarına benzer şekilde 2 x 7 tekrarlı ölçümler ANOVA analizi kullanılarak göz sabitleme sayıları ve süreleri, sağ ve sol trafik akışında, 7 sürüş tekrarı boyunca karşılaştırılmıştır. Göz sabitleme sayıları sağdan akan senaryoda 2. sürüşten, soldan akan senaryoda ise 3. sürüşten sonra sabitlenmiştir. Göz sabitleme sayıları tekrarlı sürüşe bağlı olarak azalma gösterirken, sağdan ve soldan akan trafik senaryolarında göz sabitleme sayıları farklılık göstermemiştir. Göz sabitleme süreleri incelendiğinde ise herhangi bir belirgin sonuca ulaşılamamıştır. Göz sabitleme sayıları ve sürelerinin aşina olunan ve olunmayan trafik senaryolarında benzer miktarlarda seyretmesi, görsel dikkatin benzer ölçüde doğru dağıldığı anlamına gelmemektedir çünkü aynı noktaya bakan katılımcılar aynı miktarda bilgiyi işleyemeyebilir (Carr ve Grover, 2020). Baktığı halde görememe fenomeni de buradan kaynaklanır (Young et al., 2018; Carr & Grover 2020). Thompson ve Sabik'in önerisi doğrultusunda, aşina olunmayan yol akışında bulunan yol kullanıcıları, alışkanlıkları doğrultusunad yolun yanlış kısımlarına dikkatlerini verebilmekte, bu da kazalara neden olabilmektedir (2018). Bu nedenle, göz sabitleme verileri haricinde, yolun tam olarak ne tarafına bakıldığı ve odaklanıldığı da gelecek çalışmalarda incelenmelidir.

Sonuç, Öneriler ve Sınırlılıklar

Mevcut çalışma, rota ve yol akışı aşinalıklarını bir arada ölçen ilk çalışma olması açısından önemlidir. Yine aynı şekilde, mevcut çalışma sağ ve sol akışlı trafik ortamlarının trafik iklimi ölçümlerinin tek bir çalışmada yapılması açısından bir ilk olma özelliğini taşımaktadır. Bunlara ek olarak, araştırma çıktılarının sürücülerin sürüş becerilerine yönelik değerlendirmeleri doğrultusunda incelenmesi de önemlidir. Genel olarak, aşina olunmayan trafik akışı ortamında sürücülerin daha düşük hızda araç kullanırken, şerit koruma performanslarında belirgin bir düşüş tecrübe edildiği ve daha güvensiz bir sürüş sergiledikleri görülmüştür. Sürücü becerilerine yönelik değerlendirmelerin ise trafik akışından bağımsız olarak sürüş hızına olan etkisi, insan faktörlerinin zaman zaman çevresel ve kültürel faktörlerin önüne geçebileceğini ortaya koymuştur. Aşina olunmayan trafik akışı ortamı katılımcılar tarafından trafik iklimi bakımından daha güvensiz değerlendirilirken, aşina olunan trafik ortamı daha güvenli değerlendirilmiştir. Gelecek çalışmalarda, bilişsel yük ve risk algısı değişkenleri doğrultusunda aşina olunmayan yol akışındaki araç kullanma performansı incelenmelidir. Ayrıca aşina olunmayan trafik akışı ortamlarında görsel dikkatin önemini daha net ölçmek adına katılımcıların göz sabitleme haritaları incelenmelidir. Mevcut çalışmanın sınırlılıklarından bir tanesi örneklemin yalnızca genç erkek sürücülerden oluşmasıdır. Ayrıca örneklem boyutunun deneysel çalışmanın doğası gereği düşük tutulması, öz beyana dayalı ölçümlerde elde edilen sonuçların yorumlanmasını zorlaştırmıştır. Gelecek çalışmalarda daha yüksek örneklem boyutu ve kadın katılımcıların kullanılması faydalı olacaktır. Ayrıca mevcut çalışma yol akışı aşinalığını inceleyen öncü çalışmalardan birisi olarak sade bir sürüş senaryosu kullanmıştır. Kavşakların, ışıkların, yüksek ve düşük trafik yoğunluklarının bir arada bulunduğu senaryolarda aynı çalışmayı tekrarlamak farklı sonuçlar verebilir. Son olarak, yüksek fiziksel geçerliliğe sahip sürüş simülatörlerinde ve daha gelişmiş göz izleme cihazlarında çalışmayı tekrarlamak faydalı olabilir.

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