THE EFFECTS OF AUDITORY AND VISUO-SPATIAL SECONDARY TASKS ON LANE MAINTENANCE IN PREDICTABLE AND UNPREDICTABLE DRIVING CONDITIONS

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ABSTRACT

THE EFFECTS OF AUDITORY AND VISUO-SPATIAL SECONDARY TASKS ON LANE MAINTENANCE IN PREDICTABLE AND UNPREDICTABLE DRIVING CONDITIONS

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The present study investigated the effects of auditory and visuo-spatial secondary tasks on variability in lane position in predictable and unpredictable driving conditions. The study also aimed to explore the impacts of perceived driving skills and safety skills on driving performance. Sixty-six participants filled out the Driver Skill Inventory and drove a simulated vehicle. Predictability was manipulated by adding wind gusts and secondary task load was manipulated by an auditory delayed digit recall n-back task or a visuo-spatial n back task. Results demonstrated that in the predictable driving condition, load decreased lane position variability in the auditory condition, however in the visuo-spatial condition; there was no significant difference in lane positioning between the no-load and the load conditions. In the unpredictable driving condition, there was no significant difference in lane positioning between the no-load and the load conditions in the auditory condition while, in the visuo-spatial condition, load increased lane position variability. Drivers from both auditory and visuo-spatial groups with low perceived driving skills showed the highest variability in lane position in all conditions. Results were discussed on the basis of distracted driving literature, Hierarchical Control Theory, and Working Memory Model.

Keywords: lane maintenance, hierarchic control, visuo-spatial task, auditory task, perceived skills.

ÖZ

TAHMİN EDİLEBİLİR VE TAHMİN EDİLEMEZ SÜRÜŞ ŞARTLARINDA İŞİTSEL VE GÖRSEL-MEKANSAL İKİNCİL GÖREVLERİN ŞERİDİ KORUMA ÜZERİNDEKİ ETKİLERİ

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Bu çalışma, işitsel ve görsel-mekânsal (uzamsal) ikincil görevlerin, tahmin edilebilir ve tahmin edilemez sürüş koşullarında, şerit pozisyonundaki değişkenliklere olan etkilerini araştırmaktadır. Çalışmanın bir amacı da algılanan sürüş becerileri ve güvenlik becerilerinin araç kullanma performansına olan etkilerini keşfetmektir. Altmış altı katılımcı Sürücü Beceri Anketini doldurmuş ve simülatörde araç kullanmıştır. Tahmin edilebilirlik rüzgâr eklenmesiyle ve ikincil görev yükü, işitsel n-geri göreviyle ya da görsel-mekânsal n-geri göreviyle manipüle edilmiştir. Sonuçlara göre, tahmin edilebilir sürüş koşulunda, işitsel yük şerit pozisyonundaki değişkenliği azaltmıştır fakat görsel-mekânsal yük şerit tutmada önemli bir değişikliğe yol açmamıştır. Tahmin edilemez sürüş koşulunda, işitsel yük şerit tutmada önemli bir değişikliğe yol açmamışken, görsel-mekânsal yük şerit pozisyonundaki değişkenliği arttırmıştır. Hem işitsel hem de görsel-mekânsal grubundaki, algılanan sürüş becerileri düşük sürücüler tüm koşullarda şerit pozisyonunda en yüksek değişkenliği göstermişlerdir. Sonuçlar, hiyerarşik kontrol teorisi ve çalışma belliği modeli taban alınarak tartışılmıştır.

Anahtar Kelimeler: şerit koruma, hiyerarşik kontrol, görsel-mekânsal görev, işitsel görev, algılanan beceriler.

To my dear family

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LIST OF ABBREVIATIONS

DSI	Driver Skill Inventory
GPS	Global Positioning System
HCT	Hierarchical Control Theory
ISI	Inter-Stimulus Interval
SA	Situation Awareness

CHAPTER I

INTRODUCTION

Driver distraction is one of the major causes of road accidents. There are various types of distractions that can occur behind the wheel. The current study focuses on two of these distractions, namely, auditory and visuo-spatial. Talking to someone on the mobile phone, listening to the radio, or conversing with a passenger can be gathered under a single roof and called auditory distractors while tracking navigation devices or other in-vehicle systems can be termed as visuo-spatial distractors. Visuo-spatial distractors require glances away from the road while auditory distractors take the mind off of the main task, driving. Additionally, visuo-spatial distractors such as navigation devices mostly require manual operation. This also affects driving unfavorably due to taking the hands off the steering wheel.

In the United States, 69% of citizens with a driver's license aged between 18 and 64 reported that they had cell phone conservation whilst driving within the previous month. In Europe, cell phone usage while driving ranges from 21% (UK) to 59% (Portugal) (Distracted Driving - Motor Vehicle Safety, n.d.). Again, in the US, approximately 660,000 car drivers use their cell phones or other electronic devices while on the road (Pickrell & Ye, 2013). Crashes due to driver distraction also seem to be on the rise. Accident statistics of the US show that in the year of 2012, 3,328 people lost their lives and 421,000 people got injured because of a distracted driver. Accident fatalities due to distraction were 3,360 in 2011 (Distracted Driving in the United States and Europe, n.d.).

Accident reports in Turkey do not involve sufficient information about the number of accidents caused by distracted drivers. In the report of Turkish Statistical Institute (2014), only 25 accidents are reported to be triggered by "Driving inconsiderately, pouring or throwing something from the vehicle, using phone while driving" ("Saygısızca araç kullanmak, araçtan bir şey atmak dökmek, seyir halinde telefon kullanmak"). In 2013, there were 1,207,354 reported road accidents; therefore, the number given for distraction caused crashes seems highly unrealistic. Due to lack of proper data collection methods, the real picture cannot be seen for Turkey.

1.1.Cell Phone Usage Behind The Wheel

A large amount of literature supports the fact that talking on a cell phone while driving affects driving performance negatively. Different aspects of a driving task can be affected by the distractive impact of cell phones. Based upon a 3-month long naturalistic driving data, Metz, Landau, and Hargutt (2015) demonstrated that car drivers talked over a hands-free phone around 11% of the riding time. While speaking to someone on a hands-free phone, drivers adapted their drive by decreasing their travelling speed and increasing the safety margin. This shows that drivers are aware of the fact that doing an additional task at the wheel jeopardizes road safety. Sanbonmatsu, Strayer, Medeiros-Ward, and Watson (2013) concluded that individuals who were the most incompetents in multitasking reported that they converse on their cell phones while driving. Drivers are aware of the risk posed by cell-phone usage but they are confident in their ability to multitask so they keep on using their cell phone while driving.

Strayer, Drews, and Crouch (2006) studied the similarity between talking on a cell phone and driving under the influence of alcohol by using a driving simulator. Both manipulations negatively affected safe driving. Profiles of two groups were different but unfavorable effects of the factors were parallel. Both hands-free and regular cell phones deteriorated driving performance by slowing reactions, increasing the time needed to recover speed after braking, and leading to more accidents. Intoxicated drivers had no accidents but they drove more aggressively. Strayer et al. (2006)

concluded that talking on a cell phone whilst driving impairs the performance as much as driving under the influence.

McCarley et al. (2004) investigated the effects of having a cell phone conversation and listening to a recorded conversation on detecting the changes in a traffic scene. While the attentive listening task did not give rise to any negative effects, talking on a hands-free cell phone made drivers detect fewer changes and make more mistakes in their responses. Being part of the conversation induces higher cognitive load that affects the main task, driving, more than just listening. Lethonen, Lappi, and Summala (2012) suggested that cognitive workload affect the anticipation of roadway curvature adversely by making drivers look less at the occlusion point on the road. In another study, drivers counted backwards by seven from the number that appeared on the screen in the cognitive load condition. Memory of the traffic environment was investigated. Drivers had a weaker memory of the moving objects in the road environment not the stationary ones when they were given cognitive load (Blalock et al., 2014).

Haque and Washington (2014) found that young drivers responded 40% slower to the pedestrians coming from sidewalks to go across the road in consequence of talking on the phone. Talking with the passenger in the car and making a cell phone conversation also differs in their impact on driving. Driving errors were found to be the highest when drivers talked on their cell phones. On the other hand, when the demand coming from the traffic increased, drivers adapted their conversation with the passenger by decreasing the complexity of the speech or postponing the conversation. Moreover, talking with a passenger increased the situation awareness (SA) by referring to road events and creating a team SA (Drews, Pasupathi, & Strayer, 2008). Strayer and Drews (2004) also supported the negative impacts of talking on the cell phone whilst driving. In their study, both younger and older drivers showed slower reactions than drive-only condition. Moreover, they took longer to recover lost speed after braking and rear-collision risk increased due to the cell-phone usage.

Hands-free cell phones pose a similar amount of risk compared to the hand-held cell phones in traffic. Violation rates of the car drivers and attentional lapses increased with the cell phone conversations (Beede & Kass, 2006). Hands-free cell phones caused an increment in the inattentional blindness rates during a conversation (Strayer & Drews, 2007). Lastly, practicing did not wipe out the disruptive impacts of cell-phone talk on driving performance (Cooper & Strayer, 2008).

The other side of the coin shows the complexity of human behavior. While talking on the cell phone deteriorates driving in many aspects, lane maintenance seems to be affected differently. Lane position variability decreased when drivers talked on their hands-free cell phones (Beede & Kass, 2006). Medeiros-Ward, Cooper, and Strayer (2014) also found improvement in lane keeping performance in the presence of a secondary task.

Collet, Guillot, and Petit (2010) reviewed literature about the effects of cell-phone use behind the wheel. Lane keeping performance was measured in several studies mentioned in the review. There were mixed findings. Brookhuis, de Vries, and de Waard (1991) found that hands-free phones lead to less deviation from the center lane compared to hand-held ones (as cited in Collet et al., 2010, p.595) Study also showed that practice improved lane maintenance when the traffic volume was low. In complex road conditions, no facilitation was seen. Jennes et al. (2002) stated that voice dialing did not affect the lane position but entering numbers manually did. They argued that cognitive load had no real impact on lane keeping performance as the drivers under mental load kept on looking at the roadway (as cited in Collet et al., 2010, p.595). Reed and Green (1999) further stated that the effects of manipulations on lane positioning could only be properly observed in actual driving, as opposed to simulated driving.

1.2.Navigation Systems

Navigation systems are designed with the intent to facilitate drivers' performance and lately they win their seats in a growing number of vehicles due to their affordable prices and ease of access.

Navigation devices, guide the drivers turn by turn about which way to go visually or by voice guiding. They are designed to lighten the drivers' workload. Nonetheless, benefits of the navigation systems usually depend on their type. Rizzardo, Colle, McGregor, and Wylie (2013) stated that guiding maps displayed in navigation devices led to the best learning when the spatial and verbal advisories were used together. Li, Zhu, Zhang, Wu, and Zhang (2014) investigated the effectiveness of different Global Positioning System (GPS) display scales (single and dual scale). The single scale GPS resembles regular GPS and shows a map of the highlighted path but the dual-scale GPS displays both detailed and contextual information. It was found that the dual-scale GPS was better than the single-scale in finding the destination point, via creating spatial awareness and a cognitive map.

Even though GPS is helpful in many aspects, it is also a source of distraction for the drivers. Manual data entry, such as, destination spot or checking the device at certain intervals can direct drivers' attention away from the road. Metz, Schoch, Just, and Kuhn (2014) recorded naturalistic driving data for 3 months. Drivers used both an integrated navigation device and a nomadic device within the first two months and during the last mouth no navigation support was used. Drivers adapted their driving while engaging in these systems by lowering their speeds, leaving larger safety margins, and choosing safe situations to interact with the navigation device. In the end, the number of risky driving situations did not increase due to navigation system use. This shows that drivers sensed an increment in accident risk and drove safer to compensate (Metz et al., 2014). Schömig, Metz, and Krüger (2011) further tested the drivers in engaging in secondary tasks in a situation-aware way. Drivers adapted their primary and secondary task performance based on the safety evaluation of the road environment. They rejected or postponed the secondary task in highly demanding traffic conditions (Schömig et al., 2011).

Navigation systems interfere with driving because both tasks demand visual attention. Therefore, studies utilizing other visually demanding tasks may provide valuable information on the negative effects of navigation systems. Lee, Lee, and Boyle (2007) conducted a study to investigate the effects of mental workload on visual attention while driving. They found that under cognitive workload, drivers performed much worse in the change detection task due to periodic blanking and looking at outside of the road. A large number of visual distractors manifest themselves during driving, such as warning signals or roadside advertisements. Drivers can also distract themselves voluntarily, by making a phone call, sending or reading a text-message, switching on the radio, or entering data in to the navigation system (Schömig & Metz, 2013). Drivers who hold the belief that they are skilled drivers may choose to engage in secondary tasks whilst driving, due to overestimation of abilities and underestimation of possible risks.

Text messaging during the ride deteriorates driving more than talking on the phone. Drews, Yazdani, Godfrey, Cooper, and Strayer (2009) found that drivers reacted to the onset of braking lights of the vehicle ahead slower, had worse the lateral control, and engaged in more accidents when they were reading or sending text-messages. He, Chaparro, Wu, Crandall, & Ellis (2015) further demonstrated that typing phone messages increased the standard deviation of lane position.

Tractinsky, Ram, and Shinar (2013) showed that drivers were more likely to answer incoming phone calls rather than initiating a call by dialing. This can be an indication of the perceived risk of looking at somewhere other than the road as accepting an incoming call only requires one button push while making the call can be more complicated. Lane positioning deteriorated in both manual and vocal entry of a text message to a phone (He, Choi, McCarley, Chaparro, & Wang, 2015). Knapper, Hagenzieker, and Brookhuis (2015) demonstrated that lane maintenance was affected negatively by visual-manual secondary tasks such as texting and entering the destination point into the GPS. Thapa, Codjoe, Ishak, and McCarter (2015) investigated driving performance both during and after taking on a cell phone and texting. Having conversation on a cell phone did not have a significant effect on lateral and longitudinal control for neither during and nor after the task. However, sending a text message had a significant negative effect on driving during the task.

Besides sending messages, in-vehicle systems can also break drivers' concentration. When drivers direct their attention to inside of the vehicle by the visual secondary task, they could not readjust their visual scanning and performed worse in detecting potential threats in the road scene even when they look back at outside of the vehicle (Borowsky et al., 2015). It was found that visual workload significantly affects the speed preferences and standard deviation of lane position. Drivers deviated from the central lane more when they were doing the visual secondary task (Kircher & Ahlstrom, 2012). Grane and Bengtson (2013) observed that engaging in a visual task while driving through the simulated traffic environment caused mistakenly crossed lanes. Roadway scanning techniques also differed when drivers did an additional visual task, in that, they took longer glances at the roadway and scanned a larger zone (Metz, Schömig, & Krüger, 2011). Caird, Johnston, Willness, Asbridge, and Steel (2014) review 28 studies investigating the effects of reading and writing text messages on driving performance. Authors concluded that reading messages does not affect different aspects of driving including lane keeping as much as the writing and the reading-writing conditions.

Kaber, Liang, Zhang, Rogers, and Gangakhedkar (2012) investigated the effects of visual, cognitive, and visual-cognitive secondary tasks on different levels of vehicle controlling that are operational and tactical. Michon (1985) argued that driving task consisted of 3 control levels as operational, tactical, and strategic. In the operational level, drivers react to the traffic situations without conscious processing such as sudden braking, reactive control of the steering wheel. In the tactical control level, drivers operate their vehicle in reference to the elements of the road like adjusting speed based on the leading vehicle. Strategic control level includes more time demanding processes like making route plans. First two levels are more critical as they determine the safeness of the drive. Wickens (2002) established multiple resource theory that explains the distractive effects of secondary tasks on driving if they are competing for the same cognitive sources. Attending to ocular data coming from the traffic environment is an important factor in driving. Further, central processing is also necessary to understand the roadway, anticipate the forthcoming road conditions, and taking decisions. Visual and auditory secondary tasks can affect the drivers' performance in different ways. While the visual task diverts attention away from the road, auditory task clashes with driving for central processing resources. Kaber et al. (2012) explored that visual secondary task have an impact on operational level due to taking glances away from the roadway but the auditory task interferes with the tactical level by handicapping the comprehension of the traffic conditions.

In another study with experienced taxi drivers, it was found that in case of an unexpected event, compared to the only-driving condition, in the driving-navigation searching condition variability in lateral positioning increased. Moreover, brake time also took longer when drivers interacted with the GPS (Kim, Min, Lim, & Chung, 2013). Rodrick, Bhise, and Jothi,(2013) studied drivers from different age groups and found that secondary tasks demanding visual attention and manual operation led to poorer driving performance compared to memory and auditory tasks. Moreover, older drivers (>55 years) performed the worst among all the other age groups. Lastly, visual tasks were found to be deteriorating driving performance more than cognitive tasks in terms of hazard detection and lateral control of the vehicle (Liang & Lee, 2010).

In short, there is an effect of auditory and visuo-spatial secondary tasks on driving performance but the direction of the relationship between driving and workload task can depend on the experience level in the main task and environmental conditions. Medeiros-Ward et al. (2014) found improvement in lane keeping performance under predictable road conditions when the driver were mentally loaded. Since driving is a complex task, control processes behind it can determine the impact of engaging in secondary task on driving.

1.3.Hierarchical Control Theory

Gaining enough experience on a task changes the control processes behind the performance. During the learning phase, a higher level of cognitive control that runs by explicit knowledge is required to perform a complex behavior. After becoming skillful at the task, a lower level of control shoulders the work of the higher level and at lower levels, there is an operation of implicit knowledge (Shaffer, 1976). Pianists employ the processing of two levels of cognitive control. Lower level monitors the finger movements and higher levels focuses on the melody and notes being played (Shaffer, 1976).To give an example in the context of driving, novice drivers focus more on how to drive and dynamics of the car. However, expertise makes the driving more automatized. Experienced car drivers can reach their destination without having a proper memory about the journey. Fisk and Schneider (1984) found support for the idea that well-learned skills becomes automatized and need for attending every aspect of the task diminishes. This leads to a blurred memory of the performance. Experts' performance becomes encapsulated and no conscious or higher level of involvement is needed. For experts, driving is generally more goal-directed like arriving the target location.

While the performance of experts are based on procedural knowledge, beginners of a task rely more on declarative knowledge. In the sample of golf players, it was shown that while doing two tasks simultaneously, expert players' performances were similar to their single-task performance and better than the performances of the beginner golfers. Furthermore, experts had a good recognition about the elements of the secondary task whereas their memory about the primary task was poor. When the mechanics of their skill were disrupted, they remembered better details of the primary task while performed worse in the dual-task condition and also had weaker recognition memory of the secondary task (Beilock, Wierenga, & Carr, 2002).

Hierarchical control of complex skilled behavior is explained by the usage of different metaphors. Logan and Crump (2009) used the term of control loops with reference to higher and lower levels of processing. The outer loop is under attentional control and is a more active process. On the other side, the inner loop is more automatic and outside of the conscious processing, and it includes procedural knowledge structures (Beilock, Carr, MacMahon, & Starkes, 2002). The inner loop and the outer loop are influenced from different factors generally, as their goals are different. While the inner loop deals with immediate goals, the outer loop makes sure that broader aims are reached (Logan & Crump, 2011). The outer loop does not keep track of the things processed by the inner loop until that becomes necessary. To accomplish a successful task performance, the outer loop necessitates attention but the inner loop suffers when the performer attends to its processing. Studies showed that focusing on a task deteriorates the performance of the experts. Experienced typists performed worse when they were asked to focus on individual key strokes (Logan & Crump, 2009; Tapp and Logan, 2011). When the outer loop needs to control the outputs of the inner loop, it decelerates the cycle time of the inner loop. This slowing can be due to the fragmentization of the expertized skill caused by directing attention to it. After this, each small unit processes separately like in the early phases of learning and this gives a cause for slowdown of the performance (Masters, 1992). Both control loops also use different feedbacks to check on their processing. For instance, in the case of skilled typewriting, the inner loop requires the sensation of the keyboard to place the fingers correctly on the keystrokes while the outer loop demands to see what has been written on the computer screen to be positive about they were typed accurately (Logan & Crump, 2011).

Skilled tasks like driving can be done under the control of the inner loop. The outer loop only monitors processing of the inner loop under normal conditions but when the performer becomes conscious about the task, more errors are done and operation slows down (Logan & Crump, 2009). In a predictable environment, while paying attention to the behavior, complex skills might be interrupted. On the other hand, deterioration in the performance can also be triggered by unpredictable conditions. Experts need an unchanging, foreseeable environment to perform the automatized task with the processing of the inner loop. When the environmental conditions transform into unpredictable, the outer loop is required to accomplish successful performance.

In the driving context, unpredictable traffic environment can force the inner loop delegate its job to the outer loop (Cooper et al., 2013). He, McCarley, & Kramer, (2014) found that under cognitive workload, drivers displayed of better lane maintenance. Notion behind this outcome is that demands of the secondary task makes the processing of inner loop undisturbed as no extra attention allocated to the primary task. Medeiros-Ward et al. (2014) supported the Hierarchical Control Theory (HCT) further by manipulating the predictability of the traffic environment by wind gusts and cognitive workload of the drivers. In predictable road conditions, presence of additional task improved the lane keeping performance. In contrary, unpredictability caused worse lane maintenance while engaging in a secondary task. When the environmental conditions evolve into unpredictable and inconsistent, outer loop takes over the job that inner loop can handle automatically before so the variability in lane position increased when the unpredictability sprang up.

The task to create mental workload used by Medeiros-Ward et al. (2014) was a delayed recall digit n-back task developed by Mehler, Deimer, & Dusek (2011). Since the n-back task includes both auditory input and output it can be considered as a surrogate for hands-free cell phones that are used often by drivers when the car is on the move.

1.4.Competing Resources

In the present study, two types of secondary tasks were used which are auditory and visuo spatial n-back tasks. These tasks are carried out simultaneously while driving the simulated vehicle. It was found that increased cognitive workload that coming from an auditory task (n-back) can enhance lane maintenance performance in the predictable road environment (Medeiros-Ward et al, 2014). However, it is also known that when two tasks that tap under independent slave systems of the working memory model, are performed simultaneously, it can be as productive as performing them individually. If dual task requires the use of the same subsystem, then the performance deteriorates compared to do them separately (Baddeley, 1992).

The research question underlying the current study arises from this theoretical knowledge. Drivers must be able to take the necessary actions in the context of dynamic road environment that they pass through. Driving task requires scanning of the visual environment and same demand comes from a visuo-spatial secondary task such as interacting with navigation system. Taking a glance at a navigation device while the car is in motion can deteriorate driver's performance as two tasks work under the visuospatial sketchpad. Auditory tasks like talking on a phone require the processing of phonological loop. During a phone conversation, drivers can still keep their eyes on the roadway so auditory task may not interfere the driving as much as the visual task.

Treisman and Davis also supported the notion that if two tasks are visual, performance gets worse compared to having a set of tasks consisting of one visual and one auditory task (as cited in Wickens, 2002). In the context of driving, Parkes and Coleman found that drivers performed more successfully when they were listening the instructions than when only reading the same instructions (as cited in Wickens, 2002). The multiple resource theory established by Wickens, offers four categorical dimensions, which are processing stages, perceptual modalities, visual channels, and processing codes and all dimensions are dichotomous. When every other aspect of the two tasks is kept equal, the determining factor for a successful performance depends on the sources that the two tasks demand. If two tasks require the same dimension, the interference between them increases (Wickens, 2002).

Auditory and visuo-spatial n-back tasks demands the processing of working memory. However, while auditory n-back includes auditory perceptual modality for the input, and verbal processing code for the output, the visuo-spatial n-back task comprises of visual perceptual input modality that is also required by driving, verbal processing codes for the output. In both tasks, participants respond vocally thus the outputs are similar. Separation point of the n-back tasks is the input modality. Visuo-spatial n-back task and driving demands from the same sources more than the auditory n-back task. Hence, driving will impair the visuo-spatial n-back performance or be impaired by the visuo-spatial n-back task.

Direction of the relationship between workload and lane keeping performance may be determined by the instruments used in previous studies. In the presence of a visuo-spatial secondary tasks lane maintenance can get worse in both predictable and unpredictable road conditions.

1.5.Perceived Skills

Drivers' beliefs about their driving abilities can reflect on their driving performance. If they look upon themselves as skilled drivers, they can engage in a secondary task while driving by thinking that they can handle it or minimizing the risk posed by that task. Self-evaluations about driving performance include both perceptual-motor skills and safety skills such as obeying traffic rules and avoiding risks.

Lajunen, Corry, Summala, and Hartley (1998) found that perceptual motor abilities predicted number of traffic penalties, while safety skills predicted speeding, number of road accidents and penalties. Sümer and Özkan (2002) demonstrated that scoring low on safety skills shows an inclination for dangerous driving. Drivers who reported to be low in safety skills make more violations. Safety skills can also be a buffer between high perceptual motor skills and unsafe driving. Drivers who see themselves as skilled but scored low on safety skills pose the highest risk for the traffic safety (Sümer, Özkan, & Lajunen, 2006). Warner, Özkan, Lajunen, and Tzamaloukas (2013) further showed that safety skills have a negative correlation with traffic accidents.

Sanbonmatsu et al. (2013) showed that drivers who were the most incompetents in multitasking reported that they converse on their phones while driving. Previous studies showed that drivers adapted their drive while talking on a phone or engaging in a navigation device (Metz et al., 2014; Metz et al., 2015). Knowing their limits can make the drivers compensate the negative effects of engaging in a secondary task by adapting their ride.

Metacognition of the driving abilities is just important as driving itself. Since driving is a self-paced task, drivers having high perceptual motor skills may believe that they can do two tasks equally good and this can project itself into the experiment by not sacrificing the secondary task performance for the primary task. Drivers with high safety skills score may choose not to distract themselves with a secondary task whilst driving and they can give priority to driving rather than n-back task during the experiment.

1.6.Purpose of the Study

The present study addresses the issue of distracted driving and aims to investigate the effects of auditory and visuo-spatial secondary tasks on lane positioning in predictable and unpredictable road conditions. While doing a workload task at the wheel deteriorates major aspects of driving, some performance measures such as variability in lane keeping can show different outcomes based on the environmental conditions. Apart from the environmental predictability, type of the task creating cognitive workload can also account for ups and downs of lane maintenance performance. In this study, auditory secondary task will simulate hands-free phone and visuo-spatial secondary task will be the surrogate of in-vehicle navigation device since the drivers generally spend their time in the traffic by engaging in one of these tasks. It is important to see to what extent hands-free phones and navigation devices are innocent. Outcomes of the study may be guiding in imposing necessary sanctions to improve road safety. The present study also takes drivers' perceived driving and safety skills into account with the purpose of explore their effects on lane keeping performance under different conditions.

1.7.Significance of the Study

The general structure of the study is built on the Hierarchical Control Theory (HCT) (Medeiros-Ward et al, 2014). The study will contribute to the literature in testing the HCT with different types of secondary task to take the understanding of the theory a step further. Conceptual knowledge gained by the current study may be applied in practice. Further, by asking drivers self-evaluations about their driving ability, the present study will also show the relationship between perceived skills and actual driving performance.

Human and machine interaction can be different from expectations. What is thought to be distractive may improve the human performance while what is thought to be facilitating may be distractive and damaging. Traffic safety cannot be gambled on by taking things for granted. Due to the complexity of human behavior, after effects of the technological systems should be studied to take proper actions in the latter stages such as establishment of traffic rules, enforcement of these rules, or raising public awareness. The current study intends to investigate small part of the human-machine interaction.

1.8.Hypothesis

For the auditory secondary task condition;

1. In the predictable road environment, the load condition will lead to less variability in lane position compared to the no-load condition.
2. In the unpredictable road environment, the load condition will lead to more variability in lane position compared to the no-load condition.

For the visuo-spatial secondary task condition;

3. In the predictable road environment, the load condition will lead to more variability in lane position compared to the no-load condition.
4. In the unpredictable road environment, the load condition will lead to more variability in lane position compared to the no-load condition.

CHAPTER II

METHOD

2.1. Participants

Drivers were informed of the study via Department of Psychology METU Research Sign-Up System and social networking websites. Participants were drivers who meet the criteria of holding a driver's license for at least 3 years and having driven at least 3000 km the previous year.

In total, 66 (52 males, 14 females) drivers participated in the experiment. Their ages were between 19 and 32 years old ($M = 22.74$ *years*, $SD = 2.28$). Only 15 participants reported that they had a problem in their vision but corrected to normal vision by either using glasses or contact lenses. Participants did not report any hearing problems. They also reported getting enough amount of sleep the night before the experiment ($M = 6.96$, $SD = 1.52$). All participants had a valid driving license ($M = 4.07$ *years*, $SD = 2.17$) and stated their total mileage and mileage of the previous year ($M_{total} = 32477.47$, $SD = 54897.03$; $M_{lastyear} = 10{,}007.20$, $SD = 12932.48$). Participants who were taken a course from the Psychology Department gained an extra credit in return for their participation, but the participation of the drivers gathered via social networking website announcements were purely based on voluntariness. Number of the participants in auditory group and visuo-spatial group were equal (For the Auditory Group; $M_{age} = 22.36$, $SD = 1.98$, $N_{male} = 25$, $N_{female} = 8$; For the Visuo-spatial Group $M_{age} = 23.12$, $SD = 2.53$, $N_{male} = 27$, $N_{female} = 6$).

2.2. Materials

2.2.1 Demographic Information

This section includes questions and items that were related to drivers' demographic information and variables that possibly could have an effect on the data. Besides routine questions like age and gender, the form included items that were about subjects' sleep time the night before the experiment and whether they had any trouble in sight or hearing. Rest of the list centered upon driving such as since when they had a drivers' license, total mileage they have travelled up to now, mileage of the last year, and what kind of vehicle they most frequently drive. In view of the fact that memories of accidents and traffic tickets fade away after some time, subjects were asked to report all the road accidents they had and the traffic tickets they were issued in the last three years. Lastly, their speed preferences and overtaking frequencies were asked to learn more about their driving styles.

2.2.2 Driver Skill Inventory (DSI)

The Driver Skill Inventory (DSI) is a self-reported scale that aims to measure drivers' perceptual motor abilities and safety skills (Lajunen & Summala, 1995). In the study, the Turkish Adaptation of DSI was used (Lajunen & Ozkan, 2004). The inventory consists of 20 items and drivers rate their skills with 5-point scales (very weak = 0 to very strong = 5). The scale consists of two subscales that are the perceptual motor skills subscale and the safety skills subscale. In the Turkish sample, perceptual motor skills factor includes 13 items and the safety skills includes 8 (there was a cross loading for one item which was "adjusting travelling speed based on conditions") items and both have good internal consistency scores, Cronbach's alpha values of .88 and .76 respectively.

2.2.3. STISIM Drive

Driving simulator used in the study was Stisim Drive M100W (STISIM Drive® Model 100 Wide Field-of-View Complete System) with the software of STISIM DRIVE-M100W-ASPT. The computer model the simulation program had been loaded was DELL Optiplex 980 and the driving scenario was displayed via 22'' LCD monitor.

During the study, gas and brake pedals were disused to eliminate any differences caused by speed fluctuations. Thus, drivers controlled their vehicle's position by Logitech G27 Racing Wheel. Driving scenario is the summation of 12 trials. Each trial took 100 seconds and total scenario took 20 minutes to complete. In configuration, the frame rate was calibrated to 60 Hz and screen resolution was selected as 1280 by 1024. A one-lane road with no dashed lines in the middle was the path to drive. The road was straight with no traffic flow. The width of the lane was 10 feet and width of the vehicle was 5 feet. The roadway and ground were black, sky was blue, and two white dashed lines marked off the road. Figure 1 demonstrates a snapshot of the driving scenario. There were no visual stimuli except lines that were indicatives of the road to be able to only see the pure effect of the experimental variables on lane maintenance. A single monitor was used to display the roadway as side screens were showing only black surrounding of the road. Participants had control over steering only and all crashes were ignored. Speed of the vehicle was set at 50 feet/second. Sound effects were deactivated not to interfere with the N-back task.

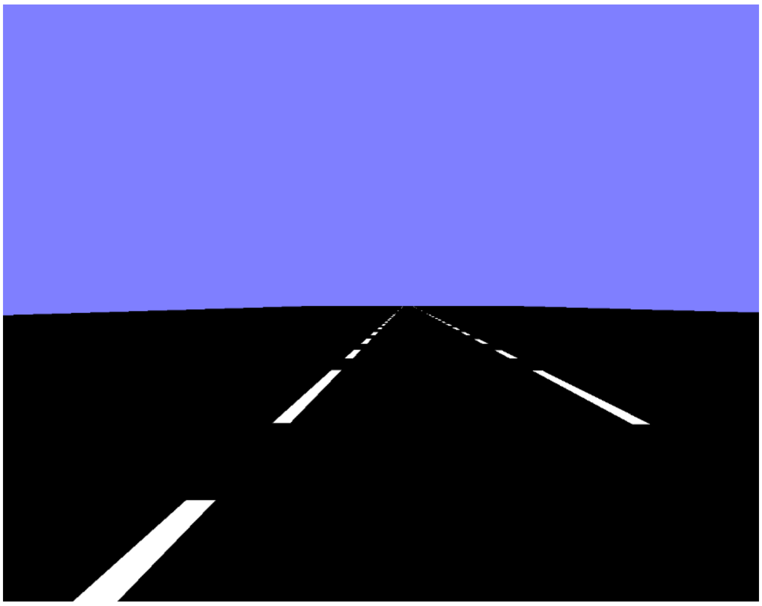


Figure 1. Driving Scenario

Low and high entropy conditions were written in separate wind gust files. In the low entropy condition, there was one sine wave with 10 peaks that lasted for 100 seconds and its amplitude was 10. In the high entropy condition, final wave that also proceed for 100 seconds was the sum of 5 separate sine waves. Each of the sine waves had the amplitude of 10 but their periods differed to create unpredictability. Sine waves had 2, 5, 10, 25, and 50 peaks respectively. The scenario had 4 main parts and each of these parts consisted of 3 trials. At the beginning of each trial, the vehicle stopped for 5 seconds for the participants to realize a new trial was about to begin. At the end of 3 trials, the vehicle stopped again but this time the restarting process was under the control of the experimenter. Within that period of time the experimenter informed the driver about the progression of the experiment and whether they would do the N-back task or drive only. At the beginning of each trial, the vehicle positioned in the middle of the road automatically. Participants were required to maintain their position, despite the wind, in the center of the road by taking 2 sidetracks as reference.

Within-subjects were randomized via Latin square design. Four scenarios changing in the order of entropy and timing of the secondary task were prepared.

2.2.4. Auditory N-Back Task

The task to create mental workload was the delayed recall digit n-back task developed by Mehler, Deimer, & Dusek (2011). The task was specifically designed for simulated driving experiments and on-road driving studies. Training instructions was translated into Turkish and extra lists consisting of 10 random single digits were added to make sure that participants gave the correct response at least 80% for each list until they fulfilled this condition for two consecutive lists. Only the 2-back condition, in which participants are required to repeat out loud the number that was read two numbers before, was used in this study.

The N-back experiments were performed via a small laptop, Acer Aspire One ZG5 with the screen size of 8.9 inch. The Auditory 2-back task was prepared in E-Prime 2.0. This task included 6 trials and each trial took 90 seconds, excluding the instructions and preparatory sounds. The experiment initiated with an instruction scene, and next, synchronously with a new driving trial, the experimenter started the 2-back task. A sound, phone ringing (3000 ms), was played at the beginning of each trail and at the end of the each list a busy tone (4000 ms) was played. At each trial, 30 stimuli randomly selected by the program were presented. In the course of this, the small laptop computer was placed 10 centimeters right side of the simulator's screen showed a black screen with the intent of eliminating any possible distraction. Digits (0-9) were played from a female voice. Sound files of each digit lasted for one second. Stimulus duration and response time was 3000 ms. After hearing the last digit, participants were required to repeat the digit read two digits before within 2 seconds. Participants heard the numbers through the experiment by Gigaware USB stereo headset and their responses were recorded to be coded afterwards by the microphone attached to the headset.

2.2.5 Visuo-Spatial N-Back Task:

One method to measure visuo-spatial working memory is the 2-back task in which continuous updating and manipulation of ongoing information within memory. Visuo-spatial N-back paradigm has been used mostly in neuroscience studies up till now and based on the research design, the structure of the n-back task can differ from one study to another. For instance, Carlson et al. (1998) used visuospatial n-back task in their study to work on brain activation. In this study, 0-back, 1-back, and 2-back paradigms were used. A white square appeared on one of the 8 locations on the monitor screen, and in the middle of the screen there was a fixation sign (X). In the 2-back condition, participants were supposed to click on the left button of the mouse if the white square was in the same spot that appeared two trials before and click on the right button if it was not. As they used functional magnetic resonance imagining technique to track activated areas in the brain, they kept the inter-stimulus interval (ISI) relatively long (3125 ms) and stimulus duration was 100 ms. Casey et al. (1998) also used a spatial n-back task which was similar in logic but differed in details. In this study, a dot was displayed in one of the four boxes placed side by side on the screen, stayed there for 500 ms, and lost for 1500 ms (ISI). Here, subjects were told to press the corresponding button to show the location of the dot two-back. The target object, the duration of stimuli, and the numbers of locations displayed on the screen varied across different studies (Hautzetl et al., 2002; Jaeggi, Buschkuehl, Jonides, & Shah, 2011; Kawagoe & Sekiyama, 2014; Lejbak, Crossley; & Vrbancic, 2011; Martinkauppi, Rama, Aronen, Korvenoja, & Carolson, 2000; Nagel, Herting, Maxwell, Bruno, & Fair, 2013; Nystrom et al., 2000; Owen et al., 1999; Smith, Jonides, & Koeppe, 1996). Therefore, in the current experiment, the task was adapted again to ensure a better match for the research question.

The difference of the present study was using the visuo-spatial n-back task as a secondary task. Other studies cited above used the n-back as the primary task, and what is more, in those studies participants responded via button pressing. In the current study, to observe the pure effects of workload and environmental predictability on the lane keeping performance, participants did not respond by a keyboard and kept their hands on the wheel and they verbally responded by simply saying yes or no. Lastly, unlike the previous studies, a fixation point was not included in the experiments as drivers had to keep their eye on the roadway at every possible opportunity.

The computer that displayed the visuo-spatial 2-back task was Acer Aspire One ZG5 with 8.9 inch sized screen. This experiment was also designed with E-Prime 2.0. The visuo-spatial 2-back task consisted of 6 trials and each trial included 30 images. A square divided into four small squares was presented. At every trial, one of the four small squares went black from grey randomly and between each stimulus the empty grid was displayed. Stimulus duration was 2000 ms and inter-stimulus interval was 1000 ms. In the same way as the auditory 2-back task, each trial started with a phone ringing sound (3000 ms) and ended with a busy tone (4000 ms) (see Fig. 2). Subjects were asked to say yes when the last location went black was the same as the one that went black 2 trials before and say no when it was different. Their responses were recorded by the microphone attached to Gigaware USB stereo headset.

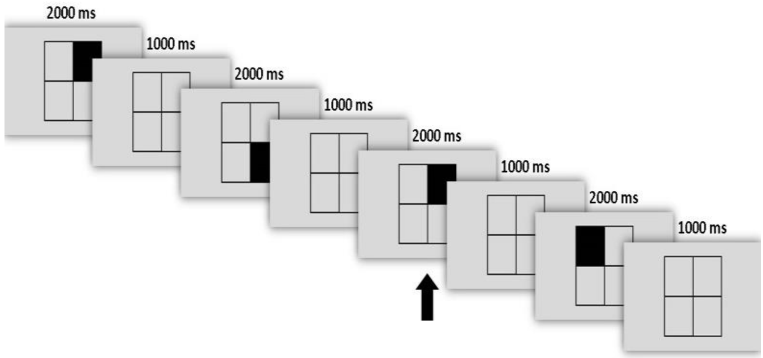


Figure 2. Illustration of four trials in the visuo-spatial 2-back task.

2.3. Design

The design of the experiment was 2 x 2 x 2 mixed design. The independent variables were cognitive load (No-load vs. Load), entropy (Low Entropy vs. High Entropy) and type of the secondary task (Auditory vs. Visuo-spatial). Type of the secondary task was the between measure. The dependent variable was the variability in lane position measured by the root mean square.

2.4. Procedure

Experiments were conducted at the Human Factor Lab at Middle East Technical University. Participants were greeted by the experimenter at the lab door and asked to sit down at the table where they filled in the required forms, and were given instructions about the tasks they were about to perform. Before starting the experiment, participants read and signed the informed consent and put their name and signature on the sign-in sheet. Subsequently, demographic information form and DSI were filled up. After this phase, the group that participants were assigned determined the rest of the experiment. Figure 3 shows the experimental setting.

Figure 3. Experimental setting

Participants in the auditory n-back condition were given an instruction paper for the auditory 2-back task. In this paper, there were clear directions for the task, and practice lists and correct responses of those lists. The same directive was also in front of the experimenter to keep up with the participant and to give extra information when needed. Next, the experimenter read new lists consisting of 10 random single digits that the other party could not see to evaluate whether the participant was able to fulfill the criterion of giving correct responses at least 80% for two consecutive lists. Next step was to practice the auditory 2-back task in the computer to accustom participants to real experiment. 30 digits were listened and responses were recorded by the microphone.

Participants in the visuo-spatial n-back condition received an instruction about the visuo-spatial 2-back task. The operation of the task was explained in detail with verbal instructions and visual examples. When participants were clear about how to do the task, they practiced the computerized version of the task. Here, the experimenter had the checklist to note every answer the respondent gave. If the participants responded correctly, at least 80 percent of time in two consecutive lists they went forward with the experiment. After, participants practiced another visuo-spatial 2-back task in which 30 images were presented and the experimenter did not interrupt the participants.

Both groups completed a warm up scenario that took 100 seconds in the driving simulator to get used to the scenario and the calibration of the steering wheel. After this step, they drove the warm-up scenario and did the secondary task simultaneously to be fully prepared for the main experiment. The driving scenario lasted 100 seconds and first half showed high entropy and second half showed low entropy. Depending upon their group participants were assigned to either the auditory 2-back or the visuo-spatial 2-back, as the secondary task.

The experiment took 20 minutes, excluding the practice. Four groups experienced this duration differently. Order of the within variables in 4 groups that randomized via Latin square design was showed in the Table 1.

Table 1

Ordering of the within variables in 4 groups

Trials	Group 1	Group 2	Group 3	Group 4
1-2-3	lowent-noload	lowent-load	highent-noload	highent-load
4-5-6	highent-noload	highent-load	lowent-noload	lowent-load
7-8-9	lowent-load	lowent-noload	highent-load	highent-noload
10-11-12	highent-load	highent-noload	lowent-load	lowent-noload

In the no load condition, participants only drove the simulated vehicle while in the load condition, they did the secondary task and drove simultaneously. Driving environment was predictable in the low entropy condition and unpredictable in the high entropy condition. At the end of the experiment, participants were received an information form about the study and thanked warmly for their contributions.

CHAPTER III

RESULTS

3.1. Auditory and Visuo-Spatial Groups

Prior to the analysis, lane position data was split up into 12 groups, as there were 12 trials in the driving scenario. Variability in lane position was measured by the root mean square as in the data set, drivers' lateral position with respect to the road dividing line were given in both negative (left side of the line) and positive (right side of the line) numbers.

Root mean squares for all the trials were calculated by taking the square root of the average of the squares of the sample and later, means for the four experimental conditions (low entropy-no load, low entropy-load, high entropy-no load, high entropy-load) were derived from these calculations.

Mixed-design 2 x 2 x 2 ANOVA was conducted for lane position variability, with type of the secondary task (auditory vs. visuo-spatial) as a between-subjects factor, and entropy (low entropy vs. high entropy) and load (no-load vs. load) as within-subject factors.

The alpha level was set at .05 and effect size was indicated by partial eta square. There was a significant main effect of entropy, $F(1, 64) = 85.08$, $MSE = .20$, $p < .001$, $\eta_p^2 = .57$. On the other hand, neither the main effect of load, $F(1, 64) = 1.36$, $MSE = .125$, $p = .24$, $\eta_p^2 = .02$, nor the two-way interaction between entropy and type of the secondary task, $F(1, 64) = 2.89$, $p = .09$, $\eta_p^2 = .04$, were statistically significant. The two-way interaction between mental workload and type of the secondary task was significant, $F(1, 64) = 8.79$, $p = .004$, $\eta_p^2 = .12$. There was also a significant interaction between entropy and load, $F(1, 64) = 33.15$, $MSE = .03$, $p < .001$, $\eta_p^2 = .34$. The three-way interaction between entropy, load, and type of the secondary task was not significant, $F(1, 64) = .19$, $p = .66$, $\eta_p^2 = .003$. Critically, the effect of type of the secondary task on lane position variability was not significant, $F(1, 64) = 2.67$, $MSE = 1.12$, $p = .10$, $\eta_p^2 = .04$.

Post hoc comparisons using t-test with Bonferroni correction indicated that in the low entropy condition, when there was no load, the difference in lane position variability between auditory and visuo-spatial conditions was not significant, $t(64) = 2.43$, $p = .018$. When there was no load, variability in lane position was significantly higher in the auditory condition than the visuo-spatial condition in the high entropy condition, $t(64) = 2.86$, $p = .006$. However, when there was a load, both in the low entropy condition, $t(64) = .005$, $p = .99$, and in the high entropy condition, , $t(64) = .83$, $p = .40$, the differences in lane position variability between auditory and visuo-spatial conditions were not significant.

In the low entropy condition, variability in lane position was significantly higher in the no-load than the load condition, $t(65) = 3.88$, $p < .001$. On the other hand, in the high entropy condition, the difference in lane position variability between no-load and load conditions was not significant, $t(65) = -1.62$, $p = .10$. In the no-load condition, lane position variability was higher in the high entropy condition compared to the low entropy condition, $t(65) = -6.48$, $p < .001$. Lastly, in the load condition, lane position variability was higher in the high entropy condition compared to the low entropy condition, $t(65) = -9.67$, $p <.001$.

3.2. Auditory Group

The means and standard errors for the root mean square of lane position are represented in Figure 4. A 2 x 2 repeated-measures analysis of variance (ANOVA) was conducted for the variability in lane position, with both entropy (low entropy vs.

high entropy), and load (no-load vs. load) as within-subject factors. The alpha level was set at .05 and effect size was indicated by partial eta square. There was a significant main effect of entropy, $F(1, 32) = 47.92$, $MSE = .25$, $p < .001$, $\eta_p^2 = .60$. Lane position variability was higher in the high entropy condition ($M = 2.19$) compared to low-entropy condition ($M = 1.58$). There was a significant main effect of load, $F(1, 32) = 8.09$, $MSE = .13$, $p = .008$, $\eta_p^2 = .20$. Lane position variability was less in the load condition ($M = 1.79$) compared to no-load condition ($M = 1.97$). Additionally, the interaction between load and entropy was also significant, $F(1, 32) = 14.32$, $MSE = .03$, $p = .001$, $\eta_p^2 = .30$.

Bonferroni corrected new alpha level was set at .0125. In the low entropy condition, variability in lane position was significantly higher in the no-load than the load condition, $t(32) = 4.06$, $p < .001$. On the other hand, in the high entropy condition, the difference in lane position variability between no-load and load conditions was not significant, $t(32) = .75$, $p = .45$. In the no-load condition, lane position variability was higher in the high entropy condition compared to the low entropy condition, $t(32) = -5.25$, $p < .001$. Lastly, in the load condition, lane position variability was higher in the high entropy condition compared to the low entropy condition, $t(32) = -7.58$, $p < .01$.

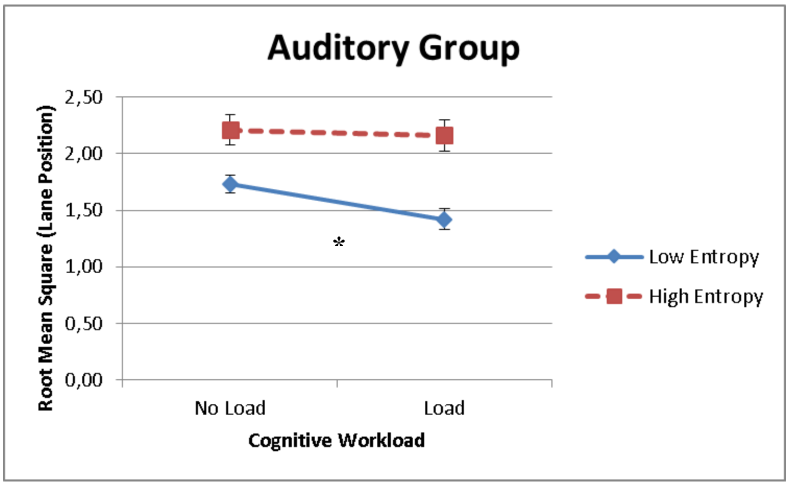


Figure 4. Interaction between entropy and load on lane position variability for the auditory condition. Error bars represent standard errors. *$p < .001$.

3.3. Visuo-Spatial Group

The means and standard errors for the root mean square of lane position are represented in Figure 5. A 2 x 2 repeated-measures analysis of variance (ANOVA) was conducted for the variability in lane position, with entropy (low entropy vs. high entropy), and load (no-load vs. load) as within-subject factors. The alpha level was set at .05 and effect size was indicated by partial eta square. Main effect of entropy was significant, $F(1, 32) = 37.50$, $MSE = .15$, $p < .001$, $\eta_p^2 = .54$. Lane position variability was higher in the high entropy condition ($M = 1.88$) compared to the low entropy condition ($M = 1.46$). The main effect of load was not statistically significant, $F(1, 32) = 1,71$, $MSE = .11$, $p = .20$, $\eta_p^2 = .05$. However, there was a significant interaction between entropy and load, $F(1, 32) = 18,96$, $MSE = .03$, $p < .001$, $\eta_p^2 = .37$.

Bonferroni corrected post hoc comparison did not reveal significant difference between the no-load and the load conditions in terms of lane position variability, in the low entropy condition, $t(32) = 1.29$, $p = .20$. However, in the high entropy condition, lane position variability was less in the no-load condition compared to the load condition, $t(32) = -2.85$, $p = .007$. In the no-load condition, lane position variability was less in the low entropy compared to the high entropy condition, $t(32) = -4.81$, $p < .001$. Finally, in the load condition, lane position variability was less in the low entropy condition compared to the high entropy, $t(32) = -6.12$, $p < .001$.

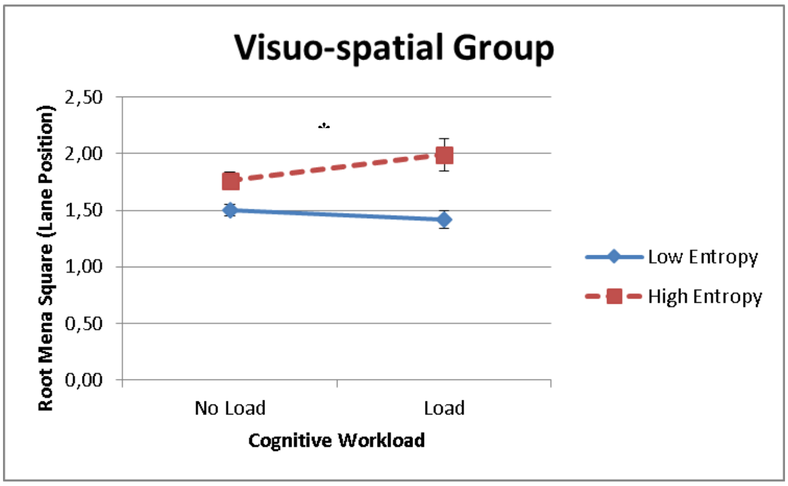


Figure 5. Interaction between entropy and load on lane position variability for the visuo-spatial condition. Error bars represent standard errors.* $p < .01$.

3.4. Secondary Task Performance

Proportion of correct responses in the 2-back tasks were calculated for the low entropy and the high entropy conditions for every participant. The means and standard errors for the accuracy in secondary tasks are represented in Figure 6.

One-way ANOVAs were conducted for the auditory group and the visuo-spatial group separately, to compare the effect of entropy (low entropy vs. high entropy) on the accuracy in the 2-back task. The alpha level was set at .05 and effect size was indicated by partial eta square. Neither in the auditory condition, $F(1, 32) = .44$, $MSE = .004$, $p = .51$, $\eta_p^2 = .01$, nor in the visuo-spatial condition, $F(1, 32) = 1.26$, $MSE = .001$, $p = .26$, $\eta_p^2 = .03$, were the effect of entropy on accuracy in the 2-back tasks significant.

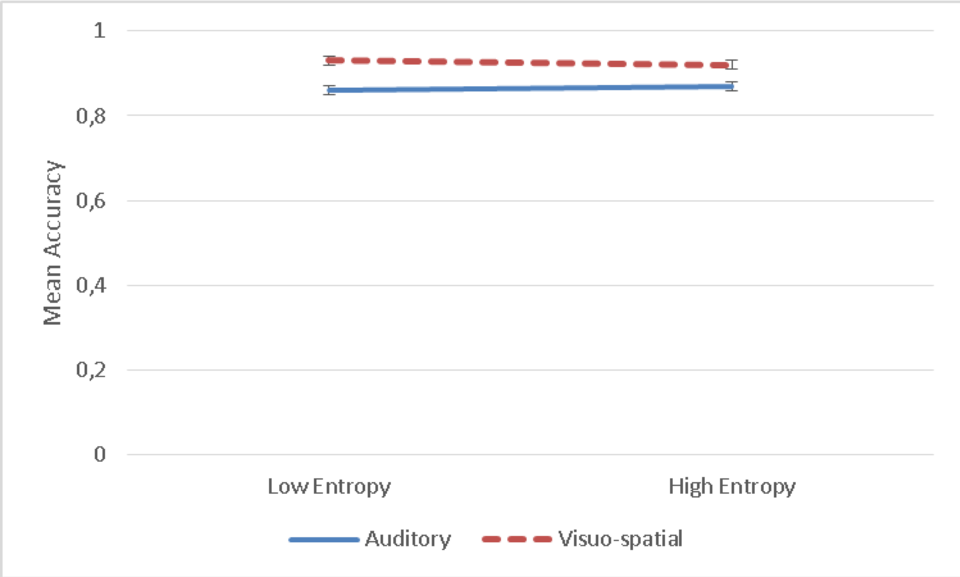


Figure 6. Mean accuracies in 2-back tasks. Error bars represent standard errors.

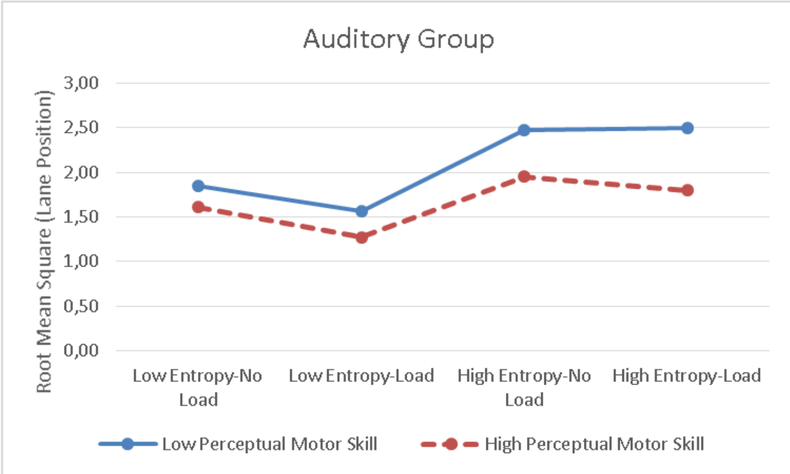
3.5. Perceptual Motor Skills and Safety Skills

Exploratory analyses were done for the subscales of the DSI. In terms of the perceptual motor skills, participants were subdivided into two as having low scores or high scores on the basis of a median split (3.88). Safety skills scores of the participants also categorized into two group as low and high by using a median split (3.63).

For the auditory group, a mixed-design 2 x 2 x 2 x 2 ANOVA was conducted for lane position variability, with perceptual motor skills (low vs. high) and safety skills (low vs. high) as between-subjects factors, and entropy (low entropy vs. high entropy) and load (no-load vs. load) as within-subject factors.

The means for the root mean square of lane position is represented in Figure 7. The alpha level was set at .05 and effect size was indicated by partial eta square. There was a significant main effect of entropy, $F(1, 29) = 45.20$, $MSE = .24$, $p <.001$, $\eta_p^2 = .60$. The two-way interaction between entropy and perceptual motor skills was not significant, $F(1, 29) = 3.55$, $MSE = .24$, $p =.06$, $\eta_p^2 = .10$. The two-way interaction between entropy and safety skills was also not statistically significant, $F(1, 29) =$

.001, *MSE* = .24, *p* =.97, η_p^2 = .00. Additionally, three-way interaction between entropy, perceptual motor skills, and safety skills was not significant, *F*(1, 29) = .07, *MSE* = .24, *p* =.78, η_p^2 = .003. There was a significant main effect of load, *F*(1, 29) = 5.70, *MSE* = .13, *p* = 02, η_p^2 = .16. However, neither the interaction between load and perceptual motor skills, *F*(1, 29) = .24, *MSE* = .13, *p* = .62, η_p^2 = .008, nor the interaction between load and safety skills, *F*(1, 29) = 1.05, *MSE* = .13, *p* = .31, η_p^2 = .03, were statistically significant. The three-way interaction between load, perceptual motor skills, and safety skills was not significant, *F*(1, 29) = .62, *MSE* = .13, *p* = .43, η_p^2 = .02. There was an interaction between entropy and load, *F*(1, 29) = 10.72, *MSE* = .04, *p* = .003, η_p^2 = .27. Neither the three-way interaction between entropy, load, and perceptual motor skills, *F*(1, 29) = .75, *MSE* = .04, *p* = .39, η_p^2 = .02, nor the three-way interaction between entropy, load, and safety skills, *F*(1, 29) = .05, *MSE* = .04, *p* = .81, η_p^2 = .002, were statistically significant. The four-way interaction between entropy, load, perceptual motor skills, and safety skills was not significant also, *F*(1, 29) = .39, *MSE* = .04, *p* = .53, η_p^2 = .01. Critically, the main effect of perceptual motor skills was significant, *F*(1, 29) = 4.35, *MSE* = 1.26, *p* = .04, η_p^2 = .13. However, the main effect of safety skills, *F*(1, 29) = .05, *MSE* = 1.26, *p* = .81, η_p^2 = .002, and interaction between perceptual motor skills and safety skills, *F*(1, 29) = .01, *MSE* = 1.26, *p* = .90, η_p^2 = .001 were not significant.



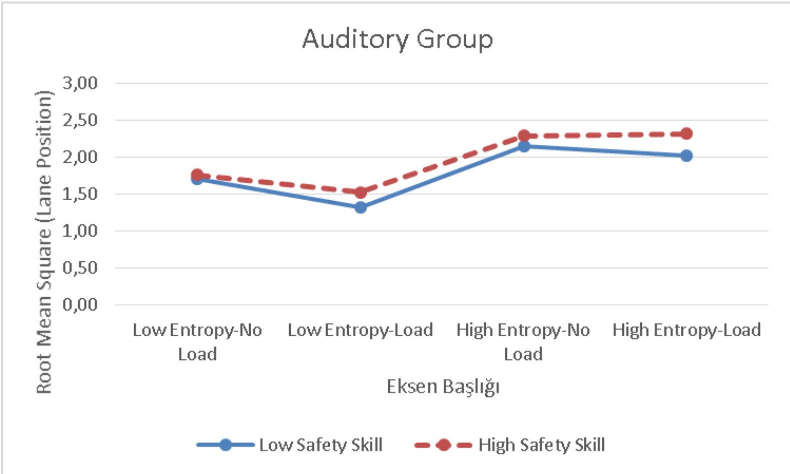


Figure 7. (Above) Interaction between entropy, load, and perceptual motor skills on lane position variability for the auditory condition. (Below) Interaction between entropy, load, and safety skills on lane position variability for the auditory condition.

For the visuo-spatial group, a mixed-design 2 x 2 x 2 x 2 ANOVA was conducted for lane position variability, with perceptual motor skills (low vs. high) and safety skills (low vs. high) as between-subjects factors, and entropy (low entropy vs. high entropy) and load (no-load vs. load) as within-subject factors. The means for the root mean square of lane position is represented in Figure 8. The alpha level was set at .05 and effect size was indicated by partial eta square.

There was a significant main effect of entropy, $F(1, 29) = 42.48$, $MSE = .13$, $p < .001$, $\eta_p^2 = .59$. While the two-way interaction between entropy and perceptual motor skills was significant, $F(1, 29) = 4.55$, $MSE = .13$, $p = .04$, $\eta_p^2 = .13$, the two-way interaction between entropy and safety skills was not statistically significant, $F(1, 29) = .05$, $MSE = .13$, $p = .82$, $\eta_p^2 = .002$. Additionally, three-way interaction between entropy, perceptual motor skills, and safety skills was not significant, $F(1, 29) = .1.24$, $MSE = .13$, $p = .27$, $\eta_p^2 = .04$. The main effect of load was not significant, $F(1, 29) = 2.42$, $MSE = .10$, $p = 13$, $\eta_p^2 = .07$. However, there was a significant interaction between load and perceptual motor skills, $F(1, 29) = 6.00$, $MSE = .10$, $p = 02$, $\eta_p^2 = .17$. Neither the two-way interaction between load, and safety skills, $F(1, 29) = 1.46$, $MSE = .10$, $p = .23$, $\eta_p^2 = .04$, nor the three-way interaction between load, perceptual motor skills and safety skills, $F(1, 29) = .32$, $MSE = .10$, $p = .57$, $\eta_p^2 = .01$, were statistically significant. The interaction between entropy and load was significant, $F(1, 29) = 16.54$, $MSE = .04$, $p < .001$, $\eta_p^2 = .36$. The three-way interaction between entropy, load, and perceptual motor skills, $F(1, 29) = .64$, $MSE = .04$, $p = .42$, $\eta_p^2 = .02$, the three-way interaction between entropy, load, and safety skills, $F(1, 29) = 1.28$, $MSE = .04$, $p = .26$, $\eta_p^2 = .04$, and the four-way interaction between entropy, load, perceptual motor skills, and safety skills, $F(1, 29) = .06$, $MSE = .04$, $p = .80$, $\eta_p^2 = .002$ were not significant. Importantly, the main effect of perceptual motor skills, $F(1, 29) = 11.80$, $MSE = .59$, $p = .002$, $\eta_p^2 = .28$, and the main effect of safety skills, $F(1, 29) = .4.42$, $MSE = 59$, $p = .04$, $\eta_p^2 = .13$ were significant. However, the interaction between perceptual motor skills and safety skills was not significant, $F(1, 29) = .32$, $MSE = .59$, $p = .57$, $\eta_p^2 = .01$.

Figure 8. (Above) Interaction between entropy, load, and perceptual motor skills on lane position variability for the visuo-spatial condition. (Below) Interaction between entropy, load, and safety skills on lane position variability for the visuo-spatial condition.

CHAPTER IV

DISCUSSION

The present study investigated the effects of auditory and visuo-spatial secondary tasks on lane maintenance in predictable and unpredictable driving conditions. Manipulating the predictability of driving was done for the purpose of testing the HCT. Skilled behaviors such as driving are performed under a hierarchical control process. The theory suggests that to perform a task successfully, the outer loop demands attention but the inner loop suffers when its processing is attended. Studies showed that focusing on a task deteriorates the performance of the experts (Logan & Crump, 2009; Tapp and Logan, 2011). In the driving context, this notion was tested by Medeiros-Ward et al. (2014). They manipulated the road predictability by adding wind gusts and the workload by an auditory delayed digit recall n-back task. In the current study, both auditory and visuo-spatial n-back tasks were used to test the HCT.

The present study showed that in the auditory condition, load decreased the variability of lane position in predictable driving environment thereby supported one part of the HCT, while in the visuo-spatial condition, there was no significant difference in lane positioning between no-load and load conditions in predictable driving environment. Furthermore, when the driving conditions turned into unpredictable, in the auditory condition, there was no worthy of note difference in lane positioning between no-load and load conditions contrary to expectation. However, in the visuo-spatial condition, load increased the lane position variability with the increment in entropy as hypothesized.

It can be inferred from these results that engaging in a visuo-spatial secondary task affects driving more than doing an auditory task. Workload caused by an auditory task can improve lane positioning in predictable driving condition but visuo-spatial task does not lead to any facilitation. This shows that driving performance does not solely based on the processing of the inner and outer loops, but it also depends on the sensory channel that the secondary task demands from.

When there was no load, both auditory and visuo-spatial groups deviated from the road more with an increase in the entropy. This shows that profiles of both groups were similar and it made more possible to see the clean effects of auditory and visuo-spatial 2-back tasks. Furthermore, in both auditory and visuo-spatial load conditions, lane position variability increased as the entropy increased.

When there was a load, both in the low entropy condition and in the high entropy condition, auditory and visuo-spatial groups did not significantly differed from each other in lane position variability. This may show that difficulty levels of both tasks were similar. Moreover, with regard to the performance in n-back tasks, in the auditory and visuo-spatial conditions, entropy did not have a significant effect on accuracy in the 2-back tasks. Participants did not compromise on secondary task performance to drive better when the road conditions changed into unpredictable. This enabled us to observe the sole effect of entropy on lane maintenance under workload not the effect of entropy on n-back performance.

A large amount the literature supported that engaging in a secondary task while driving damages the primary task's performance. Strayer et al. (2006) showed that both hands-free and regular cell phones deteriorated driving by slowing reactions, increasing the time needed to recover speed after braking, and leading to more traffic accidents. Lethonen et al. (2012) concluded that cognitive workload affected the anticipation of roadway curvature adversely by changing the roadway scanning. Haque and Washington (2014) further showed that while talking on the phone, drivers responded slower to the pedestrians coming from sidewalks to go across the road. Both younger and older drivers showed slower reactions while on the phone and it took longer to recover their speed after braking (Strayer & Drews, 2004).

Conversing on a cell phone while driving also increased violation rates of the car drivers, attentional lapses, and rate of inattentional blindness (Beede & Kass, 2006; Strayer & Drews, 2007). In the present study, the auditory n-back task aimed to simulate the hand-free cell phones. However, lane maintenance is affected differently while engaging in a cognitively auditory secondary task. Beede and Kass (2006) showed that talking on a cell phone, which is an auditory task, decreased the lane position variability. McCarley and Kramer (2014) also found that under cognitive load, drivers displayed of better lane maintenance.

Cognitive load triggered by the auditory 2-back task decreased the variability of lane position in the predictable driving environment. This result supports the HCT by showing that inner loop is enough to perform the primary task under predictable conditions and diverting attention away from the primary task by doing an additional task can improve the performance. However, in an unpredictable condition, processing of outer loop is needed to take over the job that inner loop can handle automatically before. In inconsistent road environment, attending to a secondary task deteriorates the performance. Medeiros-ward et al. (2014) found that in high entropy, there were less variability in lane position in the no-load condition compared to the load condition and supported the HCT. In present study, no significant difference was found between the no-load and the auditory load conditions for the unpredictable driving conditions. This can be explained by the dissimilar participant profiles of two studies. While the participants had their driver's licenses for 7 years in the study of Medeiros-ward et al. (2014), participants of the present study had their license for an average of 4 years. Being more expert in the driving task can polarize the differences in lane keeping between predictable and unpredictable conditions but expert drivers can also react more quickly to the abrupt changes in the traffic.

For the visuo-spatial group, it was expected to see deterioration of lane positioning in both no-load and load conditions with an increase in entropy. A number of studies showed that visually demanding tasks are more damaging than auditory tasks while driving. Drews et al. (2009) found that drivers reacted slower to the onset of braking lights of the vehicle ahead, had worsened the lane positioning, and engaged in more accidents when they were reading text-messages. Further, the damaging effect of texting was found to be more than talking on a phone whilst driving. Knapper et al. (2015) demonstrated that lane maintenance was affected negatively from visual-manual secondary tasks such as GPS. He et al. (2015) also showed that typing phone messages increased the standard deviation of lane position due to both manual operation and visual distraction. In case of an unexpected event, expert drivers showed more variability in lane position while using navigation systems than only driving (Kim et al., 2013). Results of the visuo-spatial condition of the current study bear a resemblance to these results. Unlike auditory workload, visuo-spatial workload did not facilitate the lane keeping in predictable condition and, as foreseen, affected lane keeping negatively in unpredictable condition. In the predictable driving environment, it was expected to see more variability in lane position in the load condition than the no-load condition. This hypothesis was not supported by the results. However, contrary to the HCT, lane-keeping performance did not improve either. This shows that positive effects of workload in lane maintenance depend on type of the secondary task.

It was found that directing attention to inside of the vehicle by the visual secondary task make drivers have difficulty in readjusting their visual scanning so they performed worse in detecting potential threats in the road scene even when they look back at the road (Borowsky et al., 2015). Visuo-spatial 2-back task did not improve the lane maintenance in predictable driving conditions, and deteriorated the performance in unpredictable driving conditions. Taking a glance at the visuo-spatial secondary task and not being able to adapt quickly to the roadway between two stimuli can lead to less improvement in a convenient situation and more deterioration in a complex situation.

Driving needs constant attention and scanning of the roadway. Since visual tasks demands the processing of visuo-spatial sketchpad, it collides with driving. Baddeley (1992) argued that when two tasks require the use of the same subsystem, performance deteriorates compared to do them separately. However, if two tasks that tap under independent slave systems of the working memory are performed simultaneously, performance can be as productive as doing them individually. Results showed that visuo-spatial secondary task does not improve lane maintenance unlike auditory task in a predictable driving condition. As the auditory n-back task activates phonological loop, it may not interfere with driving. 2-back tasks can also be explained in the scope of focus of attention, as limited amount of items were hold while processing new information simultaneously (McElree, 2001). If the information is in focal attention, it can be accessed more easily and quickly than less recent working memory representations so this may explain the high accuracy rates in the auditory and visuo-spatial 2-back tasks. Previous studies showed that while auditory tasks such as talking over the phone had no significant effect on lateral and longitudinal control, visual tasks had a significant negative effect (Kircher & Ahlstrom, 2012; Thapa et al., 2015). Treisman and Davis also demonstrated that if two tasks are visual, performance grows worse compared to doing one visual and one auditory task simultaneously (as cited in Wickens, 2002). Parkes and Coleman supported this notion in the driving context. Drivers showed a better performance when they were listening the instructions than when reading the instructions (as cited in Wickens, 2002). Liang and Lee (2010) further showed that visual tasks damaged driving performance more than cognitive tasks in lateral control of the vehicle. If both tasks require the processing of same dimension, interference between them arises (Wickens, 2002).

Drivers did not compromise on 2-back performances to drive better when the driving conditions changed into unpredictable. Drews et al. (2008) found that when the demand coming from the traffic increased, drivers adapted their conversation with the passenger by decreasing the complexity of the talk or postponing the conversation. Schömig e al. (2011) also showed that drivers adapted their primary and secondary task performance based on the safety evaluation of the traffic environment by rejecting or putting off the secondary task in highly demanding conditions (Schömig et al., 2011). In the current study, both auditory and visuo-spatial groups responded to the 2-back task with high accuracy and similarly in predictable and unpredictable driving conditions. For the visuo-spatial 2-back task, increment in entropy did not made the drivers focus less on the secondary task. In real traffic environment, drivers adapted their driving while engaging in a visual task by lowering the travelling speed, leaving larger safety margins and choosing safe situations to interact with the navigation device (Metz et al., 2014). It is possible that in the simulated driving, drivers may not sense a risk to take precaution by sacrificing secondary task performance.

Sanbonmatsu et al. (2013) stated that the least competent drivers reported that they talk on their cell phone whilst driving. Even though the drivers can be aware of the risks of cell-phone usage behind the wheel, they are confident in their ability to multitask so they keep on using their phones. In the present study, drivers from both auditory and visuo-spatial groups with low perceived driving skills showed the highest variability in lane position in all conditions. This result is in the different direction with Sanbonmatsu et al. (2013). Participants made realistic evaluations about their driving abilities. The controversy between two studies may root from differences in safety skills of the participants. Drivers with low perceptual motor skills can score high in safety skills to compensate their incompetence by following rules and avoiding risks. For instance, using mobile phone while driving can be more about to drivers' safety motivations. Metz et al. (2015) showed that while speaking to someone on a hands-free phone, drivers adapted their drive by decreasing their travelling speed and increasing the safety margin. This shows that drivers are aware of the fact that doing an additional task at the wheel jeopardizes traffic safety. Scores on DSI's safety skills subscale can reflect the tendency of adapting driving when necessary. Sümer et al. (2006) demonstrated that drivers scored high on perceptual motor skills but low on safety skills pose the highest risk for the traffic safety. Safety skills can play the buffer between risks of engaging in secondary task and driving. In experiment, high perceptually skilled drivers can have better lane maintenance but in real traffic, due to having confidence in their skills and low safety motivation they may engage in risky driving.

There are certain limitations of the present study that can be remedied in future studies. To understand the HCT more comprehensively, drivers in different ages and different level of experience could be included. In the study, mean age was 22.74 and majority of the participants had 4 years of experience. With this level of expertise, the distinct difference between inner loop and outer loop processing may not be seen properly. Additionally, the relationship between perceived driving skills and lane keeping may depend on participants' experience levels. In the current study, young drivers with low perceptual motor skills showed the highest variability in lane position. As the driving task become automatized through experience, the relationship between perceptual motor skills and lane maintenance may be different for expert drivers. More automatized performance may not be affected by self-evaluations of the driving skills. Forthcoming studies should have a broader sample including different levels of expertise. To see the effects of aging in the inner loop-outer loop switching, drivers from different age groups might also be included. One other limitation of the study is the background of the participants. As the sample selection was done in the Middle East Technical University, it may not represent the whole driver population. Lastly, ecological validity was also low in the current study. In future studies, unpredictable driving environment can be manipulated with road bends or pedestrians coming from nowhere. Unlike, strong wind gusts, these manipulations can be closer to the real traffic environment.

The present study shows the complexity of human performance. HCT brings explanation for the discrepancies in driving studies. While in many aspects diverting attention away from driving cause a loss in the performance, lane keeping which is an inner loop process can improve. However, the traffic is a dynamic environment and road environment is often unpredictable. Cognitive load can improve lane maintenance in predictable simulated driving scenarios but in real traffic, drivers should keep their eyes and attention on the road. Further, the study showed that the type of task triggering mind to think something else than driving is a key factor in explaining the changes in lane position. HCT may not account for lane keeping under visual workload. In designing process of in-vehicle systems, these results can be implemented by making devices that do not demand from the same working memory subsystem with driving.

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APPENDICIES

Appendix A: Driving Scenarios

Warm-Up Scenario

0,ROAD,10,3,0,0,0,0,0,.5,.5,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

-1 1.trial

0, PAUS, 5

0, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPYwarmup.PAR

0, CV, 50, 1

2498, CV, 50, 2

2499, PAUS, 5

-1 2.trial

2500, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPYwarmup.PAR

2500, CV, 50, 1

0, BSAV, 1, .016, NWARMUP, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 18, 23, 24, 26, 27, 28, 29, 30, 31, 32, 39, 41, 44, 47, 48, 50

5000, ES

Experiment Scenario - Group 1

0,ROAD,10,3,0,0,0,0,0,.5,.5,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

-1 1.trial

0, PAUS, 5

0, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

0, CV, 50, 1

4998, CV, 50, 2

4999, PAUS, 5

-1 2.trial

5000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

5000, CV, 50, 1

9998, CV, 50, 2

9999, PAUS, 5

-1 3.trial

10000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

10000, CV, 50, 1

14997, CV, 50, 2

14998, PAUS, 0

-1 4. trial

14999, PAUS, 5

15000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

15000, CV, 50, 1

19998, CV, 50, 2

19999, PAUS, 5

-1 5.trial

20000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

20000, CV, 50, 1

24998, CV, 50, 2

24999, PAUS, 5

-1 6.trial

25000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

25000, CV, 50, 1

29997, CV, 50, 2

29998, PAUS, 0

-1 7.trial

29999, PAUS, 5

30000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

30000, CV, 50, 1

34998, CV, 50, 2

34999, PAUS, 5

-1 8.trial

35000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

35000, CV, 50, 1

39998, CV, 50, 2

39999, PAUS, 5

-1 9.trial

40000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

40000, CV, 50, 1

44997, CV, 50, 2

44998, PAUS, 0

-1 10.trial

44999, PAUS, 5

45000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

45000, CV, 50, 1

49998, CV, 50, 2

49999, PAUS, 5

-1 11.trial

50000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

50000, CV, 50, 1

54998, CV, 50, 2

54999, PAUS, 5

-1 12. trial

55000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

55000, CV, 50, 1

0, BSAV, 1, .016, LOW, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 18, 23, 24, 26, 27, 28, 29, 30, 31, 32, 39, 41, 44, 47, 48, 50

60000, ES

Experiment Scenario - Group 2

0,ROAD,10,3,0,0,0,0,0,.5,.5,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

-1 1.trial

0, PAUS, 5

0, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

0, CV, 50, 1

4998, CV, 50, 2

4999, PAUS, 5

-1 2.trial

5000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

5000, CV, 50, 1

9998, CV, 50, 2

9999, PAUS, 5

-1 3.trial

10000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

10000, CV, 50, 1

14997, CV, 50, 2

14998, PAUS, 0

-1 4. trial

14999, PAUS, 5

15000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

15000, CV, 50, 1

19998, CV, 50, 2

19999, PAUS, 5

-1 5.trial

20000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

20000, CV, 50, 1

24998, CV, 50, 2

24999, PAUS, 5

-1 6.trial

25000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

25000, CV, 50, 1

29997, CV, 50, 2

29998, PAUS, 0

-1 7.trial

29999, PAUS, 5

30000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

30000, CV, 50, 1

34998, CV, 50, 2

34999, PAUS, 5

-1 8.trial

35000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

35000, CV, 50, 1

39998, CV, 50, 2

39999, PAUS, 5

-1 9.trial

40000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

40000, CV, 50, 1

44997, CV, 50, 2

44998, PAUS, 0

-1 10.trial

44999, PAUS, 5

45000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

45000, CV, 50, 1

49998, CV, 50, 2

49999, PAUS, 5

-1 11.trial

50000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

50000, CV, 50, 1

54998, CV, 50, 2

54999, PAUS, 5

-1 12. trial

55000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

55000, CV, 50, 1

0, BSAV, 1, .016, LOW, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 18, 23, 24, 26, 27, 28, 29, 30, 31, 32, 39, 41, 44, 47, 48, 50

60000, ES

Experiment Scenario - Group 3

0,ROAD,10,3,0,0,0,0,0,.5,.5,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

-1 1.trial

0, PAUS, 5

0, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

0, CV, 50, 1

4998, CV, 50, 2

4999, PAUS, 5

-1 2.trial

5000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

5000, CV, 50, 1

9998, CV, 50, 2

9999, PAUS, 5

-1 3.trial

10000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

10000, CV, 50, 1

14997, CV, 50, 2

14998, PAUS, 0

-1 4. trial

14999, PAUS, 5

15000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

15000, CV, 50, 1

19998, CV, 50, 2

19999, PAUS, 5

-1 5.trial

20000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

20000, CV, 50, 1

24998, CV, 50, 2

24999, PAUS, 5

-1 6.trial

25000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

25000, CV, 50, 1

29997, CV, 50, 2

29998, PAUS, 0

-1 7.trial

29999, PAUS, 5

30000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

30000, CV, 50, 1

34998, CV, 50, 2

34999, PAUS, 5

-1 8.trial

35000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

35000, CV, 50, 1

39998, CV, 50, 2

39999, PAUS, 5

-1 9.trial

40000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

40000, CV, 50, 1

44997, CV, 50, 2

44998, PAUS, 0

-1 10.trial

44999, PAUS, 5

45000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

45000, CV, 50, 1

49998, CV, 50, 2

49999, PAUS, 5

-1 11.trial

50000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

50000, CV, 50, 1

54998, CV, 50, 2

54999, PAUS, 5

-1 12. trial

55000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

55000, CV, 50, 1

0, BSAV, 1, .016, LOW, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 18, 23, 24, 26, 27, 28, 29, 30, 31, 32, 39, 41, 44, 47, 48, 50

60000, ES

Experiment Scenario - Group 4

0,ROAD,10,3,0,0,0,0,0,.5,.5,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

-1 1.trial

0, PAUS, 5

0, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

0, CV, 50, 1

4998, CV, 50, 2

4999, PAUS, 5

-1 2.trial

5000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

5000, CV, 50, 1

9998, CV, 50, 2

9999, PAUS, 5

-1 3.trial

10000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

10000, CV, 50, 1

14997, CV, 50, 2

14998, PAUS, 0

-1 4. trial

14999, PAUS, 5

15000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

15000, CV, 50, 1

19998, CV, 50, 2

19999, PAUS, 5

-1 5.trial

20000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

20000, CV, 50, 1

24998, CV, 50, 2

24999, PAUS, 5

-1 6.trial

25000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

25000, CV, 50, 1

29997, CV, 50, 2

29998, PAUS, 0

-1 7.trial

29999, PAUS, 5

30000, WG, 1, 0, 1,
C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

30000, CV, 50, 1

34998, CV, 50, 2

34999, PAUS, 5

-1 8.trial

35000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

35000, CV, 50, 1

39998, CV, 50, 2

39999, PAUS, 5

-1 9.trial

40000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTHIGHENTROPY.PAR

40000, CV, 50, 1

44997, CV, 50, 2

44998, PAUS, 0

-1 10.trial

44999, PAUS, 5

45000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

45000, CV, 50, 1

49998, CV, 50, 2

49999, PAUS, 5

-1 11.trial

50000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

50000, CV, 50, 1

54998, CV, 50, 2

54999, PAUS, 5

-1 12. trial

55000, WG, 1, 0, 1, C:\STISIM\Projects\SurucuDikkatCalismasi\WINDGUSTLOWENTROPY.PAR

55000, CV, 50, 1

0, BSAV, 1, .016, LOW, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 18, 23, 24, 26, 27, 28, 29, 30, 31, 32, 39, 41, 44, 47, 48, 50

60000, ES

Warm-Up Scenario: Low Entropy File

1

50

10,5

Warm-Up Scenario: High Entropy File

4

50

10,2

10,5

10,10

10,25

Experiment Scenario: Low Entropy File

1

100

10,10

Experiment Scenario: High Entropy File

5

100

10,2

10,5

10,10

10,25

10,50

Appendix B: Auditory 2-Back Instructions

Y

İşitsel 2-Geri Eğitimi

Şimdi 2-geri çalışması yapacağız. Buna göre, 10'ar rakamdan oluşan her listeyi okuduğumda, iki rakam önce okunan rakamı yüksek sesle tekrarlamanız gereklidir. Örneğin, 3 dediğimde hiçbir şey söylememeniz, 2 dediğimde hiçbir şey söylememeniz, 6'yı duyduktan sonra 3; 7'yi duyduktan sonra 2 demeniz gereklidir. Mümkün olduğunca doğru rakamı söylemeye çalışın.

Benim söylediğim:	**3**	**2**	**6**	**7**	**1**
Sizin söyleyeceğiniz:			**3**	**2**	**6**

İşitsel 2-Geri Eğitimi

K

Şimdi 2-geri çalışması yapacağız. Buna göre, 10'ar rakamdan oluşan her listeyi okuduğumda, iki rakam önce okunan rakamı yüksek sesle tekrarlamanız gereklidir. Örneğin, 3 dediğimde hiçbir şey söylememeniz, 2 dediğimde hiçbir şey söylememeniz, 6'yı duyduktan sonra 3; 7'yi duyduktan sonra 2 demeniz gereklidir. Mümkün olduğunca doğru rakamı söylemeye çalışın.

Benim söylediğim:	**3**	**2**	**6**	**7**	**1**
Sizin söyleyeceğiniz:			**3**	**2**	**6**

Y

Şimdi alıştırma yapacağız. Buna göre, onar rakamdan oluşan her listeyi okuduğumda, iki rakam önce okunan rakamı yüksek sesle tekrarlamanız gereklidir. Örneğin, 3 dediğimde hiçbir şey söylememeniz, 2 dediğimde hiçbir şey söylememeniz, sonra 6'yı duyduktan sonra 3; 7'yi duyduktan sonra 2 demeniz gereklidir. Mümkün olduğunca doğru rakamı söylemeye çalışın.

(2.25 saniye bekleyin)

Başlıyoruz:

3	2	6	7	1	4	2	5	9	8

Başka bir alıştırma daha yapacağız. İki rakam önce okunan rakamı yüksek sesle tekrar edin. Örneğin, ben 1 dediğimde, siz hiçbir şey söylemeyin. Sonra 2 dediğimde, yine hiçbir şey söylemeyin. 3'ü duyduktan sonra, siz 1 deyin ve 4'ü duyduktan sonra 2 deyin. Mümkün olduğunca doğru rakamı söylemeye çalışın.

(2.25 saniye bekleyin)

Başlıyoruz:

1	2	3	4	7	5	6	8	3	9

K

Şimdi alıştırma yapacağız. Buna göre, onar rakamdan oluşan her listeyi okuduğumda, iki rakam önce okunan rakamı yüksek sesle tekrarlamanız gereklidir. Örneğin, 3 dediğimde hiçbir şey söylememeniz, 2 dediğimde hiçbir şey söylememeniz, sonra 6'yı duyduktan sonra 3; 7'yi duyduktan sonra 2 demeniz gereklidir. Mümkün olduğunca doğru rakamı söylemeye çalışın.

Başlıyoruz:

3	2	6	7	1	4	2	5	9	8

Başka bir alıştırma daha yapacağız. İki rakam önce okunan rakamı yüksek sesle tekrar edin. Örneğin, ben 1 dediğimde, siz hiçbir şey söylemeyin. Sonra 2 dediğimde, yine hiçbir şey söylemeyin. 3'ü duyduktan sonra, siz 1 deyin ve 4'ü duyduktan sonra 2 deyin. Mümkün olduğunca doğru rakamı söylemeye çalışın.

Başlıyoruz:

1	2	3	4	7	5	6	8	3	9

Y

(Bu sayfa katılımcıya verilmeyecek) (Katılımcının cevabı kutulara not edilecek. Her bir alıştırmadan sonra katılımcının cevapları açıklanacak.)

"Şimdi birkaç alıştırma daha yapacağız. Her bir alıştırmayı geçebilmek için en fazla 2 yanlış yapmalısınız. Üst üste 2 alıştırmayı geçtikten sonra kulaklıktan dinleyeceğiniz alıştırmaya geçeceğiz."

Başlıyoruz:

4	9	1	5	8	2	4	6	3	7

(5 saniye bekleyin)

Sıradaki rakamlar:

4	5	7	6	3	2	8	9	5	1

Sıradaki rakamlar:

9	4	6	2	8	2	7	5	9	1

Sıradaki rakamlar:

3	9	5	9	8	3	1	9	6	4

Sıradaki rakamlar:

1	6	8	8	8	5	5	6	3	4

Sıradaki rakamlar:

1	7	9	9	3	3	2	6	9	1

Sıradaki rakamlar:

9	7	1	1	3	1	3	3	9	8

Sıradaki rakamlar:

1	5	7	1	2	2	5	5	1	5

Sıradaki rakamlar:

2	6	2	7	7	9	6	8	3	8

Sıradaki rakamlar:

3	7	3	9	9	6	3	2	1	6

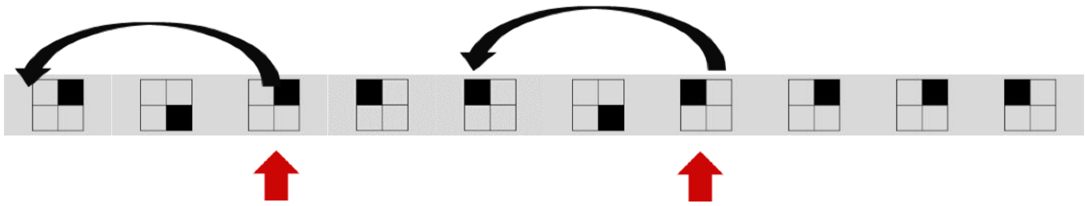
Appendix C:Visuo-Spatial 2-Back Instructions

Y

<u>Uzamsal 2-Geri Eğitimi</u>

Şimdi uzamsal 2-geri çalışması yapacağız. Burada dört bölümden oluşan bir kare şekli gösterilecektir. Şekil içerisindeki 4 küçük kare rastgele sıralarla siyah renge dönecektir. Sizden istenilen, siyah karenin 2 önceki gösterilen siyah kareyle aynı yerde olup olmadığını söylemenizdir. Eğer siyah kare 2 önce gösterilen kareyle aynı bölgedeyse <u>EVET</u> , eğer siyah kare 2 önce gösterilen kareyle aynı bölgede değilse <u>HAYIR</u> demeniz gerekmektedir.

Örneğin;



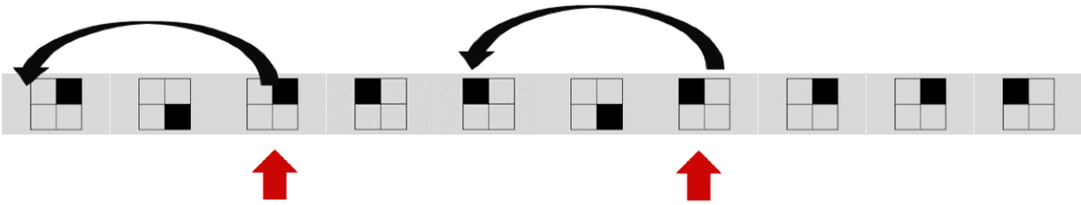
		EVET	HAYIR	HAYIR	HAYIR	EVET	HAYIR	HAYIR	HAYIR

K

Uzamsal 2-Geri Eğitimi

Şimdi uzamsal 2-geri çalışması yapacağız. Burada dört bölümden oluşan bir kare şekli gösterilecektir. Şekil içerisindeki 4 küçük kare rastgele sıralarla siyah renge dönecektir. Sizden istenilen, siyah karenin 2 önceki gösterilen siyah kareyle aynı yerde olup olmadığını söylemenizdir. Eğer siyah kare 2 önce gösterilen kareyle aynı bölgedeyse EVET , eğer siyah kare 2 önce gösterilen kareyle aynı bölgede değilse HAYIR demeniz gerekmektedir.

Örneğin;

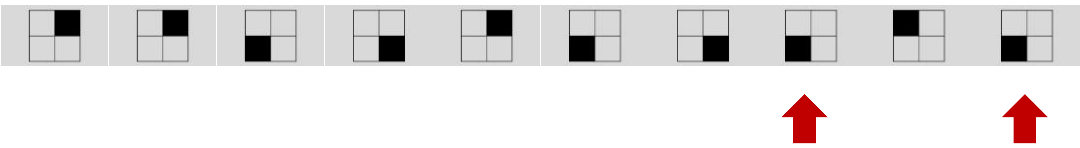


		EVET	HAYIR	HAYIR	HAYIR	EVET	HAYIR	HAYIR	HAYIR

Y

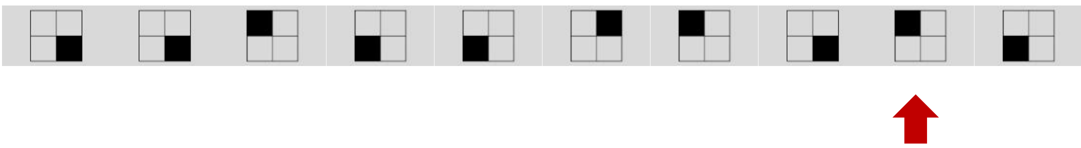
Şimdi alıştırma yapacağız. Burada dört bölümden oluşan bir kare şekli gösterilecektir. Şekil içerisindeki 4 küçük kare rastgele sıralarla siyah renge dönecektir. Sizden istenilen, siyah karenin 2 önceki gösterilen siyah kareyle aynı yerde olup olmadığını söylemenizdir. Eğer siyah kare 2 önce gösterilen kareyle aynı bölgedeyse <u>EVET</u> , eğer siyah kare 2 önce gösterilen kareyle aynı bölgede değilse <u>HAYIR</u> demeniz gerekmektedir.

Başka bir alıştırma daha yapacağız. Görünen kare iki önce görünen kareyle aynı yerdeyse <u>EVET</u>, değilse <u>HAYIR</u> deyin.

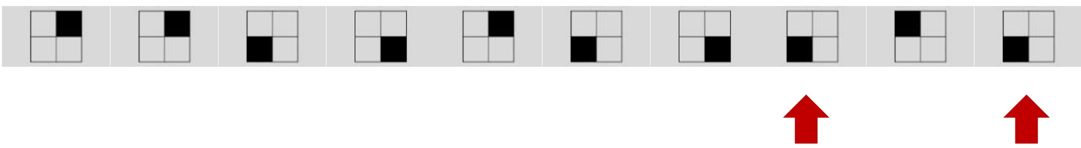


K

Şimdi alıştırma yapacağız. Burada dört bölümden oluşan bir kare şekli gösterilecektir. Şekil içerisindeki 4 küçük kare rastgele sıralarla siyah renge dönecektir. Sizden istenilen, siyah karenin 2 önceki gösterilen siyah kareyle aynı yerde olup olmadığını söylemenizdir. Eğer siyah kare 2 önce gösterilen kareyle aynı bölgedeyse <u>EVET</u> , eğer siyah kare 2 önce gösterilen kareyle aynı bölgede değilse <u>HAYIR</u> demeniz gerekmektedir.



Başka bir alıştırma daha yapacağız. Görünen kare iki önce görünen kareyle aynı yerdeyse <u>EVET</u>, değilse <u>HAYIR</u> deyin.



Katılımcılar bu bölümü bilgisayarda yapacaktır. Katılımcı cevap verdikçe doğru ve yanlış cevaplarını ilgili trialdaki boş kutucuklara not edeceksiniz. Üst üste 2 trialda 2'den fazla yanlış yapılmaz ise katılımcı bu bölümü tamamlamış sayılacak, yapıldıysa katılımcı aynı alıştırmayı tekrar yapacak (session no 2)

1	2
3	4

1. Trial

1	2	1	3	3	1	2	4	1	3
		EVET	HAYIR	HAYIR	HAYIR	HAYIR	HAYIR	HAYIR	HAYIR

2. Trial

1	2	1	4	2	4	4	1	3	3
		EVET	HAYIR	HAYIR	EVET	HAYIR	HAYIR	HAYIR	HAYIR

3. Trial

1	2	3	1	3	3	4	3	4	4
		HAYIR	HAYIR	EVET	HAYIR	HAYIR	EVET	EVET	HAYIR

4. Trial

1	3	4	4	3	1	3	3	3	1
		HAYIR	HAYIR	HAYIR	HAYIR	EVET	HAYIR	EVET	HAYIR

5. Trial

1	3	1	2	1	4	1	3	3	1
		EVET	HAYIR	EVET	HAYIR	EVET	HAYIR	HAYIR	HAYIR

Appendix D: Informed Consent Form

Gönüllü Katılım Formu

Bu çalışma, Orta Doğu Teknik Üniversitesi Trafik ve Ulaşım Psikolojisi Yüksek Lisans programı öğrencilerinden Seda Özbozdağlı tarafından, Psikoloji Bölümü öğretim üyelerinden Doç. Dr. Mine Mısırlısoy ve Doç.Dr. Türker Özkan danışmanlığında yürütülen bir tez çalışmasıdır. Çalışmanın gayesi, sürücülerin şerit pozisyonlarını korumada ikincil görevlerin etkisini incelemektir. Bu görevler araç kullanmada cep telefonu ile konuşmanın ve navigasyon cihazı kullanmanın olumlu ve olumsuz tesirlerini tespit etmek için oluşturulmuştur. Deneyin tamamlanması yaklaşık olarak 1 saat sürecektir. Katılım tamamıyla gönüllülük esasına dayalıdır. Kimlik ya da ehliyet bilgileri alınmayacaktır. Sonuçlarınız gizli tutulacak ve sadece araştırmacılar tarafından bilimsel yayınlarda kullanılmak amacıyla değerlendirilecektir. Bu çalışma ile elde edilen bireysel sonuçlar rapor edilmeyecektir. Yalnızca gruplardan elde edilen toplu sonuçlar rapor edilecektir.

Deney esnasında herhangi bir sebepten dolayı kendinizi rahatsız hissedersiniz yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda sizden bir açıklama yapmanız istenmeyecektir. Deney sonunda, çalışmayla ilgili sorularınız cevaplanacaktır. Daha fazla bilgi almak için yüksek lisans öğrencisi Seda Özbozdağlı (Oda: BZ08; Tel: 05069849605; E-posta: sedaozbozdagli@gmail.com), tez danışmanları Doç. Dr. Mine Mısırlısoy (Oda: B127; Tel: 03122105107; E-posta: mmine@metu.edu.tr) ve Doç. Dr. Türker Özkan (Oda: B123; Tel: 03122105118; E-posta: ozturker@metu.edu.tr) ile iletişim kurabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayınlarda kullanılmasını kabul ediyorum. (Formu doldurup imzaladıktan sonra deney yürütücüsüne veriniz).

İsim Soyad Tarih İmza Alınan Ders

___/___/___

Appendix E: Debriefing Form

Katılım Sonrası Bilgi Formu

"İşitsel ve görsel ikincil görevlerin şerit korumadaki etkisi: Bir simülatör çalışması" başlıklı bu tez çalışması Orta Doğu Teknik Üniversitesi Trafik ve Ulaşım Psikolojisi Yüksek Lisans programı öğrencilerinden Seda Özbozdağlı tarafından, Psikoloji Bölümü öğretim üyelerinden Doç. Dr. Mine Mısırlısoy ve Doç.Dr. Türker Özkan danışmanlığında yürütülmektedir.

Çalışmanın amacı, sürücülerin şerit pozisyonlarını korumada ikincil görevlerin farklı yol koşullarında etkisini incelemektir. Bu görevler araç kullanmada cep telefonu ile konuşmanın ve navigasyon cihazı kullanmanın olumlu ve olumsuz tesirlerini tespit etmek için oluşturulmuştur.

Bu çalışma ile elde edilen bireysel sonuçlar rapor edilmeyecektir. Yalnızca gruplardan elde edilen toplu sonuçlar rapor edilecektir. Katıldığınız için teşekkür ederiz. Sorularınız için aşağıdaki iletişim kanallarından istediğiniz zaman araştırmacılarla temasa geçebilirsiniz.

Araştırmacılar:

Seda Özbozdağlı

Oda: BZ08; Tel: 05069849605; E-posta: sedaozbozdagli@gmail.com

Doç. Dr. Mine Mısırlısoy

Oda: B127; Tel: 03122105107; E-posta: mmine@metu.edu.tr

Doç. Dr. Türker Özkan

Oda: B123; Tel: 03122105118; E-posta: ozturker@metu.edu.tr

Appendix F: Demographic Information Form

Lütfen, aşağıdaki soruları size göre doğru olan seçeneği işaretleyerek veya doğru cevabı yazarak cevaplayınız. Seçenekler arasında seçiminizi yaptığınız zaman, lütfen siyah kurşun kalem kullanarak aşağıda gösterildiği şekilde dairenin içerisini karalayınız.

1. Yaşınız:_________ 2. Cinsiyetiniz **O** Kadın **O** Erkek

3. Herhangi bir görme ya da işitme bozukluğunuz var mı? **O** Evet **O** Hayır

Cevabınız evetse lütfen açıklayınız

____

4. Deneye gelmeden önceki gece kaç saat uyudunuz? ___

5. Son 2-3 haftadır herhangi bir nedenle ilaç alıyor musunuz? ___

6. Ne kadar süredir ehliyet sahibisiniz**?** _______________yıl

7. **Geçen yıl** kaç km araç kullandınız**?**______________________ Km

8. **Ehliyetinizi aldığınızdan bu yana** kaç km araç kullandınız? _____________ ______ Km

9. En sık kullandığınız araç türü: ____________________

10. **Son üç yıl içerisinde** sürücü olarak başınızdan geçen kaza sayısı (en ufak çarpışmaları dahi sayarak)

kaçtır **?**_______________

11. **Son üç yıl içerisinde,** sürücü olarak başınızdan geçen **aktif kaza** (sizin bir araca yayaya veya nesneye çarptığınız kazalar) sayısı kaçtır **?** ______________

12. **Son üç yıl içerisinde,** sürücü olarak başınızdan geçen **pasif kaza** (bir başka araç sürücüsünün size çarptığı kazalar) sayısı kaçtır **?** ______________

13. **Son üç yıl içerisinde,** aşağıda verilen her bir trafik ceza türü ile kaç kere cezalandırıldınız?

a) Park cezası________b) Hatalı sollama cezası___________ c) Aşırı hız cezası_______

d) Kırmızı ışıkta geçme cezası _______e) Diğer cezalar___________

14. İyi koşullar altında otobanda kaç kilometre hızla gitmeyi tercih edersiniz? __ ____________ Km/saat

15. İyi koşullar altında şehir içi yollarda kaç kilometre hızla gitmeyi tercih edersiniz? ____________ Km/saat

16. Normal bir seyahatinizde kendinizi diğer sürücülerle kıyaslayınız. Sollandığınızdan daha fazla sollama yapıyor musunuz?

Sollandığımdan daha az sollama yaparım. **O**

Sollandığım kadar da sollama yaparım. **O**

Sollandığımdan daha fazla sollama yaparım. **O**

Appendix G: Driver Skill Inventory

Araç kullanırken güçlü ve zayıf yönleriniz nelerdir?

Özellikle araç kullanmanın farklı yönlerinde olmak üzere sürücüler arasında pek çok farklılıklar vardır. Hepimizin güçlü ve zayıf yönleri vardır. Lütfen, sizin güçlü ve zayıf yönlerinizi size göre doğru olan seçeneği karalayarak belirtiniz. Her bir soru için cevap seçenekleri:

1= Kesinlikle zayıf 2 = Zayıf 3= Ne zayıf ne de güçlü 4= Güçlü 5= Kesinlikle güçlü

		1	2	3	4	5
1	Seri araç kullanma	O	O	O	O	O
2	Trafikte tehlikeleri görme	O	O	O	O	O
3	Sabırsızlanmadan yavaş bir aracın arkasından sürme	O	O	O	O	O
4	Kaygan yolda araç kullanma	O	O	O	O	O
5	İlerideki trafik durumlarını önceden kestirme	O	O	O	O	O
6	Belirli trafik ortamlarında nasıl hareket edileceğini bilme	O	O	O	O	O
7	Yoğun trafikte sürekli şerit değiştirme	O	O	O	O	O
8	Hızlı karar alma	O	O	O	O	O
9	Sinir bozucu durumlarda sakin davranma	O	O	O	O	O
10	Aracı kontrol etme	O	O	O	O	O
11	Yeterli takip mesafesi bırakma	O	O	O	O	O
12	Koşullara göre hızı ayarlama	O	O	O	O	O
13	Geriye kaçırmadan aracı yokuşta kaldırma	O	O	O	O	O
14	Sollama	O	O	O	O	O
15	Gerektiğinde kazadan kaçınmak için yol hakkından vazgeçme	O	O	O	O	O

16	Hız sınırlarına uyma	**O**	**O**	**O**	**O**	**O**
17	Gereksiz risklerden kaçınma	**O**	**O**	**O**	**O**	**O**
18	Diğer sürücülerin hatalarını telafi edebilme	**O**	**O**	**O**	**O**	**O**
19	Trafik ışıklarına dikkatle uyma	**O**	**O**	**O**	**O**	**O**
20	Dar bir yere geri geri park edebilme	**O**	**O**	**O**	**O**	**O**

Appendix H: Etik İzin Formu

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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24.02.2015

Gönderilen : Doç. Dr. Mine Mısırlısoy
Psikoloji Bölümü

Gönderen : Prof. Dr. Canan Sümer
IAK Başkan Vekili

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz Psikoloji Bölümü öğrencisi Seda Özbozdağı'nın "Effects of auditory and visual distractors on lane maintenance: A simulator study" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

24/02/2015

Prof.Dr. Canan Sümer
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkan Vekili
ODTÜ 06531 ANKARA

Appendix I: Turkish Summary

GİRİŞ

Direksiyon Başında Cep Telefonu Kullanımı

Direksiyon başında cep telefonu ile konuşmanın araç kullanmayı olumsuz etkilediği pek çok çalışmada gösterilmiştir. Sürücüler cep telefonu ile görüşme yaptıklarında hızlarını düşürmüş ve takip mesafelerini arttırmışlardır (Metz ve ark., 2015). Sürüşlerini adapte etmeleri, sürücülerin ikincil görevin oluşturduğu riskin farkında olduklarını göstermektedir. Fakat becerilerine güvenin bazı sürücüler aynı anda birkaç görevi yerine getirmede başarısız bulunsalar da araç kullanırken telefon görüşmesi yaptıklarını rapor etmiştir (Sanbonmatsu ve ark., 2013).

Seyahat sırasında telefonla görüşmenin, kaydedilmiş bir sohbeti dinlemekten daha olumsuz etkileri olduğu da gösterilmiştir. Dinlemenin aksine, aktif bir telefon görüşmesinde bulunmak sürücülerin yolda meydana gelen değişiklikleri kaçırmalarına ve cevaplarında daha çok hata yapmalarına yol açmıştır (McCarley ve ark., 2004). Başka bir çalışmada, sürücülerin telefonda konuşurken yoldan geçen yayalara daha yavaş tepki verdikleri görülmüştür (Haque ve Washington, 2014). Araçtaki yolcu ile sohbet etmekle telefon görüşmesi yapmak sürüş performansını aynı şekilde etkilememektedir. Sürücüler, trafikten gelen yükün arttığını düşündüklerinde, yolcu ile olan konuşmalarının zorluğunu azaltmış ya da sohbete başlamayı ertelemiştir. Ek olarak, yolcu, gereken durumlarda sürücünün dikkatini yola çekebilmektedir. Bu sayede riskli durumlarda bir artış olmamıştır. Ancak telefonla görüşmenin daha fazla sürüş hatasına yol açtığı bulunmuştur (Drews ve ark., 2008). Telefonda konuşurken ellerin serbest olması da riskleri azaltmamaktadır. Kulaklık kullanarak ya da telefonu elde tutarak görüşme yapan sürücülerin kural ihlali sayısı artmış ve dikkatleri kötü yönde etkilenmiştir (Beede ve Kass, 2006). Pratik yapmamın da araç kullanırken cep telefonu kullanmanın yarattığı olumsuz etkileri azaltmadığı görülmüştür (Cooper ve Strayer, 2008).

Bulunan olumsuz etkilere rağmen bazı çalışmalar da insan davranışının karmaşıklığını göstermektedir. Telefon kullanmak sürüşü pek çok yönden kötü etkilese de şerit tutma davranışının bu durumdan farklı etkilendiği bulunmuştur. Sürücüler kulaklık aracılığı ile telefonda konuştuklarında şerit pozisyonundaki değişkenlik azalmıştır (Beede ve Kassi 2006; Medeiros ve ark., 2014).

Seyir Sistemleri

Seyir sistemleri, sürücülerin yüklerini hafifletmek ve gidecekleri noktaya daha kolay ulaşmalarını sağlamak amacıyla tasarlanmıştır. Olumlu etkilerinin yanı sıra, takip gerektiren bu cihazlar sürücüler için dikkat dağıtıcı bir unsur konumuna da düşebilirler.

Çalışmalar sürücülerin seyir cihazı kullandıklarında sürüşlerini adapte etiklerini göstermiştir. Sürücüler hızlarını azaltmış, takip mesafesini arttırmış ve güvenli olarak değerlendirdikleri durumlarda bu cihazlarla uğraşmışlardır (Metz ve ark., 2014). Bu davranış, sürücülerin seyir sistemlerini kullandıklarında kaza riskinin arttığını hissettiklerini ve bu riski sürüşlerini değiştirerek telafi etme ihtiyacı içinde olduklarını göstermektedir. Çünkü bu sistemler hem görsel takip hem de elle müdahale gerektirmektedir. Görsel ikincil görevlerin kullanıldığı başka çalışmalar da seyir sistemlerinin sürüşe olan etkilerini anlamada yardımcı olabilirler. Sürüş performansı açısından, telefon mesajı okumanın telefonla konuşmaktan daha kötü etkileri olduğu bulunmuştur. Sürücüler mesaj okuduklarında daha geç tepkiler vermiş, şerit korumaları kötüleşmiş ve yaptıkları kazalar artmıştır (Drews ve ark., 2009). Başka bir çalışma, sürücülerin telefonda arama yapmaktansa gelen aramayı kabul ettiklerini göstermiştir (Tractinsky ve ark., 2013). Bu, bakışı başka yöne çevirmenin daha riskli olarak algılandığının bir belirtisi olabilir. Sürücüler bakışlarını bir kez yoldan çektiklerinde, tekrar yola baksalar da görsel taramanın hemen eski haline dönmediği ve yoldaki tehditleri tespit etmelerinin kötüleştiği görülmüştür (

Borowsky ve ark., 2015). Görsel ikincil görev yapıldığında sürücülerin orta şeritten daha çok saptıkları tespit edilmiştir (Kircher ve Ahlstrom, 2012). Başka bir araştırmada, deneyimli taksi şoförlerinin beklenmeyen bir durum olduğunda, seyir cihazı takip etmelerinin şeritten sapmayı arttırdığı izlenmiştir (Kim ve ark., 2013). Görsel görevlerin zihni meşgul eden diğer görevlerden sürüş açısından daha zarar verici oldukları da görülmüştür (Liang ve Lee, 2010).

İşitsel ve görsel-mekânsal (uzamsal) ikincil görevlerin sürüşü etkiledikleri literatürde bilinmektedir. Fakat bu etkilerin yönü ikincil görevin doğasına, çevresel koşullara ve sürücünün deneyime bağlı olarak değişebilir. Tahmin edilebilir sürüş ortamında, aynı anda başka bir görevle meşgul olmanın şerit tutmayı olumlu etkilediği bulunmuştur (Medeiros-Ward ve ark., 2014). Araç kullanmak karmaşık bir görevdir ve ikincil görevlerin sürüş üzerindeki etkilerini belirleyen performansın arkasında yatan kontrol işlemleri olabilir.

Hiyerarşik Kontrol Teorisi

Bir görevde yeterli deneyim kazanmak, performansın arkasında yatan kontrol süreçlerini değiştirmektedir. Öğrenme aşamasında, üst seviye kontrol gerekmektedir. Görevde ustalaştıkça, alt seviye kontrol performansın gerçekleştirilmesi için yeterli hale gelmektedir (Shaffer, 1976). Deneyim kazandıkça, yapılan görev otomatikleşir ve asgari oranda dikkat performans için yeterli hale gelir (Fisk ve Schneider, 1984). Araç kullanmada da bu durum geçerlidir. Usta şoförler yolculuklarıyla ilgili detaylı bir anıya sahip olmadan hedefledikleri yere ulaşabilirler.

Davranışın arkasında yatan kontrol süreçlerini açıklamada farklı metaforlar kullanılmıştır. Kontrol döngüleri de kullanılan terimler arasındadır (Logan ve Crump, 2009). Dış döngü, etkin bir süreçtir ve dikkat talep eder. Öte yandan, iç döngü otomatikleşmiştir ve bilinçli sürecin dışında işler (Beilock ve ark., 2002). Dış döngü, iç döngünün işlemlerini takip etmez. Başarılı bir performans için, dış döngüye dayanan davranış dikkat gerektirirken, iç döngüye dayanan davranış odaklanıldığında zarar görür. Odaklanmanın görevi kötüleştirdiği çalışmalar tarafından da gösterilmiştir. Usta daktilo kullanıcıları tuş vuruşlarına dikkatlerini yönelttiklerinde daha kötü performans sergilemiştir (Logan ve Crump, 2009; Tapp ve Logan, 2011).

Uzun süredir yapılan görevler iç döngünün kontrolü altında yerine getirilebilir. Önemli olan nokta, çevresel koşulların sabit olmasıdır. Tahmin edilemez koşullar altında, dış döngü devreye girmektedir. Araç kullanma açısından, tahmin edilebilir sürüş şartlarında ek görevle meşgul olmanın şerit tutmayı iyileştirdiği bulunmuştur. Tahmin edilemez sürüş şartlarında ise, ikincil bir görev yapmak şerit tutmayı kötü yönde etkilemiştir (Medeiros-Ward ve ark., 2014). Fakat bahsedilen araştırmada kullanılan ikincil görev işitsel bir görevdir. Bu görev ellerin serbest olduğu durumda telefonla konuşmayla bağdaştırılabilir.

Rekabet Eden Kaynaklar

Bu çalışmada hem işitsel hem de görsel-mekânsal ikincil görevler kullanılmıştır. Önceki çalışmalar, işitsel ikincil görevin şerit tutmayı iyi yönde etkilediğini göstermiştir (Medeiros-Ward ve ark., 2014). Fakat aynı anda yapılan iki görev, aynı işler bellek alt sisteminin çalışmasını gerektirdiğinde performans kötü yönde etkilenmektedir (Baddeley, 1992). Çalışmanın altında yatan araştırma sorusu da bu bilgilerden doğmaktadır. Araç kullanan kişi görsel çevreyi taramalıdır. İkincil görevin de görsel dikkat talep etmesi iki görevi çakıştırmaktadır. Sürüş esnasında işitsel bir görev yapılsa dahi şoför gözlerini yolda tutabilmektedir ve bu yüzden görsel ikincil bir görev kadar performansı kötü etkileyemeyebilir. Özetle, bilişsel yük ve şerit tutma arasındaki ilişki ikincil görevin türüne bağlı olabilir. Hiyerarşik kontrol teorisinin önerdiğinin aksine görsel-mekânsal ikincil görev şerit tutmayı çevresel tahmin edilebilirlikten bağımsız olarak kötü etkileyebilir.

Algılanan Beceriler

Sürücülerin, sürüş becerileri hakkındaki değerlendirmeleri performanslarını etkileyebilir. Sürücü kendini becerikli bir sürücü olarak görürse, araç kullanırken ikincil bir görevle meşgul olmakta bir sakınca görmeyebilir. Kendilerinin oluşan riskin altından kalkacaklarını düşündükleri için sürüşlerini adapte etmeye gerek duymayabilirler. Sürüş performansının öz değerlendirmesi hem algısal motor becerileri hem de güvenlik becerilerini, kurallara uymak ve riskten kaçınmak gibi, kapsar.

Algısal motor beceriler trafik ceza sayısını yordarken, güvenlik becerileri hızı, kaza sayısını ve ceza sayısını yordamaktadır (Lajunen ve ark., 1998). Güvenlik becerileri alt ölçeğinde düşük puan alan sürücülerin tehlikeli araç kullanma eğilimleri olduğu bulunmuştur (Sümer ve Özkan, 2002). Becerilerinin sınırlarını bilen sürücüler aynı anda hem araç kullanıp hem de ikincil görevle uğraştıklarında iki görevden birinden ödün vererek riski belli bir seviye tutabilirler.

Çalışmanın Amacı

Bu çalışmanın amacı tahmin edilebilir ve tahmin edilemez sürüş koşullarında işitsel ve görsel-mekânsal ikincil görevlerin şerit tutma üzerindeki etkilerini incelemektir. İkincil bir görevle uğraşma, sürüşü pek çok yönden kötü etkilese de çevresel koşullara bağlı olarak şerit tutmayı farklı etkilediği görülmektedir. Yalnızca sürüş koşullarının değil bilişsel yük yaratan ikincil görevin türünün de şerit korumadaki değişiklikleri açıklayacağı düşünülmektedir. İşitsel ikincil görev kulaklıkla telefon görüşmesi yapmayı simüle ederken, görsel-mekânsal ikincil görev seyir sistemlerini simüle etmektedir. Ek olarak, çalışma algılanan becerilerin şerit tutmayı ne şekilde etkilediğini de keşfetmeyi amaçlamaktadır.

Çalışmanın Önemi

Çalışma Hiyerarşik Kontrol Teorisini temel alarak oluşturulmuştur. Teoriyi farklı ikincil görevlerle test ederek literatüre katkıda bulunacaktır. Sürücülerin becerilerini değerlendirmeleri ile sürüş performansının ilişkisini de gösterecektir.

Hipotezler

İşitsel ikincil görev koşulunda,

1. Tahmin edilebilir yol koşulunda, yük, yüksüz koşula nazaran, şerit pozisyonundaki değişkenlikleri azaltacaktır.

2. Tahmin edilemez yol koşulunda, yük, yüksüz koşula nazaran, şerit pozisyonundaki değişkenlikleri arttıracaktır.

Görsel-mekânsal ikincil görev koşulunda,

3. Tahmin edilebilir yol koşulunda, yük, yüksüz koşula nazaran, şerit pozisyonundaki değişkenlikleri arttıracaktır.
4. Tahmin edilemez yol koşulunda, yük, yüksüz koşula nazaran, şerit pozisyonundaki değişkenlikleri arttıracaktır.

YÖNTEM

Katılımcılar

Toplamda 66 sürücü (52 erkek, 14 kadın) deneye katılmıştır. Katılımcıların yaş aralığı 19 ve 32 olup, ortalama yaş 22.74'tür. Katılımcılar 2 deney grubuna (işitsel ve görsel-mekânsal) eşit olarak dağıtılmıştır.

Materyaller

Demografik Bilgi Formu

Bu formda yaş, cinsiyet, deneyden önceki uyku süresi, ilaç kullanımı, duyma/işitme problemi olup olmadığı gibi maddeler bulunmaktadır. Ek olarak, ehliyet alınmasından itibaren geçen süre, toplam kat edilen mesafe, kaza ve ceza sayısı gibi sürüşle doğrudan ilgili sorular yöneltilmiştir.

Sürücü Beceri Anketi

Anket 20 maddeden oluşmaktadır ve sürücülerin algısal motor becerileri ile güvenlik becerilerini değerlendirmeleri istenmektedir.

Araç Simülatörü (STISIM Drive)

Sürüş senaryosunun tamamlanması 20 dakika sürmektedir. Sürücüler yalnızca direksiyonu kontrol edebilmektedirler. Tek şeritli, iki tarafından kesik çizgilerle sınırları çizilen bir yolda ilerlenmektedir. Tahmin edilemez sürüş koşulu rüzgâr eklenmesiyle (düzensizlik) oluşturulmuştur.

İşitsel N-Geri Görevi

Bilişsel yükü tetiklemek için işitsel n-geri görevi kullanılmıştır (Mehler ve ark., 2011). Katılımcıların 2 önce okunan rakamı yüksek sesle tekrarlamaları istenmiştir.

Görsel-Mekânsal N-Geri Görevi

Görsel- mekânsal 2-geri görevi koşulunda, simülatörün yanında bulunan ekranda 4 eşit parçadan oluşan bir kare şekli belirmektedir. Bu 4 parçadan biri her seferinde siyaha dönmektedir ve katılımcıdan istenen son siyah kare ile 2 önce görülen siyah kare aynı yerde ise evet diyerek, değilse hayır diyerek cevaplamalarıdır.

Deneysel Desen

Deneydeki bağımlı değişkenler, bilişsel yük (yük-yüksüz), düzensizlik (düşük düzensizlik-yüksek düzensizlik) ve ikincil görevin (işitsel-görsel mekânsal) türüdür. Bağımlı değişken ise şerit pozisyonundaki değişkenliklerdir ve ortalama karekök ile hesaplanmıştır.

İşlem

Deneyler Orta Doğu Teknik Üniversitesi'nde bulunan İnsan Faktörü laboratuvarında gerçekleştirilmiştir. Katılımcılar sırasıyla gönüllü katılım formunu, demografik bilgi formunu ve sürücü beceri anketini doldurmuşlardır. Sonrasında, katılımcılara bulundukları gruba göre (işitsel veya görsel-mekânsal) deney yönergesi anlatılmıştır. Birincil ve ikincil görevlerin tam anlaşılması için ayrı ayrı ve birlikte alıştırmalar yapılmıştır. Akabinde 20 dakikalık asıl deney gerçekleşmiştir. Deney sonunda katılımcılara araştırma bilgi formu verilmiştir.

BULGULAR

İşitsel ve Görsel-Mekânsal Gruplar

Şerit pozisyonundaki değişiklik her deney koşulu için ortalama karekök ile hesaplanmıştır. 2 x 2 x 2 karışık tasarım varyans analizi (ANOVA)kullanılarak yük (yük-yüksüz), düzensizlik(düşük-yüksek) ve ikincil görev türünün (işitsel-görsel mekânsal) şerit pozisyonundaki değişkenlik üzerindeki etkilerine bakılmıştır. Düzensizliğin ana etkisi anlamlı bulunurken yükün anlamlı bir etkisi bulunamamıştır. Düzensizlik ve ikincil görevin türünün etkileşim etkisi anlamlı bulunamamıştır. Yükün ve ikincil görev türü arasında ve düzensizlik ve yük arasında anlamlı etkileşim etkileri bulunmuştur. Düzensizlik, yük ve ikincil görev türü arasında üç-yönlü anlamlı etkileşim etkisi bulunamamıştır. Önemli olarak da, ikincil görev türünün şerit pozisyonundaki değişkenlik üzerinde anlamlı ana etkisi bulunmamıştır.

Post hoc test sonuçlarına göre, düşük düzensizlik koşulunda, yük olmaması durumunda, işitsel ve görsel-mekânsal koşulları arasında şerit pozisyonundaki değişkenlikler açısından anlamlı bir fark yoktur. Yüksek düzensizlik koşulunda ise, yük yok iken, şerit pozisyonundaki değişkenlik görsel-mekânsal grubuna oranla işitsel grupta daha yüksek çıkmıştır. Yük olduğunda ise, düşük düzensizlik koşulunda ve yüksek düzensizlik koşulunda iki grup arasında şerit pozisyonundaki değişkenlikler açısından anlamlı bir fark bulunamamıştır. Genel olarak yük koşulunda düzensizliğin artması ile sapmada da artış görülmüştür.

İşitsel Grup

2 x 2 ilişkili varyans analizi (ANOVA) kullanılarak düzensizliğin (düşük-yüksek) ve yükün (yük-yüksüz) şerit pozisyonundaki değişkenlikler üzerindeki etkileri araştırılmıştır. Düzensizliğin ve yükün anlamlı ana etkileri ve etkileşim etkisi bulunmuştur. Hipoteze uygun olarak düşük düzensizlikte, işitsel yük şerit pozisyonundaki değişkenliği azaltmıştır. Fakat yüksek düzensizlikte anlamlı bir fark bulunamamıştır.

Görsel-Mekânsal Grup

2 x 2 ilişkili varyans analizi (ANOVA) kullanılarak düzensizliğin (düşük-yüksek) ve yükün (yük-yüksüz) şerit pozisyonundaki değişkenlikler üzerindeki etkileri araştırılmıştır. Düzensizliğin anlamlı ana etkisi bulunmuş ama yükün anlamlı ana etkisi bulunamamıştır. Yük ve düzensizlik arasında ise etkileşim etkisi anlamlı bulunmuştur. Hipotezin aksine düşük düzensizlik koşulunda, görsel-mekânsal yük ve yüksüz koşulları arasında şerit pozisyonundaki değişkenlik açısından anlamlı bir fark bulunamamıştır. Fakat hipotez edildiği gibi, yüksek düzensizlikte yük şerit pozisyonundaki değişkenliği arttırmıştır.

İkincil Görev Performansı

İkincil görevlerdeki doğru cevap miktarı hem düşük düzensizlik hem de yüksek düzensizlik koşulları için hesaplanmıştır. İşitsel ve görsel-mekânsal gruplar için iki ayrı tek yönlü varyans analizi (ANOVA) kullanılarak düzensizliğin (alçak-yüksek) ikincil görevdeki doğruluğa etkisine bakılmıştır. İki grup için de düzensizliğin anlamlı ana etkileri bulunamamıştır.

Algısal Motor Beceriler ve Güvenlik Becerileri

Sürücü Beceri Anketi'nin alt ölçekleri için keşfedici analizler yapılmıştır. İki ölçek için de katılımcılar medyan ayrım yöntemiyle yüksek ve düşük olarak ikiye ayrılmıştır. Karmaşık tasarım varyans analizi (ANOVA) kullanılarak algısal motor becerilerin ve güvenlik becerilerinin şerit pozisyonundaki değişkenlik üzerindeki etkileri araştırılmıştır. İşitsel ve görsel-mekânsal gruplarında algısal motor becerileri düşük olan sürücüler bütün koşullarda en çok şeritten sapmayı göstermişlerdir. Yalnızca görsel-mekânsal grubunda olup yüksek güvenlik becerisine sahip olanlar en fazla şerit pozisyonundaki değişkenliği göstermiştir.

TARTIŞMA

Bu çalışma, işitsel ve görsel-mekânsal ikincil görevlerin tahmin edilebilir ve tahmin edilemez sürüş koşullarında şerit koruma üzerindeki etkilerini araştırmak için yapılmıştır. Hiyerarşik Kontrol Teorisi'ni görsel-mekânsal bir görevle çalışarak teorinin kapsamını geliştirmek amaçlanmıştır. Araç kullanma bağlamında teori önceki çalışmada işitsel ikincil görevle test edilmiştir (Medeiros-Ward ve ark., 2014).

Teorinin öngördüğü şekilde işitsel yük, tahmin edilebilir durumda, şeritten sapmayı azaltmıştır ve performansı geliştirmiştir. Öte yandan, beklenenin aksine, tahmin edilemez sürüş koşulunda, yük sapmayı arttırmamış ve anlamlı bir farka yol açmamıştır. Görsel-mekânsal görevin yarattığı bilişsel yük ise tahmin edilemez sürüşü koşulunda beklenildiği gibi sapmada artışa neden olmuş, tahmin edilemez koşulda ise anlamlı bir farka yol açmamıştır.

Sürücüler, ikincil bir görevle meşgul olmayıp yalnızca araç kullandıklarında sürüş koşulları beklenmedik hale geldikçe şeritten daha çok sapmışlardır. Bu iki grubun profillerinin benzer olduğunu göstermiş ve ikincil görev türünün yalın etkisinin görülmesine olanak sağlamıştır. Buna ek olarak, aynı anda araç kullanma ve ikincil görevle meşgul olma beklenmeyen yol koşullarında sapmanın artmasına neden olmuştur.

2-geri görevindeki performansların iki grupta benzer seviyede iyi olması, görevlerin zorluk derecesi açısından denk olduğunu gösterebilir. Düzensizlik arttıkça katılımcılar ikincil görevlerinden ödün vermemişlerdir. Bu sayede düzensizliğin ikincil görev performansına etkisini görmek yerine düzensizliğin şerit koruma üzerindeki etkisini görmek mümkün olmuştur.

Literatür ağırlıklı olarak ikincil bir görevle uğraşmanın araç kullanmayı kötü yönde etkilediğini gösteren çalışmalardan oluşmaktadır. Direksiyon başında telefonla konuşmanın tepki hızını yavaşlattığı, fren yaptıktan sonra hızın yeniden kazanılmasını için geçen süreyi uzattığı, daha çok trafik kazasına yol açtığı bulunmuştur (Haque ve Washington, 2014; Strayer ve Drews, 2004; Strayer ve ark., 2006). Bu çalışmada ise cep telefonu işitsel 2-geri göreviyle simüle edilmiştir. Önceden yapılan bazı çalışmalarda işitsel ikincil görevin araç kullanırken şeritten sapmayı azalttığı görülmüştür (Beede ve Kass, 2006; McCarley ve Kramer, 2014).

İşitsel yükün tahmin edilebilir durumda sapmayı azaltması Hiyerarşik Kontrol Teorisi'ni desteklemektedir. Fakat tahmin edilemez durumda yükün sapmada anlamlı bir etkisinin olmaması deney katılımcılarının yeterince sürüş deneyimine sahip olmamasından kaynaklanıyor olabilir. Görsel-mekânsal grupta yükün hem tahmin edilebilir hem de tahmin edilemez sürüş şartlarında şeritten sapmayı arttıracağı beklenmiştir. Önceki araştırmalarda, görsel ikincil bir görevle uğraşmanın sürüşe zarar verdiği bulunmuştur. Mesaj okuyan sürücülerin tepkilerinin yavaşladığı, daha çok kaza yaptıkları ve şeritten daha fazla saptıkları görülmüştür (Drews ve ark., 2009). Başka çalışmalarda da ikincil görsel görevin, seyir sistemleri gibi, beklenmeyen durumlarda yalnızca araç kullanma koşuluna nazaran daha çok sapmaya yol açtıkları izlenmiştir (Kim ve ark., 2013). Mevcut çalışmanın sonuçları da bu doğrultudadır. İşitsel görevin aksine, görsel-mekânsal yük tahmin edilebilir durumda performansta bir gelişmeye yol açmadığı gibi beklenmeyen durumda ise sapmayı arttırmıştır. Hiyerarşik Kontrol Teorisi'nin aksine tahmin edilebilir sürüş koşulunda sapmada azalma olmaması, yükün olumlu etkilerinin ikincil görevin türüne bağlı olduğunu göstermektedir.

Dikkatin görsel göreve yönetildiği durumlarda yola tekrar bakıldığında görsel taramanın yeniden ayarlanmasında sürücülerin zorluk çektiği ve bu nedenle de yoldaki tehditleri fark etmede başarısız oldukları önceki bir çalışmada bulunmuştur (Borowsky ve ark., 2015). İkincil görsel-mekânsal görevin sapmayı tahmin edilebilir ortamda olumlu etkilemediği ve tahmin edilemez ortamda kötüleştirdiği bu çalışmanın bulguları arasındadır. Bu duruma ikincil görev için bakışın diğer ekrana yönelmesi ve bu yüzden yola tekrar adapte olmada zorlanılması neden olmuş olabilir.

Araç kullanma daimi dikkat ve yolun taranmasını gerektirir. Görsel ikincil görevler araç kullanma ile aynı alt sistemin işlemesini gerektirdiği için performansa zarar verir (Baddeley, 1992). Eğer iki görev farklı alt sistemlerin çalışmasını gerektiriyorsa performans, görevlerin ayrı ayrı yapılmasıyla aynı oranda verimli olabilir. Buradan yola çıkarak, görsel-mekânsal görevin sapmayı tahmin edilebilir koşulda azaltmaması ve tahmin edilemez koşulda arttırması açıklanabilir. Önceki araştırmalar da araç kullanırken işitsel ikincil görevle uğraşılmasının yanal kontrol üzerinde anlamlı bir etkisin olmadığını gösterirken, görsel görevin olumsuz etkisi olduğunu göstermiştir (Kircher ve Ahlstrom, 2012; Thapa ve ark., 2015).

Çalışmaya katılan sürücüler düzensizlik arttığında daha iyi sürebilmek için 2-geri görev performanslarını düşürmemişlerdir. Normal trafik koşullarında sürücülerin yoldan gelen talep arttığında ikincil görevlerini geri plana attıkları bilinmektedir (Drews ve ark., 2008). Riskli koşullarda sürücüler ikincil görevi yapmayı reddetmiş ya da beklemeye almışlardır (Schömig ve ark., 2011). Bu çalışmada da, hem işitsel grubu hem de görsel-mekânsal grubu düzensizlik artsa da 2-geri görevine yüksek oranda doğru cevap vermişlerdir. Gerçek yol koşullarında hissedilen riskin simülatörde hissedilmemesi bu durumu açıklayabilir.

Önceki bir araştırmada aynı anda iki görevi yerine getirmede yetersiz bulunan sürücülerin araba sürerken cep telefonu kullandıkları belirtilmişti (Sanbonmatsu ve ark., 2013). Sürücüler direksiyon başındayken ek bir görevle meşgul olmalarının yarattığı riskin farkında olsalar da becerilerine güvendikleri durumda kendileri için bu riskin geçerli olmadığını düşünebilirler. Mevcut çalışmada, hem işitsel hem de görsel-mekânsal koşulunda yer alan motor becerilerini düşük algılayan sürücülerin şeritten en çok sapanlar oldukları görülmüştür. Bu önceki bulgularla aynı yönde değildir (Sanbonmatsu ve ark., 2013). Katılımcılar sürüş becerileri ile ilgili gerçekçi bir değerlendirmede bulunmuştur. İki çalışma arasında farkın kaynağı katılımcıların güvenlik algıları olabilir. Algısal motor becerileri düşük olan fakat güvenlik motivasyonları yüksek olan sürücüler zayıf becerilerini güvenli sürüş tarzlarıyla telafi edebilir. Sürücülerin direksiyon başında telefon konuşması yapmaları daha çok algıladıkları güvenlik becerileri ile ilgili olabilir. Araç kullanırken telefonda konuşanların hızlarını düşürdükleri ve güvenlik mesafelerini arttırdıkları geçmiş bir çalışmanın bulgusudur (Metz ve ark., 20015). Bu, sürücülerin ikincil bir görevle meşgul olduklarında trafik güvenliklerini tehlikeye attıklarının farkında olduklarını göstermektedir. Güvenlik becerileri gerekli durumlarda sürüşün ya da ikincil görevin adapte edilmesini yansıtabilir. Motor becerilerini yüksek algılayan ama düşük güvenlik becerisine sahip sürücüler trafik güvenliği açısından en yüksek riski oluşturmaktadır (Sümer ve ark., 2006). Mevcut çalışmada, motor algısı yüksek sürücüler simülatör senaryosunda şeritten daha az sapma gösterseler de, gerçek yol koşullarında becerilerine olan güvenleri düşük güvenlik algısıyla desteklenirse tehlikeli araç kullanabilirler.

Mevcut çalışmayı kısıtlayan bazı etkenler ileride yapılacak olan çalışmalarda giderilebilir. Hiyerarşik Kontrol Teorisi'nin kapsamını genişletmek için farklı yaş gruplarından ve farklı deneyim seviyelerinden olan sürücüler ile çalışılabilir. Bu çalışmada ortalama yaş 22.74'tür ve ehliyet alınmasından bu yana geçen süre ortalama 4 senedir. Bu derecedeki deneyim, iç döngü ve dış döngü işleyişindeki farklılıkları net bir biçimde ortaya koymayabilir. Ek olarak, algılanan sürüş becerileri ile şerit koruma arasında ilişkinin katılımcıların araç kullanma tecrübelerine bağlı olması mümkündür. Çalışmada motor becerilerine güveni az olan genç sürücüler en çok şeritten sapmayı gösterenler olmuştur. Deneyimle araç kullanmanın otomatik hale gelmesinden dolayı şerit koruma ve algılanan beceriler arasındaki ilişki tecrübeli sürücü örnekleminde farklı olabilir. Otomatikleşen performans öz-değerlendirmelerden etkilenmeyebilir. Gelecekte farklı deneyim seviyelerinde sürücülerle çalışılmalıdır. Yaşlanmanın iç-dış döngü ilişkisi üzerindeki muhtemel etkisini görmek için farklı yaştan sürücülerle de çalışılmalıdır. Çalışmanın bir diğer kısıtlayıcısı ise katılımcıların Orta Doğu Teknik Üniversitesi'nden seçilmiş olmalarıdır. Bu kitle genel sürücü topluluğunu yansıtmayabilir. Son olarak, ekolojik geçerlilik çalışmanın doğası gereği düşüktür. Gelecek çalışmalarda sürüş ortamının tahmin edilebilirliği virajlarla ya da yola fırlayan yayalarla manipüle edilebilir. Güçlü rüzgârlara nazaran bu tür senaryolar gerçeğe daha yakın olabilir.

Çalışma insan davranışının karmaşıklığını göstermektedir. Hiyerarşik Kontrol Teorisi literatürdeki çelişen çalışma sonuçlarına bir açıklama getirmektedir. Dikkatin sürüşten alıkoyulması sürüşe pek çok açıdan zarar verse de şerit tutma performansı iç döngüye dayandığından gelişebilir. Fakat trafik ortamı dinamiktir ve genellikle tahmin edilemezdir. Bilişsel yük şerit korumayı iyileştirse de tahmin edilebilir ortam şartları çoğunlukla gerçek trafikte değil de kontrollü deney ortamında sağlanabilir. Çalışmanın bir katkısı da bilişsel yük yaratan ikincil görevin türünün şerit korumada kilit bir faktör olduğu göstermesidir. Teori görsel yük açısından şerit tutma davranışını açıklayamayabilir. Uygulama açısından sonuçlar araç içi sistemlerin tasarım aşamasında göz önüne alınabilir.

Appendix J: Tez Fotokopisi İzin Formu

ENSTİTÜ

Fen Bilimleri Enstitüsü [ ]

Sosyal Bilimler Enstitüsü [X]

Uygulamalı Matematik Enstitüsü [ ]

Enformatik Enstitüsü [ ]

Deniz Bilimleri Enstitüsü [ ]

YAZARIN

Soyadı : Özbozdağlı

Adı : Seda

Bölümü: Psikoloji/Trafik ve Ulaşım Psikolojisi

TEZİN ADI: THE EFFECTS OF AUDITORY AND VISUO-SPATIAL SECONDARY TASKS ON LANE MAINTENANCE IN PREDICTABLE AND UNPREDICTABLE DRIVING CONDITIONS

TEZİN TÜRÜ: Yüksek Lisans [X] Doktora [ ]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. [ ]

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: