Driving Anxiety’s impact on Driving Performance and Skills: A mixed methods exploration

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Abstract

This thesis investigated the impact of driving anxiety on driving performance and its potential implications for road safety. While prior research has largely focused on individuals who have experienced road collisions, this research expands understanding by interviewing anxious drivers to comprehend their anxious driving experiences. A predictive model of driving anxiety was developed and tested within a large UK sample to assess its relationship with driving errors. Findings indicated a positive association between driving anxiety and errors, particularly those related to anxious driving behaviours. Key driving situations that evoke anxiety were also identified.

To explore whether driving anxiety affects drivers' attentional processes, hazard perception and reaction time were assessed across anxious and non-anxious driving situations. Results showed no significant differences in these measures between anxious and non-anxious drivers. However, anxious drivers reported heightened anxiety in stressful driving scenarios, and all drivers exhibited increased visual search behaviours in these situations, suggesting that such environments present more stimuli to process.

Subsequent studies evaluated anxious drivers' actual performance during driving tasks. Although anxious drivers committed more stalls, most other driving errors and violations required an interaction between anxiety and driving experience. This finding suggested that driving anxiety alone may not directly impair driving performance but might influence post-perceptual decision-making processes, rather than attentional mechanisms.

In conclusion, while driving anxiety is associated with increased driving errors, its effect on performance appears to be mediated by experience and decision-making processes rather than attentional deficits. These findings highlight that driving anxiety is based on self-perception of anxious driving individuals and provides a suggestion to target self-perception anxiety management to enhance road safety.

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Chapter 1: General introduction

For the past four and a half decades, road traffic injuries have remained a persistent and substantial public health challenge, as highlighted in reports by the World Health Organization (WHO, 2023). Despite concerted efforts to address this issue, the statistics regarding road traffic collisions have shown little improvement. Each year, an estimated 1.19 million lives are lost due to road traffic collisions, with an additional 20 to 50 million individuals sustaining injuries resulting in disability or non-fatal harm (WHO, 2023). These injuries continue to rank among the leading causes of morbidity, disability, and mortality globally, underscoring the urgency of effective intervention strategies. Numerous traffic safety programs and countermeasures have been implemented by governments and organizations worldwide over the past 45 years to mitigate the associated human and economic costs (Dragutinovic & Twisk, 2006; Fisa et al., 2022; Peterman, 2013). For example, In 2020, the UN General Assembly adopted the "Improving global road safety" resolution, proclaiming the Decade of Action for Road Safety 2021-2030, with the ambitious target of preventing at least 50% of road traffic deaths and injuries by 2030 (WHO, 2020). The WHO, along with their partners, the UN Road Safety Collaboration, aim to reduce road traffic deaths by improving the design of roads and vehicles, enhancing law enforcement, and providing timely provisions for the injured. However, despite these endeavours, road traffic injuries persist as a significant public health burden.

The WHO (2023) have identified several risk factors contributing to traffic collisions, including those related to human behaviour, infrastructure, vehicles, and inadequate law enforcement. In particular in England alone from 2022, human error has been found as the cause of 34.7% of road incidents which have led to a fatality of a collision (Department of Transport, 2023). Historically, Green and Senders (1999) corroborated this, citing human error as the sole cause in 57% of all incidents and a contributing factor in over 90%. Studies within the UK have underscored the predominance of human factors, accounting for 94% of road accidents, followed by road and environmental factors at 28%, and vehicle-related factors at 8% (Shinar, 2007). Additionally, a smaller-scale study conducted in China reaffirmed the dominance of human factors in road safety, surpassing 90% (Evans, 2004). The similarity in these proportions across studies is noteworthy and suggests a consistent pattern of the influence of human factors on global road safety.

To mitigate the impact of human error in driving, drivers must develop specific skills to ensure theirs and other road users' safety. These skills include the safe operation of a vehicle, which involves a broad range of knowledge, technical abilities, and perceptual and cognitive competencies necessary for effective driving. This proficiency is expected to adapt and improve with accumulated structured training, such as official driving lessons and regular practice (Elander et al., 1993). Central to this competency is the adept execution of diverse driving tasks, which necessitates a high degree of cognitive and psychomotor skills. Such components of driving competence include essential skills such as steering control, maintaining proper tracking of the road, and timely response to identified hazards (Lajunen et al., 2022). However, driving competence extends beyond these tasks. Some tasks that extend beyond essential skills include navigating varied driving environments while effectively managing complex situational demands (Dickerson et al., 2018). This encompasses the integration of perceptual skills to accurately assess the roadway, cognitive abilities to anticipate and respond to potential hazards, and psychomotor coordination to execute precise manoeuvres (Özkan et al., 2006). These skills are crucial for handling a car and are measured by the potential actions of drivers in particular traffic situations (Bener et al., 2006; Martinussen et al., 2014).

A notable distinction exists between motor skills and perceptual skills in terms of their learning trajectories and developmental timelines. While motor skills, involving physical capabilities such as steering and manoeuvring, can often be acquired and refined relatively quickly through practice, perceptual skills demand a more protracted period of cultivation and refinement (Lajunen et al., 2022). This discrepancy arises from the underlying nature of these skills: whereas motor skills primarily rely on physical dexterity, perceptual skills are intricately tied to higher-order cognitive processes (Üzümcüoğlu et al., 2020). Therefore, there is an opportunity for individual differences to intervene with cognitive capabilities, and more practice and training could be needed for a safe drive (Sümer et al., 2006; Xu et al., 2018).

Alongside perceptual-motor skills, safety skills are also essential when driving. Safety skills encompass a range of aptitudes crucial for anticipatory collision avoidance, reflecting a driver's capacity to execute driving tasks within the confines of their capabilities while pre-emptively mitigating risks. An individual exhibiting high levels of safety skills demonstrates adherence to traffic rules and regulations, exercises caution, and proactively avoids potential hazards on the road (Özkan & Lajunen, 2011). Research indicates an asymmetric relationship between safety skills and perceptual-motor skills in driving. Individuals with low safety skills often exhibit high perceptual-motor skills, leading to elevated crash rates and penalties (Lajunen et al., 2022; Sümer et al., 2005). This highlights the importance of drivers' awareness and perception of their own driving abilities. Cross-cultural studies have confirmed this relationship, emphasising its universal relevance (Özkan & Lajunen, 2006; Özkan et al., 2006; Özkan et al., 2006a; Sümer et al., 2006).

A variety of factors have historically been shown to influence the relationship between driving skills and driving behaviour. Key concepts in this area include driver experience, personality traits (Lajunen & Summala, 1995), age and age-related factors (Anstey et al., 2005; Shope & Bingham, 2008), gender differences (Oltedal & Rundmo, 2006), mood states (Garrity & Demick, 2001), aggression (Yang et al., 2022), intoxication

(White, 1989), distractions (Engelberg et al., 2015), and cross-cultural influences (Özkan & Lajunen, 2006; Ventsislavova et al., 2019). A number of studies have also examined drivers' subjective perception of their own skills. Evidence suggests that individuals who perceive their driving skills as superior may exhibit overconfidence (Lajunen et al., 1998). This is due to, self-deception which is the driver's over-confidence in their ability to make rational decisions. Self-perception in ones driving skills, have led to the widening of safety margins and an increase in traffic violations (Lajunen et al., 1998). This typically occurs for experienced drivers (Duncan et al., 1991). On the other hand, various groups may perceive their driving abilities as diminished or insufficiently developed. These groups include new drivers (Scott-Parker, 2012), individuals with impairments such as the elderly (Freund et al., 2005), and those who have experienced collisions or trauma (Senserrick, 2006). These findings underscore the importance of considering drivers' perceptions of their own abilities in understanding their behaviour on the road. Expectations on task difficulty and negative feedback from peers can impact the local confidence of an individual on subsequent tasks (Katyal et al., 2023). For example, if an under-confident driver makes an error while driving, this error could maintain their under-confidence in similar driving situations. Emotions such as anxiety and under-confidence are linked, with anxiety increasing the persistence of under-confidence (Katyal et al., 2023). The association between anxiety may also become more prominent with metacognitive judgements (Kaytal & Fleming, 2024). Although these individuals typically continue to drive, due to increased anxiety misbalancing cognitive processes, they may experience more unintentional aberrant behaviours related to driving (Azık, 2015; Moták et al., 2014).

The impact of emotions on driving

In recent years, an increasing body of research has shed light on the influence of emotions on driving behaviours (Pêcher et al., 2009; Trick et al., 2012). For example, drivers tend to focus on emotional advertisements for longer periods compared to neutral ones (Megías et al., 2011). Similar effects are seen with emotional words and images on roadside signs, which can lead to reduced speed (Chan & Singhal, 2013; Hancock et al., 2012), poorer lane control (Hancock et al., 2012; Jeon et al., 2014; Trick et al., 2012), and a decreased ability to recognise hazardous situations (Jones et al., 2014).

Driving behaviour appears to be influenced by specific emotional states. Higher risk taking, aggressive driving and violations of traffic rules seem to be specific for angry drivers (Abdu et al., 2012; Jeon et al., 2014) with Stephens and Groeger (2011) evidencing how manipulated anger through time pressure and enforced following of a slow-moving vehicle impacted speed and lane positioning. Drivers who had been impeded approached simulated hazards with less caution and attempted more dangerous overtaking manoeuvres.

Emotional states caused by stress have been shown to interact with the driving environment, impacting driving behaviours. For example, Scott-Parker et al. (2018) conducted focus groups ($n = 38$) to examine courteous and discourteous driving experiences, and to explore the impact of stress associated with such driving experiences. Road infrastructure, including roadworks, roundabouts, traffic lights, and posted speed limits, were identified as a source of driver stress. Additionally, external factors such as the behaviour of other road users, particularly discourteous or dangerous actions like tailgating, speeding, territoriality, and ignoring signage, frequently caused stress (Scott-Parker et al., 2018). When driving stress occurs, it can affect driving behaviour, often triggering emotional responses like anger, which can lead to risky behaviours such as driving aggressively. Stress can also lead to more cautious behaviours, such as pulling over to let other cars pass or acting apologetically, as stressed drivers may feel they are at fault. Another study by Dogan et al. (2019) examined the direct impact of stress on driving using a combination of physiological measures and questionnaires. The galvanic skin response data showed strong correlations with self-reported stress (87.5% accuracy), identifying stressors across six categories. Participants rated their responses from ‘I will drive normally’ (non-stressed) to ‘It is too stressful. I would not want to drive under this condition’ (high-stressed). Results showed that females exhibited higher stress responses overall, while inexperienced drivers (with less than two years of experience) were more stressed when driving on unfamiliar roads or after a stressful workday. Additionally, those who drove daily reported lower stress on unfamiliar roads compared to weekly drivers, who experienced higher stress levels. In an investigation into the relative impact of various sources of stress (life stress, work stress, environment stress) on driving outcomes, Rowden et al. (2011) demonstrated that extraneous stress factors were associated with three classes of violations, as measured by the driving behaviour questionnaire (DBQ; Reason et al., 1990). Their findings showed that general mental health and daily hassles were significantly associated with increased violations, lapses, and errors on the DBQ. Work stress was also positively correlated with these outcomes. Multivariate analyses further highlighted the connection between external stress and driving, with the Driver Stress Inventory (Brantley et al., 1987) factors 'negative affect' and 'risk-taking' strongly linked to higher levels of external stress. The study raised the possibility of stress "spillover" from other areas of life, such as work or home, into the driving environment. Bivariate analyses supported this, showing correlations between work stress, daily hassles, mental health symptoms, and Driver Stress Inventory factors, although it was noted that stress in driving could also influence stress in other aspects of life.

While stress has a noticeable effect on driving behaviour, it tends to be temporary, and its impact can fluctuate depending on the more or less stressful periods in a person's routine. Stress is often driven by external factors that are transient. Anxiety, on the other hand, can have a more lasting influence on an individual’s driving behaviour. Driving anxiety, in particular, can stem from internal stressors that are more persistent, resulting in a more permanent effect on how one drives. Research into driving anxiety has established a connection between anxiety and both driving errors and dangerous driving behaviours. Much of the existing literature has relied primarily on self-report surveys to assess these relationships. Dula et al. (2010), for instance, conducted an online survey of 1,121 students to explore how anxiety and sex differences influence driving behaviour. Their findings revealed that while sex differences were statistically significant for many of the dependent variables measured by the Dula Dangerous Driving Index (Dula & Ballard, 2003), the effect sizes were relatively modest ($\eta^2 = .10$). Interestingly, the study also demonstrated that higher levels of anxiety were linked to a greater propensity for dangerous driving behaviours, though the effect size for anxiety was similarly low ($\eta^2 = .07$). Despite the smaller effect size for anxiety compared to sex differences, Dula et al. (2010) argued that anxiety was a more significant predictor of dangerous driving outcomes. This was particularly important because individuals with higher levels of anxiety were found to have a significantly greater number of 'at-fault' crashes in the previous three years compared to those with lower anxiety levels. This suggests that even though the effect size of anxiety may be small, its real-world impact—specifically in terms of road traffic collisions—cannot be overlooked. Therefore, understanding and accounting for the variance in dangerous driving caused by anxiety is crucial for practical applications, such as improving road safety and reducing accident rates.

Moving away from a student sample, Shahar, (2009) focused upon self-reported driving behaviour as a function of trait anxiety in males aged between 22 and 50. The study identified a logarithmic effect, showing that risky driving behaviours increased more sharply at lower levels of anxiety than at higher levels. This suggested that once a certain anxiety threshold is reached, further increases in anxiety resulted in smaller increments in risky behaviours. This contradicted Dula et al.'s (2010) study which found that higher anxiety led to more dangerous driving behaviours. Shahar (2009) also found that errors and lapses were most strongly associated with high levels of anxiety. The study theorised that cognitive interference from worries related to anxiety reduced the available working memory for driving tasks, leading to more frequent mistakes. Driving violations also showed a positive relationship with anxiety, though this finding was more complex. The study speculated that high-anxious individuals might commit more violations due to reduced attention rather than deliberate rule-breaking. A notable aspect of the study was the positive correlation between anxiety and aggressive violations, though this correlation was weaker compared to errors and lapses. It was suggested that high-anxious drivers might display more aggressive behaviours due to lower emotional adjustment. However, the male only sample limits the generalisability of Shahar's study.

When the focus shifts to older adults, the implications of driving anxiety become more complex and far-reaching. Hempel et al. (2017) examined driving anxiety among young-older adults (ages 55–70) and found that it was linked not only to poorer mental and physical health but also to a diminished quality of life. These findings underscore the broader, real-world impacts of driving anxiety. For older adults, anxiety related to driving can lead to a reduction in driving frequency or even the complete cessation of driving altogether. This can, in turn, limit access to essential and meaningful activities such as visiting friends, participating in community events, or completing basic tasks like grocery shopping or attending medical appointments. The resulting isolation and lack of mobility may have profound negative effects on mental health and overall quality of life (Marottoli et al., 2000).

Moreover, the reduction in driving due to anxiety can significantly curtail an older adult's sense of freedom and independence. Losing the ability to drive often means having to rely on others for transportation, using public transit, or changing one's routine to accommodate alternative transportation methods. This loss of autonomy can further exacerbate feelings of helplessness and contribute to a decline in mental well-being (Chihuri et al., 2016). Taylor et al. (2011) found that among young-older adult participants who reported some degree of driving anxiety, many had begun to use alternative modes of transportation. Common substitutes included transportation provided by family or friends (31.1%), walking (24.5%), and public transit (16.5%).

Dula et al. (2010) argued that dangerous driving and collision rates are linked. If driving anxiety is linked to dangerous driving, then this gives credence to investigating driving anxiety and collision rates. Mann et al. (2010) found that when controlling for demographic factors, the odds of collision involvement significantly increased with higher depression-anxiety scores. Each unit increase in the depression–anxiety score was associated with a 5% increase in the odds of reporting involvement in a collision. A more recent study also found a similar a link between anxiety or mood disorder with self-reported collisions risk. Wickens et al. (2013) aimed to measure the association between anxiety or mood disorder and collisions due to the increased mortality rates of individuals with psychiatric disorder on the road. Using a longitudinal telephone survey, individuals with anxiety or mood disorder were 78% more likely of having a collision compared with a control sample. Both studies highlighted that anxiety amongst other mood disorders can have an impact on road collision rates. However, both studies were only able to look at anxiety in relation to other mood disorders, limiting the understanding of anxiety's sole impact on collision rates.

These studies have highlighted that anxiety may have an important role to play in relation to impact on dangerous driving behaviour at a younger age, moving to an issue with driving cessation, independence and quality of life as drivers get older. However, when focusing specifically on driving anxiety, the understanding of its impact on driving performance remains limited. Furthermore, the available literature has provided a limited knowledge of what driving anxiety is. Dula et al. (2010) measured driving anxiety using the Beck Anxiety Inventory (Beck et al., 1988). The Beck Anxiety Inventory had typically been used in clinical settings and can only measure clinical anxiety within the past week. Shahar (2009) used the trait subscale of the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) to measure driving anxiety. Although this subscale is reasonable to measure individual's predisposition to anxiety (Endler & Kocovski, 2001), there is a limited link between state-trait anxiety and driving anxiety. According to Barnard and Chapman (2018a), trait anxiety measured by the STAI is only able to account for the frequency of reactive behaviours, rather than the frequency of negative thoughts typical for anxiety. Finally, Hempel et al. (2017) did not use an officially validated driving anxiety scale, instead they used one question from Taylor et al. (2007) which asked how anxious participants felt about their driving, with anxiety being described as an "unpleasant feeling of nervousness or distress that may have no explanation." Responses ranged from 0 (not at all anxious) to 10 (extremely anxious) and were categorised as no driving anxiety (rating of 0), mild level of driving anxiety (rating of 1–4), and moderate to severe level of driving anxiety (rating of 5–10). Reliability and validity statistics were not reported. Therefore, while the studies have attempted to measure anxiety within a driving context, the measurement of driving anxiety as a concept has been lacking. In order to better measure driving anxiety, a holistic understanding of driving anxiety needs to be considered.

Defining driving anxiety

One of the main reasons for the inconsistent findings on the effects of driving anxiety is the ongoing debate regarding its definition, diagnosis and classification (Hidalgo-Muñoz et al., 2021). Terminology remains a significant point of contention utilised to explain driving anxiety across research and clinical domains. This inconsistency in terminology often leads to a conflation of driving anxiety with concepts such as driving fear or driving phobia, despite notable behavioural differences among these conditions (Jeon et al., 2014). Therefore, it is essential to disentangle the terminology and differentiate between driving anxiety, fear and phobia for a comprehensive understanding of how driving-related anxieties manifest.

The definition of driving fear can change dependent on the associated onset. Within the literature, driving fear has three distinct definitions. One definition of driving fear is in the context of panic attacks. Panic attacks are most frequently attributed to driving fear (Taylor & Deane, 1999) and can occur in both driving and non-driving situations. Another definition of driving fear is in the context of motor vehicle collisions (MVCs). After experiencing an MVC, post-traumatic stress disorder (PTSD) might develop, which often leads to avoidance and maintenance of driving fear (Fischer et al., 2020; Taylor et al., 2002). Finally, driving fear can happen in the context of phobias. In this context, driving fear is defined as an intense and consistent fear of driving a car for at least six months and driving is avoided at the cost of reduction in independence (American Psychiatric Association, 2013; da Costa et al., 2010; Taylor et al., 2002). While driving fear can occur with the context of phobia, the term ‘driving phobia’ is different to driving fear. The definition of driving phobia is dependent on the degree of impact on daily life activities (Agras, 1985; Bourne, 1990). The defining feature of driving phobia lies in the exaggerated and persistent nature of the fear response, leading to avoidance behaviours that significantly disrupt an individual's ability to engage in routine activities (Emmelkamp, 1982). Understanding these distinctions is crucial for accurate classification and appropriate interventions, as phobias represent a specific subset of fear responses that markedly impair an individual's quality of life and functioning. These classifications outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) provide a framework for clinicians and researchers to comprehend and address the diverse manifestations and implications of phobic conditions on individuals' mental health and daily functioning.

In contrast, anxiety is broadly defined as a feeling of tension or unease in response to the anticipation of a potentially threatening, but not guaranteed, event (Rachman & Wilson 2013). Anxiety and fear are known to be distinct constructs (Talisman, 2021). Fear is based on a conditioned stimulus which is in the environment, whereas anxiety is based on potential stimuli (Daniel-Watanabe & Fletcher, 2022; Davis et al., 2010). Driving anxiety builds upon Rachman and Wilson's (2013) definition by suggesting that anxious drivers may perceive their abilities as insufficient to deal with the potentially threatening driving environment, resulting in increased stress and use of emotion-focused coping (Lazarus & Folkman, 1984). Driving anxiety can manifest either as a temporary state based on specific driving situations which can heighten nervousness or as a more enduring personality trait which is based on dysfunctional thoughts that dominate anxious minds, such as worrying about having a collision or mortality (da Costa et al., 2014). Consequently, anxiety may reduce individuals' desire to drive, leading to diminished mobility and independence (Taylor et al., 2011). However, the difference between driving anxiety and driving phobia is that anxious drivers only reduce their driving, they do not stop driving altogether like individuals with driving phobia.

A number of studies have focused on identifying the key constructs that define and assess driving anxiety, recognising that it is a multidimensional phenomenon that spans both behavioural and cognitive domains. Research suggests that driving anxiety is not a singular experience but is instead influenced by a range of factors that can manifest in various ways, affecting an individual's thoughts, actions, and emotional responses while driving. In the behavioural domain, driving anxiety can be observed through several distinct patterns. A key study which investigated the behavioural domain of driving anxiety was Clapp et al. (2014). The first behavioural domain linked to driving anxiety was performance deficits, where individuals may struggle with tasks requiring decision-making which may result in errors.

Additionally, driving anxiety was often associated with exaggerated caution, where drivers may exhibit overly cautious behaviours such as driving at significantly reduced speeds (Clapp et al., 2014). Another key behavioural manifestation of driving anxiety was aggressive driving. Though it may seem counterintuitive, driving anxiety and aggression have been linked (Zinzow & Jeffirs, 2018) as individuals who feel overwhelmed or stressed in traffic often exhibit aggressive actions such as shouting, honking and gesturing (Deffenbacher et al., 2000; Lucidi et al., 2010). Finally, driving anxiety and avoidance behaviours are common. Stephens et al. (2010) found that driving anxiety was strongly related to avoidance of specific driving and riding situations measured by the Driving and Riding Avoidance Scale (DRAS; Stewart and Peter, 2004). Anxious drivers reported more avoidance behaviour than non-anxious drivers. Furthermore, the extreme driving anxiety group scored significantly higher on avoidance behaviour for general traffic as well as weather and riding, compared to moderate and mild anxiety groups.

In the cognitive domain, driving anxiety encompassed a range of intrusive and distressing thoughts (Ehlers et al., 2007). Ehlers et al. (2007) identified three distinct components within the cognitive domain. The first one was panic-related concerns, where individuals fear losing control of their vehicle or experiencing a panic attack while driving. These concerns often lead to anticipatory anxiety, making the act of driving—or even the thought of driving—a trigger for significant distress. Another cognitive factor was accident-related concerns, where individuals have an overwhelming fear of being involved in a collision, causing harm to themselves or others, or encountering hazardous road conditions. Finally, social concerns also played a role in driving anxiety. For some individuals, the presence of other passengers or other drivers on the road could amplify anxiety. They may worry about being judged by passengers for their driving abilities or fear causing an accident that could harm others.

The definition of driving anxiety used within this thesis aimed to incorporate both cognitive and behavioural domains linked to driving anxiety. Therefore, driving anxiety is a feeling of tension or unease in response to the anticipation of a potentially threatening, but not guaranteed, driving event (Rachman & Wilson 2013). The feeling of unease is linked to a range of intrusive and distressing thoughts (Ehlers et al., 2007) and negative driving behaviours (Clapp et al., 2014) that may lead to temporary avoidance (Stephens et al., 2010). This definition does not make assumptions on the impact of driving performance.

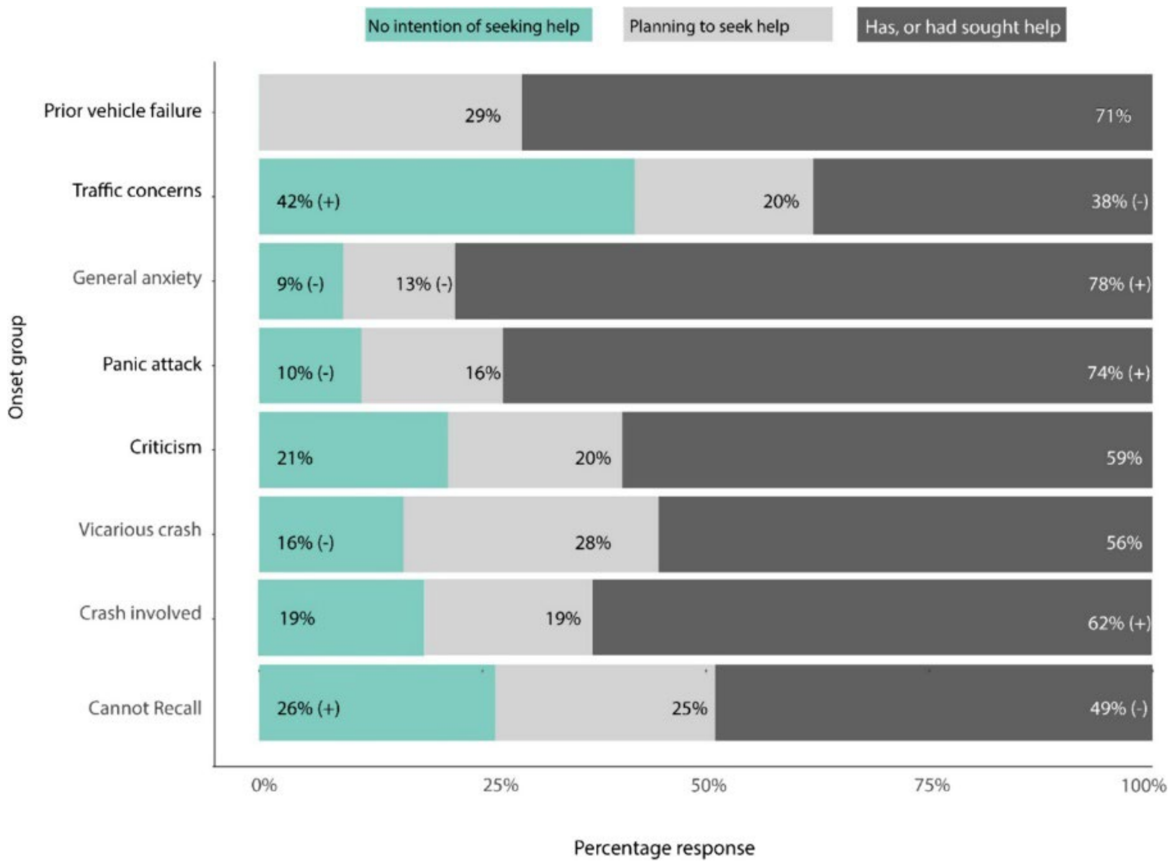
Origins and impact of driving anxiety

There is consistent evidence of the negative impact of driving anxiety on quality of life (Hempel et al., 2017; Stephens et al., 2024). Presently, humans have grown accustomed to motor vehicles to provide independence and mobility. Mobility is considered to be an essential factor for maintaining health and quality of life (Bauer et al., 2003). Driving anxiety, however, can significantly affect daily driving routines and lead to reluctance in driving (Hempel et al., 2017; Taylor et al., 2002), or driving avoidance overall (Stewart & St Peter, 2004). Driving avoidance may be partial, involving the avoidance of specific driving situations, such as dense traffic or highways. However, there is a possibility that driving anxiety could also lead to the total avoidance of driving. Higher levels of driving anxiety are associated with greater avoidance (Ehlers et al., 2007; Stephens et al., 2020; Taylor, 2018). Even if some alternatives to driving may exist (public transport, home service, cycling, etc.), avoidance can be very detrimental, particularly in areas with poor or no public transport services (Marottoli et al., 2000). Therefore, people may have limited access to important and enjoyable daily activities such as commuting to work, visiting friends, helping in the community, and satisfying basic needs such as shopping or accessing healthcare, which may affect their mental health and quality of life (Marottoli et al., 2000). This restriction on mobility can have a significant impact extending beyond mobility. Driving anxiety can not only make it more difficult for social interactions, or potential caring responsibilities, but, at a professional level, it also could make it difficult to carry out certain work-related activities (da Costa et al., 2014). While there is evidence to suggest that driving anxiety can impact work-related factors (Stephens et al., 2020), the effect is more noticeable with drivers who experience extreme driving anxiety (Fort et al., 2021). Overall, there is a consensus that driving anxiety can lead to avoidance of driving and by extension poorer quality of life in general (da Costa et al., 2014; Fort et al., 2021; Hempel et al., 2017).

At the end of the 19th century and beginning of the 20th century, anxiety disorders related to driving were thought to be based on traumatic events, such as road traffic collisions (RTCs) (Blanchard & Hickling, 2004; Taylor & Koch, 1995). For example, Taylor and Koch (1995) recognised that a RTC could lead to driving phobia and travel phobia under the combined title of "accident phobias". This research primarily focused on cases of severe anxiety that met the diagnostic criteria of the DSM-V. The anxiety was triggered by a previous collision and led to avoidance behaviours driven by the fear of being involved in another accident (Kuch et al., 1991; 1994). Therefore, earlier research suggested that severe driving anxiety primarily developed from an initial collision which could lead to immediate driving cessation, leading to a bleak future for individuals with driving anxiety. Studies on driving and accident phobia in crash victims are useful to some degree, but the experience of driving anxiety is not always related to a crash or near-miss (e.g., Clapp et al., 2011), so this body of work only partially addresses the scope and impact of driving anxiety in the population. Furthermore, any treatments to help with such severe anxiety may not have been appropriate for the rest of the driving anxiety population.

More recently, the trajectory of research in this domain has transcended this narrow scope. It is widely acknowledged that driving anxiety extends beyond its association solely with RTCs. Studies have progressively evidenced that driving anxiety could originate without having experienced a road traffic collision (Ehlers et al., 1994; Munjack, 1984; Stephens et al., 2024; Taylor et al., 2007), with a wider scope of understanding of what driving anxiety is considered to be. Some people with driving anxiety do not know where their onset of driving anxiety has come from. In a study on help-seeking behaviour for driving anxiety, Stephens et al. (2024) surveyed 1,314 participants through an online questionnaire. Half of the respondents (50%) were unable to recall when their driving anxiety began or could not specify its origin. Among those who could identify the cause, the most common reasons were: involvement in a crash (24%: 14% directly involved, 10% indirectly), criticism from others, particularly during the learning phase (9%), experiencing a panic attack while driving (7%), general anxiety disorder (5%), concerns about traffic (4%), or a previous negative vehicle-related experience, such as a breakdown (1%). See Figure 1 for more information.

Figure 1: *Percentage of help seeking behaviour across driving anxiety onset NB: rounding errors apply; () denotes adjusted residuals +/- with '-' indicating under-represented and '+' indicating over representation within onset group (Stephens et al., 2024). Reprinted with permission.*



Some individuals experience driving anxiety in specific situations, such as certain weather or traffic conditions. While some may feel mild anxiety or reluctance to drive, others may completely avoid driving or riding in a vehicle. Many people fall somewhere between these extremes. The specific fears can vary, with some fearing accidents, getting stuck in traffic, or criticism from others about their driving. For others, the anxiety may involve a combination of these cognitions, blending features typically associated with different types of anxiety (Ehlers et al., 1994; Taylor et al., 2000; Taylor et al., 2007).

As driving anxiety becomes more widespread, often stemming from concerns about traffic, general anxiety, or fear of social judgment, it has gained increasing attention in the literature. Recent studies conducted across the world have shed light on the prevalence of driving anxiety in the driving contexts. Taylor's (2018) research conducted in New Zealand with a sample of 441 participants found that approximately 52% of the sample reported experiencing mild forms of driver anxiety, whereas 16% reported moderate to severe driving anxiety. This finding emphasised the potential widespread nature of driving-related anxiety concerns among individuals in New Zealand. Moreover, a study conducted in France by Fort et al. (2023) observed varying degrees of driving anxiety among a substantial sample size of 5000 participants. The study indicated that 37.6% of drivers experienced mild driving anxiety, while 30% reported moderate driving anxiety, and 32.4% had severe driving anxiety. This comprehensive examination of driving anxiety across different severity levels further accentuates the prevalence of driving anxiety faced by drivers in France. The prevalence of driving-related anxiety across distinct geographical regions could suggest that driving anxiety may be universal. Nonetheless, more research needs to be conducted to determine prevalence rates of driving anxiety across the globe.

Of the individuals who do have some form of driving anxiety, certain demographic factors, such as gender, seem to be associated with driving anxiety. According to Taylor

(2018) women (60%) were significantly more likely to have driving anxiety than men (40%). This finding corroborates with other studies which found similar findings for sex differences related to driving anxiety (Fort et al., 2023; Taylor et al., 2011). Although research is limited on why women have a higher prevalence of driving anxiety than men, one explanation could be due to driving stereotypes in which women are perceived to be more cautious drivers, but also as having poorer driving skills and lack of self-control (Degraeve et al., 2015; Granié & Papafava, 2011). It is known that stereotypes may impact the perceived driving skills and the way people are prone to talk about the extent of their weaknesses according to their gender (Özkan et al., 2024). Furthermore, women are more prone to anxiety disorders than men, and this finding could suggest that women are more prone to driving anxiety (Farhane-Medina et al., 2022). Although there is agreement of sex differences for anxiety with women showing a higher prevalence of anxiety than men (See Craske, 2003), researchers have not shown the same level of consistency for age differences. For example, Taylor et al. (2018) found that adults over 70 years of age had the highest level of driving anxiety which further increased after 80 years old. Due to the age range, driving anxiety was attributed with retirement, disability, health, and loss (Taylor et al., 2011). Older people can start to feel that driving is a source of stress and insecurity, and this type of anxiety or low confidence, rather than the effects of ageing, is an independent predictor of driving self-regulation (Gwyther & Holland, 2012). However more recently, Fort et al. (2023) found a negative correlation between age and driving anxiety. It was found that as the population grew older driving anxiety reduced in intensity. Fort et al. (2023) argued that drivers may become more confident with time and the acquired driving experience. These contradictive findings suggest that further research should be conducted to determine the relationship between age on driving anxiety.

Among individuals who experience driving anxiety, it has been found that this anxiety can negatively impact their driving performance. Some studies have suggested that driving anxiety has a negative impact on driving skills and impairs driving performance. Shoham et al. (1984) found that driving anxiety was significantly associated with traffic offences. It was concluded that anxious drivers are more prone to traffic offences due to the conflict between emotional reactions and the need for rapid decision-making increasing the risk of a collision. However, the results of this study should be interpreted with caution due to the single self-report measure and the fact that the original paper does not provide example items of such traffic norms. More recent research has suggested that driving anxiety can contribute to an increase in driving errors (Taylor et al., 2007). In Taylor et al.'s (2007) study, participants underwent an on-road driving assessment using the Advanced Driver Assessment with a professional instructor. This 40-minute evaluation included at least 20 minutes in medium to heavy traffic conditions. Drivers' skills were observed across four main areas—search, hazard identification, manipulating controls, and observing traffic regulations—across seven different driving scenarios. Error frequency for these skills was recorded using a standardised grid form. An error pattern was operationally defined as three or more errors in any box or vertical column (Harwood, 1992). The study found that anxious drivers made more errors than the control group during the assessment. However, the types of errors were consistent across both groups, suggesting that anxiety affects the frequency rather than the nature of driving errors. However, since the study used an all-female sample, it is difficult to determine whether the nature of the errors was influenced by gender. Controlling for gender may have revealed differences in both the frequency and type of hazards encountered.

In contrast, some studies have concluded that there is no relationship between driving anxiety and driving skill. For example, Jeon et al. (2014), measured the impact of affective emotions on both subjective risk and driving performance. Subjective risk judgements were measured using three questions: (1) How do you think about your confidence level for driving? (2) How much do you feel there is an accident risk in your driving? (3) Do you think your driving is safer than other drivers at same age and gender? To assess driving performance, the study used a driving simulator and measured eight types of errors into four performance categories (Jeon et al., 2014). Error data were collected by system logging and manually by a real-time judge who was present at all times. Deviations from the centre line and side-lines were combined into ‘‘Lane Keeping’’. Violations of stop signs, red lights, and turn signals were categorised under ‘‘Traffic Rules’’. Exceeding the speed limit and flooring the gas pedal, were included under ‘‘Aggressive Driving’’. The total number of collisions was categorised under ‘‘Collision’’. Anxiety was found to increase levels of subjective risk, but did not result in a statistically greater amount of driving errors compared to controls. This study was the first to demonstrate the difference between perceived risk and objective driving error in drivers who experience driving anxiety (Jeon et al., 2014). There is support for the idea that some people underestimate their skills and abilities (Ehrlinger & Dunning, 2003), while others fail to recognise their lack of skill or overestimate it (Dunning et al., 2003). Self-perception of driving skill may therefore be important, and anxiety could be one reason for an unrealistic or inaccurate self-view. However, a limitation of Jeon et al.'s (2014) is that the terms anxiety and fear are used interchangeably. This makes it difficult to understand which emotion was measured, limiting the clarity of the results.

Other studies have also found mixed results regarding anxiety's impact on driving performance. For example, Barnard and Chapman (2018) conducted two experiments which attempted to manipulate state anxiety of participants and measured their state anxiety via the STAI. State anxiety was manipulated by informing the experimental group that the motion base of the simulator needed to be activated so the stairs connecting the simulator to the ground needed to be removed. Additionally, the experimental group were made aware that if the fire alarm sounded, the stairs would not be in place, and they would have to wait for a researcher to collect them and use the emergency escape ladder instead. For the first experiment, state anxiety was manipulated. Anxious and non-anxious participants drove on a single section of motorway with traffic in a driving simulator while their eye movements were measured. Despite increases in state anxiety, there were no differences in driving behaviour. Experiment two failed to manipulate anxiety between the control and experimental group. This suggested that the experimental group were not anxious about the removal of the stairs or the fire alarm sounding. For experiment two, while state anxiety was not manipulated, there was an interaction between state anxiety and visual complexity levels on lane positioning. When visual complexity was low, state anxiety was associated with decreased deviation of lane positioning. When visual complexity was high, increased state anxiety was associated with increased deviation of lane positioning. This could suggest that state anxiety leads to a reduction in top-down attentional control in driving.

Finally, some studies have also found that anxiety can have facilitative or positive effects that are specific to driver behaviour and driving skills (Kottenhoff, 1961; Payne & Corley, 1994; Ulleberg & Rundmo, 2003). For example, Ulleberg and Rundmo (2003) measured personality traits that have been demonstrated to have a significant relationship with risk-taking behaviour in traffic or involvement in traffic accidents in previous research (see Hilakivi et al., 1989; Jonah, 1997; West et al., 1993). Adolescents scoring high on trait anxiety, were more likely to have a positive attitude towards traffic safety and were less likely to report risk-taking in traffic. The link between trait anxiety and behaviour in traffic may be due to the fact that anxious individuals are characterised by the tendency to be fearful and nervous. Pertaining to traffic situations, this may cause an anxious driver to be more aware of the risk of collisions, hence being more careful and defensive when driving. Anxiety has been reported to elevate the state of vigilance and heightened sensitivity to potential threats (Fan et al., 2005; Posner & Rothbart, 2007), resulting in enhanced ability to identify hazardous situations (Mao et al., 2023). The variety of results from these studies suggests that driving anxiety’s impact on driving performance and skills is contentious, with further research required to understand these discrepancies.

Theoretical foundations of the impact of driving anxiety on driving behaviour

Whilst no specific theory exists to address the role of driving anxiety on driving behaviour, anxiety has been observed to impact various cognitive processes across differing domains. For example, one prominent theory which considers anxiety's impact on cognitions is the cognitive avoidance theory of worry (Sibrava & Borkovec, 2006). In this theory the term worry follows a similar definition of anxiety which is the “focus on possible, but non-existent, future bad things that might happen” (Sibrava & Borkovec, 2006, p. 240). This theory is grounded within the clinical Generalised Anxiety Disorder. The theory proposes that worry functions as a cognitive avoidance strategy to cope with emotional distress and negative affect. Worry is seen as a repetitive, verbal-linguistic thought process about potential future threats. It is primarily abstract and involves thinking about “what if” scenarios, rather than directly facing emotional or sensory aspects of feared outcomes (Borkovec et al., 1998). Worry, according to this theory, prevents the emotional processing of fear by keeping thoughts in a verbal-linguistic mode, which reduces the vividness of mental images. By doing so, it decreases the emotional intensity that would normally arise from imagining the feared outcomes vividly (Borkovec, et al., 2004). Worry provides short-term emotional relief by allowing individuals to cognitively avoid fully confronting distressing thoughts or situations. However, this avoidance prevents full emotional processing, which may maintain or even exacerbate anxiety in the long term (Borkovec & Roemer, 1995). The avoidance of emotional distress is negatively reinforcing, meaning that individuals are more likely to continue using worry as a coping mechanism because it temporarily reduces emotional discomfort. However, this can lead to chronic worry and anxiety disorders because the underlying fear is never fully addressed (Newman & Llera, 2011). Although the cognitive avoidance theory of worry

(Sibrava & Borkovec, 2006) is useful in providing a general understanding of how worry can provide short term relief by avoiding situations, the theory does not consider task performance. Driving as a concept is a complex task which requires complex information processing within a moving environment. Therefore, theories which consider complex information processing need to be considered.

A key study which explained how anxiety could impact the processing of threat-related stimuli was conducted by Sussman et al. (2016). Key findings of this study suggested that anxiety alters the way individuals process threatening stimuli through both top-down and bottom-up mechanisms. Bottom-up processing is automatic and driven by the salience of a stimulus (e.g., a sudden threat) (Davis et al., 2010; Grupe & Nitschke, 2013; LeDoux, 2015). Bottom-up processes involve structures like the amygdala, which rapidly processes threat cues and communicates with sensory areas of the brain to enhance threat perception (Cunningham & Brosch, 2012; Sander et al., 2003). In individuals with anxiety, the amygdala is more active, leading to heightened sensitivity to threats (Cisler & Koster, 2010; Dolan, 2002; Ohman, 2002, 2005). In contrast, top-down processing involves prior knowledge, expectations, and goals that shape perception and attention before encountering the stimulus (Gregory, 1968; Summerfield et al., 2006). When anxiety is present, threat-related stimuli are more likely to be prioritised due to a bias towards detecting potential dangers, but this prioritisation is not solely driven by the physical properties of the stimuli (bottom-up) as expectations and anticipations (top-down factors) also play a critical role (Bar-Haim et al., 2007; Cisler et al., 2009). The interaction between bottom-up and top-down processes is impacted by anxiety as bottom-up threat detection can be exaggerated, while top-down control (e.g., ability to focus on non-threatening stimuli) can be weakened. This interaction leads to increased attentional biases towards threat and difficulty disengaging from threatening stimuli. However, this theory has not been applied to a driving context and within a driving context, the capacity to attend to driving stimuli may depend on some degree on the severity of anxiety.

In the driving context, anxiety affects the ability to process information, and its impact depends on the severity of the anxiety (Silverstone, 1988). According to the Yerkes-Dodson law (Yerkes & Dodson, 1908), there is a curvilinear relationship between anxiety and performance. Moderate anxiety can increase threat detection, helping to identify potential hazards (Berggren et al., 2015; Mathews et al., 2003). This heightened awareness allows appropriate action when necessary (Walklin, 1993). However, as anxiety becomes more intense, it can impair skilled motor movements, complex intellectual tasks, and the ability to perceive new information (Andrews et al., 1994). High levels of anxiety can interfere with driving performance, increasing the risk of motor vehicle crashes (Silverstone, 1988). Anxiety about other drivers can also divide attention between oneself and task-relevant stimuli (Yinon & Levian, 1988).

Eysenck and Calvo (1992) introduced Processing Efficiency Theory (PET), which explains how stress and environmental stimuli affect cognitive task performance by increasing arousal. When distractions threaten goal completion, attention is allocated to identifying the source of distraction and developing a response strategy. If no strategy can be formed, state anxiety may increase over time. Attentional bias studies show that anxiety speeds up threat detection and causes individuals to focus more on threats, making it harder to shift attention away from them (Egloff & Hock, 2001; Mogg et al., 2000; Wilson & MacLeod, 2003). Individuals with high trait anxiety are particularly vulnerable to distractions, leading to negative effects on cognitive performance (Calvo & Eysenck, 1996; Hopko et al., 1998).

PET highlights how anxious thoughts interfere with task-related functions. As anxiety increases, worrying thoughts become more frequent, reducing the efficiency of cognitive processing and leading to performance deficits (Barnard & Chapman, 2018, 2018a). PET identifies two main effects of worry on cognition: 1) Worry reduces working memory capacity, limiting the resources available for task-relevant processing (Sari et al., 2017). Worry increases the effort needed to manage performance declines caused by worrisome thoughts (Crowe et al., 2007; Sari et al., 2017). PET distinguishes between performance effectiveness (accuracy) and processing efficiency (the resources and effort required to achieve a given level of performance) (Eysenck & Calvo, 1992). Anxiety can reduce processing efficiency even if performance effectiveness remains the same. Complex tasks may affect both performance and efficiency, especially in driving, where anxious individuals require more time to complete central executive tasks (Elliman et al., 1997; Ikeda et al., 1996).

PET helps identify how anxiety affects components of the information processing system, particularly working memory. Anxiety leads to task-irrelevant thoughts and allocates more resources to monitoring the environment (Eysenck, 1992). Anxious drivers may experience increased scanning, risk estimation, and attention to potential threats, reducing the resources available for critical driving tasks (Taylor et al., 2008). Using PET in a simulated rally driving context, Wilson et al. (2006) supports PET as a theoretical framework as it was found that increased anxiety had a negative effect on processing efficiency as indexed by the self-report, pupillary response and variability of gaze data. Although both groups of drivers performed worse under the threatening condition, the performance of the high trait anxious individuals was affected to a greater extent.

Eysenck et al. (2007) refined PET into Attentional Control Theory (ACT), which provides a more detailed explanation of how anxiety affects cognitive processing. According to ACT, anxiety disrupts attentional control, causing individuals to focus more on threats and less on task-relevant information. ACT targets specific central executive components that are significantly affected by anxiety based on Miyake et al.'s (2000) inhibition, shifting and updating components. Inhibition is where attentional control must be utilised to resist the effects of distraction from perceived threat stimuli. The second, shifting, describes how attentional control must adapt depending on the demands of the task. The third function, updating, describes monitoring and updating information in working memory.

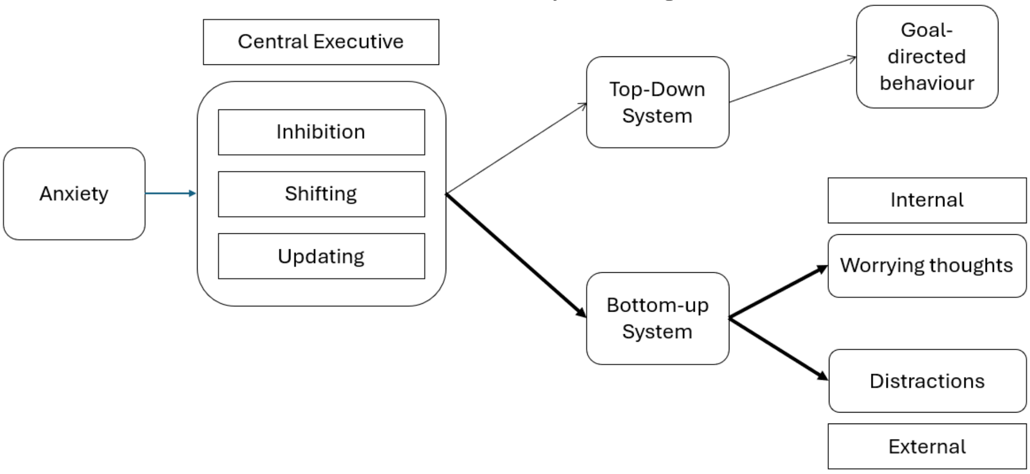
Some evidence suggests that inhibition is particularly important when resisting distractions from irrelevant stimuli (Friedman & Miyake, 2004), while shifting directs attention toward the task goal. Updating, however, is less affected by anxiety, as it deals with the temporary storage of information (Eysenck et al., 2007). Although these functions are somewhat interdependent, anxiety may affect one function, leading to potential impacts on the others (Collette & Van der Linden, 2002; Miller & Cohen, 2001). In driving contexts, heightened anxiety may lead to hypervigilance toward perceived hazards, compromising attention to critical driving cues (Schmidt-Daffy, 2012).

ACT assumes that anxious individuals are more likely to allocate cognitive resources towards threat-perceived stimuli instead of the central executive components, which leads to greater difficulty in disengaging. These threats can be internal (worrying thoughts) or external (environmental distractions), similar to PET. ACT is based on a dual attention system involving 1) top-down, goal-directed system affected by knowledge, expectations, and current goals, and 2) a bottom-up, stimulus-driven system focused on reacting to salient stimuli (Corbetta & Shulman, 2002; Petersen & Posner, 2012). Anxiety disrupts the balance between these systems, increasing reliance on the stimulus-driven system and reducing goal-directed control. A key distinction between ACT and the theory proposed by Sussman et al. (2016) lies in their conceptualisation of top-down processes. Sussman et al. (2016) argued that top-down processes involve both expectations and goals. In contrast, Eysenck et al. (2007) posited that top-down processes are solely based on goal-directed behaviour.

According to ACT, negative expectations are not part of top-down processing but are instead amplified through increased attention to bottom-up processes (See Figure 2).

ACT makes key improvements on PET when considering the driving context. Driving requires managing attention and shifting focus between numerous stimuli (e.g., traffic, pedestrians, signals). ACT explains how anxiety leads to attentional shifts toward perceived threats, which is crucial in driving situations, where quick and accurate attention to relevant stimuli is key. PET's broader focus on processing efficiency lacks this specific emphasis on attentional control and distractibility.

Figure 2: *A diagrammatic representation of Attentional Control Theory highlighting anxiety's impact on the central executive functions which lead to more attentional processing to bottom-up stimuli which can impact both internal negative expectations through worrying thoughts and external expectations in the environment which can lead to distractions from the goal directed task.*



Although ACT is a prominent theory used within attention research, ACT's influence on driving research remains limited. Only a handful of studies have looked at ACT and driving. For example, Wong et al. (2015) reported that increased anxiety can lead to an increased number of attentional lapses during self-reported driving performance on the Manchester Driver Behaviour Questionnaire (Lawton et al., 1997). The underlying logic posits that anxiety-prone drivers can accurately evaluate the difficulty of driving tasks. They may perform adequately when the task demands are high. However, during tasks with lower demands, they are more likely to make errors as their attention shifts from the driving task to their anxiety and the associated preoccupations (Matthews, 2002). Additionally, research indicates that elevated anxiety levels worsen task performance due to the increased consumption of attentional resources (Hardy et al., 2007; Sarason, 1998). More recently, anxiety has also been associated with prolonged attentional focus on stimuli within the driving context (Gotardi et al., 2019). Interestingly, the effects of anxiety appear to differ between experienced and inexperienced drivers. Anxious novice drivers tend to closely monitor other vehicles, while anxious experienced drivers are more focused on monitoring task-related goals, such as checking their speed (Gotardi et al., 2019). Although relatively few studies have examined the relationship between anxiety and driver performance, existing findings suggest a significant, albeit limited, connection between these variables.

In summary

Although there has been considerable interest in driving anxiety, knowledge of driving anxiety is limited. While there is more acceptance that driving anxiety is no longer based on RTC, there still seems to be a gap in relation to the origins of driving anxiety. This was recently evidenced by Stephens et al. (2024) as the origin of participants' driving anxiety was unspecified in 50% of the cases. While there is some evidence suggesting the types of situations where driving anxiety may originate (Stewart & Peter, 2004), these scenarios need further verification to determine if they can indeed induce driving anxiety.

The definition of driving anxiety has also been inconsistent (Jeon et al., 2014), leading to an inconsistency in measuring driving anxiety. Most studies have used state and trait anxiety exclusively to measure driving anxiety which does not capture driving anxiety effectively (e.g. Banyard and Chapman, 2018). This has resulted in inconsistent outcomes in relation to the impact of driving anxiety. Some studies have claimed that driving anxiety can facilitate driver behaviour through reduced risk-taking behaviours (Kottenhoff, 1961; Payne & Corley, 1994; Ulleberg & Rundmo, 2003). Other studies have suggested that driving anxiety hinders driving performance through increased traffic offences and frequency of driving error (Shoham et al., 1984; Taylor et al., 2007).

Research on driving anxiety and driving performance is also limited with mixed findings. This is due to differences in findings between studies that measured driving performance via self-report measures and more objectively via actual driving. In addition some studies have also claimed an impact of driving anxiety on driving performance without including actual anxious drivers in their study (See experiment two in Banyard & Chapman, 2018a). Other studies have looked at driving anxiety's impact on driving performance outcomes such as errors, speeding and braking. While anxious drivers may make more frequent errors (Taylor et al., 2007) there are inconclusive results on specific behaviour such as speeding and braking performance (Roidl et al., 2014; Stephens et al., 2015; Gotardi et al., 2019). In several studies, the type of sample used presents an additional challenge, as the impact on driving performance may be attributed to comorbid emotional conditions (Roidl et al., 2014; Stephens et al., 2015) rather than solely to driving anxiety. Consequently, there is a need for further research that specifically measures the exclusive effect of driving anxiety on driving performance.

Aims of the thesis

This thesis aimed to answer the overarching question of: Does driving anxiety have an impact on driving performance and skills? Although this is the primary aim of thesis, the literature has demonstrated that driving anxiety has been poorly defined and measured. To understand driving anxiety, one should talk to individuals who have driving anxiety. Therefore, the first part of this thesis sought to develop an understanding of the origins of driving anxiety and how individuals with driving anxiety perceive both their driving performance and overall experience as anxious drivers. Once this understanding of driving anxiety was established, the different dimensions of driving anxiety were measured. These dimensions were fitted in a predictive model to explore a possible relationship between driving anxiety and self-perceived driving errors. Self-reported driving error has been consistently linked to driving anxiety. Naturally, it was necessary to explore the impact of driving anxiety on actual driving performance and driving skill. For this end, driving situations that were found to trigger driving anxiety was included in the subsequent studies. The following studies focused on assessing the attentional and perceptual processes of anxious drivers during hazard perception performance and compared it against subjective and objective measures of driving anxiety. Actual driving behaviour such as braking, speeding, hesitation, collisions etc was also measured on a driving simulator to explore whether driving anxiety indeed has an impact on these skills.

The following subsidiary aims facilitated and supported the research questions of this thesis and helped answer the overarching research question:

1. To overcome the limited research on the origins and impact of driving anxiety by offering an in-depth exploration of anxious drivers' lived experiences.
2. To determine what driving scenarios, give rise to driving anxiety and the specific triggers that maintain it.
3. To develop a predictive model to assess whether the identified dimensions of driving anxiety can predict intentional and unintentional driving errors.
4. To assess whether driving anxiety has an impact on perceptual and attentional processes related to the ability to perceive hazards while driving.
5. To assess whether driving anxiety has an impact on post perceptual driving performance on a driving simulator and whether more stressful driving routes can induce more driving errors in comparison to less stressful ones.

Overview of the thesis

This chapter introduces the research topic, and the theoretical framework applied to the research programme documented in this thesis. This chapter (Chapter One) has introduced road safety literature and highlighted key statistics and risk factors within the area before moving onto the driving skills needed to ensure safe driving. The chapter then discussed the types of factors which can impact driving skills before focusing on the main topic area of driving anxiety and its inconclusive impact on driving skills. The inconclusive impact of driving anxiety could be due to the lack of driving anxiety definition. Therefore, existing definitions of driving anxiety and similar conditions were discussed before providing a definition for the thesis. While the definition of driving anxiety has been inconclusive, research has agreed that driving anxiety does have an impact on the quality of life through the reduction of independence and mobility. The chapter then explored how driving anxiety can affect driving behaviour, drawing on theoretical frameworks such as Processing Efficiency Theory and Attentional Control Theory, before presenting the rationale for the thesis. Lastly, the chapter outlined the aims of the research and previewed the content to be covered in the subsequent sections of the thesis.

Chapter Two will highlight the types of methodology used in this thesis. As this thesis employed a mixed methods design, the ontology and epistemology of the qualitative portion of the thesis will be introduced before moving onto the research design of the thesis, emphasising the types of methods such as semi-structured interviews, questionnaires, eye-tracking equipment, physiological equipment, and the driving simulator.

Chapter Three details study one which explored what driving anxiety is, as well as its inception and sustaining factors. This study addresses aims one and two. Semi-structured interviews were utilised with anxious driving individuals to gain an understanding of driving anxiety from the anxious driver's perspective. Their experiences were interpreted in light of the Attentional Control Theory and the existing driving anxiety research.

Chapter Four details study two which explored whether driving anxiety is associated with driving error through different driving anxiety components identified in the previous study. This study addressed aim three of the thesis. A large-scale online questionnaire was administered using valid and reliable driving anxiety and driving error measures while moderating for driving experience and controlling for age.

Following the outcome of study two, Chapter Five details study three which utilised a face-to-face experimental design to measure driving anxiety's impact on perceptual and attentional processes relating to the ability to perceive hazards. Eye-movements, reaction times and physiological responses to hazards were recorded. At the time of study three, the UK had entered a roadmap to recovery from COVID-19 and legal restrictions on socialisation and social distancing that were implemented during national lockdowns were easing (Institute for Government Analysis, 2022). This allowed for face-to-face experimentation, however additional risk assessments had to be put in place which delayed data collection for the study.

Following the outcome of study three, Chapter Six details study four which investigated the types of situations which can lead to driving anxiety. Two simulated CGI driving routes were used: anxious and non-anxious. The non-anxious route was based on a country drive with limited traffic and no anxious driving situations. The anxious route was based within a city centre with complex junctions, heavy traffic, narrow roads, and tailgating. The aim was to measure driving performance between anxious and non-anxious drivers alongside the impact of the routes on driving performance.

Following Chapter Six, Chapter Seven provides an overall discussion of the research presented in this thesis. Discussions on how the research aims were met, and how each study builds upon the other are present. The implications of the research, the potential applications, and the potential impact of the project are discussed. The strengths and limitations of the thesis are discussed before presenting future thoughts.

Chapter 2: Methodology

Chapter overview

This chapter will commence with a concise overview of the specific methodological choices adopted in this thesis. Although each subsequent study will include its own method section, this chapter will explain overarching considerations and shared methodological approaches for comprehensive reference.

Methods used in this thesis

For the purposes of this thesis, several methods were used. Qualitative methodology using thematic analysis were implemented to understand how driving anxiety impacts the ability of drivers to perceive and react to hazards. The first study adopted a qualitative approach to understand the individual experiences of anxious drivers and delve into the reasons behind their driving anxiety, as well as what specific situations trigger their driving anxiety. Due to COVID-19 limiting face-to-face research, a large-scale online survey was employed for study 2 to assess the relationship between self-reported driving error and driving anxiety. After developing safety protocols for in-person testing and obtaining permissions for it during the COVID restrictions, Study 3 adopted real-world video-based hazard perception stimuli and measured eye movements, as well as skin conductance response to determine whether anxious participants differ in their hazard perception performance compared to non-anxious participants. Finally, study 4 featured a driving simulator to measure complex driving behaviour such as speeding, braking, stalling, hesitation, and collisions in both anxious and non-anxious drivers during two different routes to find out whether the type of driving environment (anxious vs non-anxious) has an impact on the driving behaviour of anxious vs non-anxious drivers.

This chapter will describe each one of the methods used in this PhD, providing a brief rationale for the inclusion of each method.

Qualitative research philosophies

Philosophical assumptions and research paradigms play a pivotal role in determining the most suitable research methodology (Kivunja & Kuyini, 2017). Research paradigms encompass philosophical perspectives concerning the nature of reality and knowledge (Creswell et al., 2007), rooted in varying ontological and epistemological beliefs (Madill et al., 2000).

Ontology, a branch of philosophy, concerns the study of reality (Tubey et al., 2015). Researchers form ontological assumptions regarding what they believe to be real and how they perceive reality (Kivunja & Kuyini, 2017). These assumptions influence the researcher's perspective and approach to studying their subjects. In this thesis, the primary ontological assumption is realism, which posits that there is a single, objective reality independent of individual perceptions (Al-Ababneh, 2020; Ryba et al., 2022; Saunders et al., 2015; Sobh & Perry, 2006). Realists acknowledge that while individuals may perceive reality differently, there is a fundamental, shared reality underlying these varied perspectives (Al-Ababneh, 2020; Sobh & Perry, 2006).

Realists contend that the real world is accessible through probabilistic means, acknowledging the inherent complexity and diversity of human experiences (Braun & Clarke, 2021; Michell, 2003; Sobh & Perry, 2006; Williams, 2003). The objective of research for realists is to generate a range of insights that collectively capture the multifaceted nature of reality (Sobh & Perry, 2006). Given the existence of an external reality, realists recognize the value of theory in interpreting individuals' perceptions of reality, as well as the importance of building on existing research and experiences to advance understanding (Emmel et al., 2018; Sobh & Perry, 2006; Williams, 2003).

Alongside ontology, epistemology focuses on the study of knowledge and addresses how knowledge is acquired and what qualifies as knowledge (Fazlıoğulları, 2012; Kivunja &

Kuyini, 2017). Our epistemological position shapes our understanding of legitimate forms of knowledge generation in research (Saunders et al., 2015). The research in this thesis adopts a contextualist epistemology, which views knowledge of reality as contextually situated, partial, and perspectival (Braun & Clarke, 2021; DeRose, 1999; Madill, 2000). Contextualism acknowledges that participants and their knowledge cannot be divorced from their context, recognising the existence of multiple versions of reality without assigning superiority to any particular perspective (DeRose, 1999; Lloyd, 2023). This perspective aligns with a realist ontology, which acknowledges the potential for multiple worldviews of a single reality (Braun & Clarke, 2021; Michell, 2003; Sobh & Perry, 2006).

Qualitative research methods

Semi-structured interviews and open answer questions in an online survey aided data collection. Study one utilised semi-structured interviews, study two utilised a survey consisting of both quantitative and qualitative questions.

Semi-structured interviews

The Transport psychology literature often adopts mixed methods research and qualitative research (Jamshed, 2014). Semi-structured interviews are a useful and frequent data collection method in this type of research (See Mars et al., 2016).

Semi-structured interviews include open and structured questions, allowing for deeper exploration of participant responses through follow-up questions (Adams, 2015; Doody & Noonan, 2013; Knox & Burkard, 2014). An interview schedule is often developed to collect participant responses on a targeted research area of interest (DeJonkheere & Vaughn, 2019; Kallio et al., 2016). Semi-structured interviews offer several advantages compared to unstructured and structured interviews, such as being flexible, iterative, inclusive of individual participants or groups, and provide deep exploration of participant thoughts and experiences (Adams, 2015; DeJonkheere & Vaughn, 2019). For example, researchers can explore new topics of interest that arise during the interview which may have been overlooked previously (Doody & Noonan, 2013). However, Doody and Noonan (2013) recognise novice researchers may not know when to probe responses resulting in relevant data not being captured. This suggests semi-structured interviews require a certain level of skill or competence and planning, to effectively capture rich and relevant data, as indicated by Adams (2015).

Typically, semi-structured interviews last between 30 minutes to one hour, are audio-recorded for reliability (Jamshed, 2014) and are suitable for a variety of participant types (Adams, 2015). Regarding sample size, DeJonkheere and Vaughn (2019) suggest semi-structured interviews can provide meaningful data from small sample sizes consisting of eight to twelve participants. Generally, there is no hard guidelines for determining qualitative sample sizes, although saturation of data is often considered the endpoint for qualitative research (DeJonkheere & Vaughn, 2019). Saturation of data occur when new themes emerge from the data with the addition of participants (Glaser & Strauss, 1967), although how this is achieved has been contested and recommendations proposed for reporting data saturation (see Francis et al., 2010).

Qualitative surveys

Study two utilised an online survey containing both quantitative and qualitative items. Qualitative surveys consist of open-ended questions and collect in-depth responses on a topic (Braun et al., 2021; Riggle et al., 2005; Zuell et al., 2015). Qualitative surveys are flexible, affordable, cost effective, accessible over geographical boundaries, and provide access to a range of participant views and experiences (Braun et al., 2021). However, qualitative questions in surveys may lead to higher non-response than closed questions (Zuell et al., 2015), due to the effort required to construct an answer. There are also concerns surrounding clarity of questions, privacy, digital exclusion and literacy when conducting online qualitative surveys (Riggle et al., 2005). Should participants misunderstand the question being asked, this can impact responses provided (Braun et al., 2021). Furthermore, unlike interviews, qualitative questions in online surveys cannot be explored further (Ball, 2019). For surveys collecting qualitative data, sample sizes tend to be larger than standard qualitative data collection methods of interviews and focus groups. Braun et al. (2021) indicate a sample size between 20 to over 100 participants may be used, depending on the scope of the study.

Quantitative research methods

Quantitative surveys were used throughout the remaining three studies of the thesis after study one. Quantitative surveys were the main method in study two. Other than the quantitative surveys, each study used bespoke methods. Study three utilised hazard perception clips and measured eye movement behaviours. To measure driving anxiety objectively, physiological measures such as electrodermal activity (EDA) to produce skin conductance responses (SCRs) was used. Study four utilised a driving simulator with pre-designed driving scenarios to measure both anxious and non-anxious situations.

Quantitative surveys

The majority of driving anxiety research typically features surveys and questionnaires. Surveys investigate participant perceptions or experiences through set questions (Nayak & Narayan, 2019). In the context of driving anxiety, quantitative questionnaires were used to measure different dimensions of driving anxiety identified from previous research and findings from study one (See Chapter Three). These dimensions included generalised anxiety, anxious driving cognitions, anxious driving behaviours and driving avoidance (Clapp et al., 2011; Ehlers et al., 2007; Spitzer et al., 2006; Stewart & Peter, 2004). Often, multiple items are used to measure one variable or construct, however single item measures can also be utilised (Fuchs & Diamantopoulos , 2009). Multiple items tend to be from validated measures, but Fuchs and Diamantopoulos (2009) note use of multiple items in an online survey may risk overloading participants. Alternatively, single item measures reduce risks of overload but may not be validated.

Online surveys are useful for descriptive, evaluation, cross-sectional, and case control cohort studies (Nayak & Narayan, 2019). They are time effective, cost effective, flexible and convenient, and they overcome geographical boundaries (Ball, 2019; Evans & Mathur, 2005, 2018). Data entry and analysis are also easy through online surveys, and there is an increase chance of obtaining diverse answers from a larger sample size (Evans & Mathur, 2018). However, there are risks with conducting online surveys. Nayak & Narayan (2019) note researchers cannot be certain the sample population is from the targeted population in an online survey. Furthermore, online surveys also have ethical issues relating to privacy, anonymity, informed consent, and confidentiality (Evans & Mathur, 2018; Nayak & Narayan, 2019). There are also limited guidelines for determining an appropriate sample size. Ball (2019) recommends conducting sample size calculations to determine the minimum number of participants required, should statistical analysis be performed on the data. As an exploratory survey on a topic area that had limited published research, the researcher opted to utilise a sample size calculator provided by Qualtrics, the survey building software utilised for study three (Qualtrics, 2020). The parameters utilised were 95% confidence level and 5% margin of error. These are generally accepted standardised parameters (Lakens, 2013).

Qualtrics is an online survey tool designed for research and data collection purposes. It provides a user-friendly interface and offers over 85 question types, enabling researchers to incorporate multimedia content. Since Qualtrics collects data from participants in settings outside laboratory control, it includes various features to assess data validity. For instance, researchers can track the time participants spend on specific questions, monitor participant interactions such as clicking on question pages, and confirm whether questions were displayed to participants as intended. These tools help researchers ensure the quality and reliability of the data collected through the platform.

Eye movements

Eye-tracking is a useful tool to track participants' eye movements during driving, providing insights into their visual scanning behaviour. Two main types of eye trackers used in driving research are head mounted systems and remote eye-tracking systems. The first type contains cameras in helmets or glasses, while the second type has cameras mounted on the monitor. Desktop systems are typically more precise than head-mounted systems. For naturalistic driving research, dashboard-mounted cameras such as Smart Eye Pro are used, which are less accurate but do not require participants to wear them.

Modern eye tracking systems utilise infrared light to track gaze. The eye-camera extracts the pupil's blackness and determines the location of the reflected IR light within the pupil image, which can then be related to fixating objects in the real world (Penedo et al., 2023). This information is often represented by a moving cursor overlaid on a scene view captured from the participant's perspective.

Studies have investigated eye movements during driving, revealing that novice drivers tend to focus on a central point in their visual field and fixate longer on hazards compared to experienced drivers (Crundall & Underwood, 1998; Underwood et al., 2002). Furthermore, eye tracking has been used to assess training interventions aimed at improving hazard detection (Fisher et al., 2006). Novice drivers' glances at mirrors have been found to improve after six months of driving (Olsen et al., 2007). Peripheral vision is also important in driving as it monitors unexpected information from the sides (Crundall et al., 2012;) and helps maintain lane position (Land & Horwood, 1995).

Hazard perception clips

Video-based hazard perception clips were featured for this thesis as they offer the assessment of real-time decision-making in hazardous traffic situations that could be difficult or unethical to text during real driving. Hazard perception methodology is a consolidated method of assessing drivers’ hazard perception skills (Horswill, 2016). This method offers a cost and time-efficient alternative with non-staged or deliberately arranged hazards. Hazard perception clips allow for the measurement of specific aspects of the driving task in controlled environments while exposing participants to realistic, hazardous driving scenarios. The validity of these tests has been established (Crundall et al., 2012; Horswill & McKenna, 1999; Wetton et al., 2011), with studies showing a connection between strong hazard perception skills and lower collision rates (Drummond, 2000; Wells, 2008).

Spicer's (1964) study was the first to use hazardous video clips, which required participants to select important traffic features from a checklist. The study revealed that accident-involved drivers involved in a collision were less accurate than collision-free drivers in perceiving important traffic features. This technique has been replicated in numerous studies, such as Pelz and Krupat's (1974) lever adjustment task and Watts and Quimby's (1979) simulator study. McKenna and Crick (1991) developed an alternative version where participants watched videos and pressed a button every time, they identified a hazard. Accident-involved drivers performed worse than accident-free drivers in all studies. At the time of writing, there have been no video-based tests to measure driving anxiety’s impact on driving performance such as hazard perception. However, historically, driving anxiety has been linked to collision involvement, therefore this lack of accuracy may be found in anxious driver populations (Wickens et al., 2013).

Several studies have established a relation between collision rates and individuals' hazard perception scores (Cheng et al., 2011; Horswill et al., 2015). Notably, Horswill and

McKenna (1999) identified that a driver's speed choice, measured via video-simulation assessments, could predict prior speed-related collisions. Additionally, Hull and Christie (1992) underscored the potential hazards associated with drivers' judgment regarding the gaps between vehicles.

The investigation of eye movement behaviours through video-based tests has also yielded significant insights. Studies, including those by Mourant and Rockwell (1972) and Crundall and Underwood (1998), have delineated differing scanning patterns between experienced and novice drivers. Novices tend to maintain longer fixations on specific targets, while experienced drivers demonstrate shorter fixations and display an adaptive scanning behaviour tailored to diverse road situations. This distinction in eye movement behaviour underscores the adaptive nature of experienced drivers in contrast to the more focused yet potentially less flexible fixation tendencies observed among novice drivers.

Hazard perception stimuli have evolved substantially over the past 50 years, starting with 50 mm cine film (e.g., Spicer, 1964) and progressing to the use of photo-realistic computer-generated imagery (CGI) in the current DVSA test. These stimuli typically consist of clips of variable duration, often around 60 seconds, filmed from the driver's perspective, simulating a view through the windscreen of a moving vehicle. Some hazard perception tests used in research have been filmed with cameras mounted on the roof or bonnet of a car (e.g., Shahar et al., 2010), while others positioned the cameras inside the windscreen.

The format of hazard perception tests can also vary. The traditional format involves a single-screen video (e.g., McKenna & Crick, 1991). Other versions have expanded the field of view (Shahar et al., 2010), altered the type of vehicle used for filming (Crundall et al., 2012; Horswill & Helman, 2003), or included mirror information (Engström et al., 2005; Mackenzie & Harris, 2017; Recarte & Nunes, 2003; Savage et al., 2013). For this thesis, examples are drawn from Ventsislavova and Crundall (2018), where mirror information is added to the forward view. This design allows for the early detection of overtaking hazards, which was not possible with the traditional hazard perception test.

Filming hazard perception clips

Hours of hazard perception footage was already recorded by the transport research team and included in a database which contained videos from Nottingham and other parts of the UK. For this thesis, the existing footage was examined to identify hazardous and non-hazardous situations suitable for the aims of the study included in Chapter 5. This section will provide details on how this footage was filmed, synchronised and edited into short hazardous video clips, as well as how the scenarios of interest were identified. It should be noted that no footage was recorded specifically for this thesis.

Camera placement

Four cameras were mounted on the car to capture footage from the forward view, side mirrors, and rear-view mirror (see Figure 3). The rear-view mirror footage was recorded by a camera placed on the rear window. Finally, the right and left mirror information was captured by cameras were installed on the outside of the car, just below the side mirrors, to capture images typically seen in those mirrors. The driving footage was filmed in Nottingham by a native UK driver with a full driving licence. Filming occurred over several hours each day to capture a wide range of hazards.

From the raw pre-recorded footage, 24 UK video clips were designed specifically for study three of this thesis (see Chapter 5). The available footage was carefully examined by two experts in the field and clips were selected, each containing a hazard. For the thesis, a hazard was defined as: an event that causes the driver to either slow down, stop or change direction relative to the driver's previous action (Muttart & Fisher, 2016). All selected hazards represented typical situations that drivers might encounter on UK roads during everyday driving. None of the scenarios included in the UK clips were staged.

Figure 3: *This graphic from Ventsislavova (2019) represents the positions of the 4 cameras. The green arrows show the placements of the front and rear-view camera and the blue arrows the positions of the left and right cameras. Reprinted with permission.*

Editing, synchronisation and clip selection

Driving footage was edited and synchronised using Adobe Premiere Pro. The footage from the cameras capturing the mirror information was imported into Adobe Premiere and synchronised with the forward-view footage. A graphic overlay provided by the research group of the interior of a Ford Focus containing mirror placeholders was created in Adobe Photoshop and the synchronised footage was placed within this overlay. The overlay was generated from internal photographs of the Ford Focus which were stitched together in Photoshop. This overlay was designed using stitched internal photographs of the Ford Focus, with semi-transparent A-pillars and roof to simulate stereopsis and small head movements that allow drivers to access otherwise occluded information. For instance, when first in a queue of vehicles at a red traffic signal, the nearest signals might be hidden by the roof, requiring the driver to lean forward to see the light.

Clip selection was informed by the results of Chapter Three and Chapter Four (See Design Section of Chapter 5, p.146, for more information on all clip types with examples). During the editing process, the image quality of some clips was slightly enhanced, particularly by adjusting brightness for the UK clips, as cloudy weather resulted in darker images compared to real-world conditions. The forward view was captured using a medium-width lens, necessitating some anti-fisheye corrections. All clips were produced at a resolution of 1920x1080 with a frame rate of 30 frames per second. See Figure 4 for one example of a finalised clip showing an anxious hazardous situation on a high-speed road. For full details see the video editing protocol see Appendix B).

Figure 4: *Example of a finalised clip after editing and synchronisation of driving footage of each camera.*

Experiment apparatus

SMI RED 500Hz

To record eye-movement data, an SMI RED 500 system was used. This system included a suite of programs: I-View X to control the eye tracker, Experiment Centre to program and run the studies, and BeGaze to analyse the data. The sample frequency of the SMI RED 500 was 500 Hz, with an accuracy of 0.4 degrees and a headbox size of 39.9 cm x 20.1 cm. The system also collected behavioural responses, such as response times to hazards, through mouse clicks.

Participants were typically positioned 60 to 70 cm away from the computer monitor. The monitor used for the experiment measured 49 cm x 29.5 cm, with a resolution of 1920 x 1080. A four-point calibration was performed, where participants were instructed to follow a dot until the infrared light captured their pupils, allowing for gaze location calculation. Calibration had to be repeated multiple times if the system could not capture the pupil or if participants had difficulty following the dot correctly. In such cases, participants received guidance on how to follow the point, and calibration continued until it was successful.

Data analysis was conducted using BeGaze software. For each hazard, onset and offset were defined, and areas of interest (AOIs) were created for both precursors and hazards to capture fixations. Occasionally, the equipment failed to capture some fixations as smooth pursuits. A smooth pursuit occurs when participants gradually move their gaze across the screen while fixating on a moving object. These types of smooth pursuits often occur in driving as AOIs are not static and are often moving. If this movement happened within an AOI, the equipment did not recognize the fixation. To ensure valid participant data, these fixations were identified and calculated manually by subtracting the hazard onset from the start time of the fixation (measured in milliseconds) and dividing the result by the duration of the hazard.

Biopac MP160

To measure Electrodermal Activity (EDA), the Biopac MP160 Module alongside the Bionomadix Wireless Photo Plethysmogram and EDA transmitter was used as data acquisition hardware. The Bionomadix is a wearable device designed for continuous, real-time data acquisition. To connect the Biopac to the participant, the transmitter was strapped onto the wrist of the non-dominant hand and electrodes were attached to the second and third finger of the left hand using pre-lubricated GEL101A electrode gel on EL509 electrodes. The reason the non-dominant hand was selected so that participants were still able to perform experimental tasks such as the response to hazards. To measure skin conductance responses (SCRs), the device applied an external low voltage to the skin. Figure 5 demonstrates the placement location for the two electrodes used to measure SCRs and Figure 6 shows a real-life example.

Figure 5: *Electrodes sites on the palm for measurement of skin resistance and skin potentials (A and B). Adapted from Martin & Venables (1980). Reprinted with permission.*

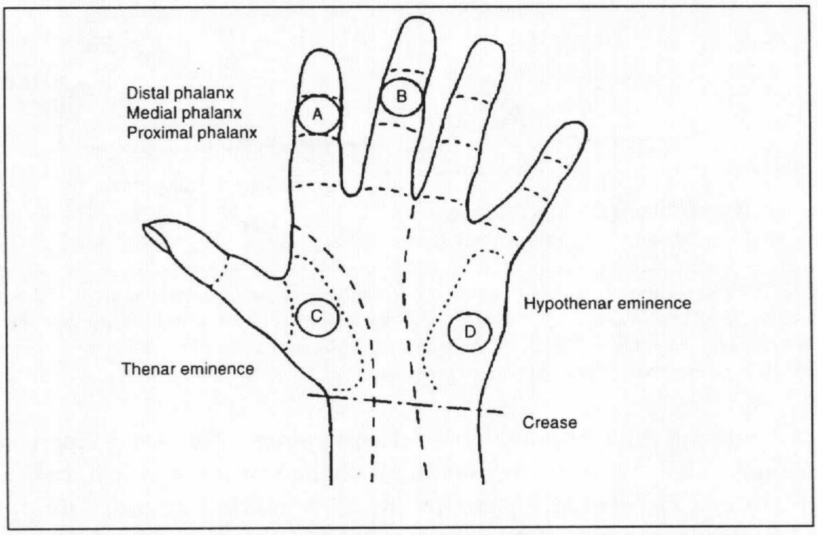
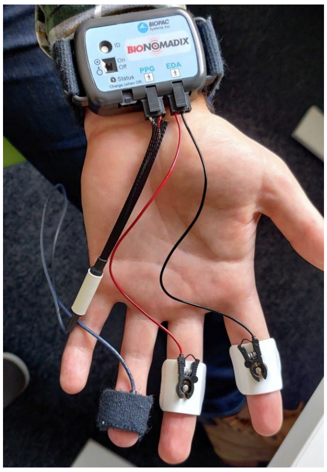


Figure 6: *Example of Bionomadix Transmitter being strapped to the wrist and, two EL509 electrodes connected to the middle section of both the index and middle finger.*



Synchronising EDA with video stimuli

Typically, if the research wishes to identify which SCRs are based on certain stimuli or events, the MP160 need to be paired with additional hardware known as the STP100D. For the duration of this PhD, we were unable to acquire the STP100D therefore synchronisation had to be done manually. For more information, see the biopac synchronisation and cleaning protocol (Appendix C). Although it is possible to manually synchronise the EDA and video stimuli, it is impossible to measure which event-related SCRs compared to regular SCRs. Therefore, all regular SCRs are used in the analysis. To overcome any bias, normalisation of the SCRs was conducted (Horvers et al., 2021). To normalise the SCRs, a square-root transformation was undertaken. This process was necessary because the video clips varied in duration, and without standardisation some clips might exert a greater influence on the final mean than others (Wetton et al., 2010).

Before discussion on the synchronisation method, it should be noted that the EDA is written into Biopac's Acq*Knowledge v5.0* software in real time. While collecting the EDA data, the researcher input markers onto the timeline. These markers would come in use when the SMI data was imported into AcqKnowledge to find out when each video stimuli started and ended. Typically, the marker used to synchronise the experiment was the 'baseline' marker as the research has control of when the baseline started in both SMI's experiment centre as well as AcqKnowledge. If synchronisation failed between the baseline markers due to human error, then the second or third calibration points were also used for synchronisation.

The method of synchronising is as follows. Once the experiment was complete, the SMI even markers are imported into AcqKnowledge. Because the MP160 is collecting data before the SMI machine, in order to test the equipment, there is a difference in start time between the SMI and EDA data. To resolve this, the Delta T between the SMI baseline marker and the EDA baseline marker needs to be calculated. Typically, this can range from 60 - 120 seconds. Once this value is known, AcqKnowledge is closed and reopened with just the EDA data on the timeline. The Delta T value is removed from the beginning of the EDA timeline before the SMI is imported back in. Once this is done, the SMI markers are reimported onto the EDA data, so the researcher knows which SCRs correspond with each video stimuli.

Cleaning EDA signal

Once synchronisation is complete, there are a range of steps in order to clean the EDA signal and get SCRs. The researcher, among other members of the transport research group at Nottingham Trent University was trained by an employee of Biopac on how to clean EDA data. First, a low pass filter at 1Hz was applied to the EDA signal. The low pass filter suppresses extrinsic noise in EDA based on differences in signal characteristics, such as frequency, magnitude, amplitude, and morphology (Lee et al., 2020). After the low pass filter, median smoothing was applied to the waveform. Median smoothing was selected because it rejects outliers and eliminate rap transient spikes (EDA data analysis and correction, 2016). After this, the waveform was resampled from 2000Hz to 62.5Hz. EDA produces a slow signal therefore there was no data loss from down sampling, and it speeds up the computing process of the EDA analysis. The down-sampled signal was then checked for further rapid transients manually and removed by using the 'Connect Endpoints' math function. Once all cleaning was completed, SCRs were located by deriving phasic from tonic signal with a cut-off point of 0.02 microsiemens (μS). See Figure 7 for an example of a before cleaning EDA signal and Figure 8 for an after-cleaning EDA signal with SCRs present. Both examples show the same hazardous anxious driving situations. For more information on the cleaning process including a step-by-step guide on how to clean the EDA signal, please see Appendix C.

Figure 7: *Example of a raw EDA signal from a participant for two events. SCRs have not been extracted at this point.*

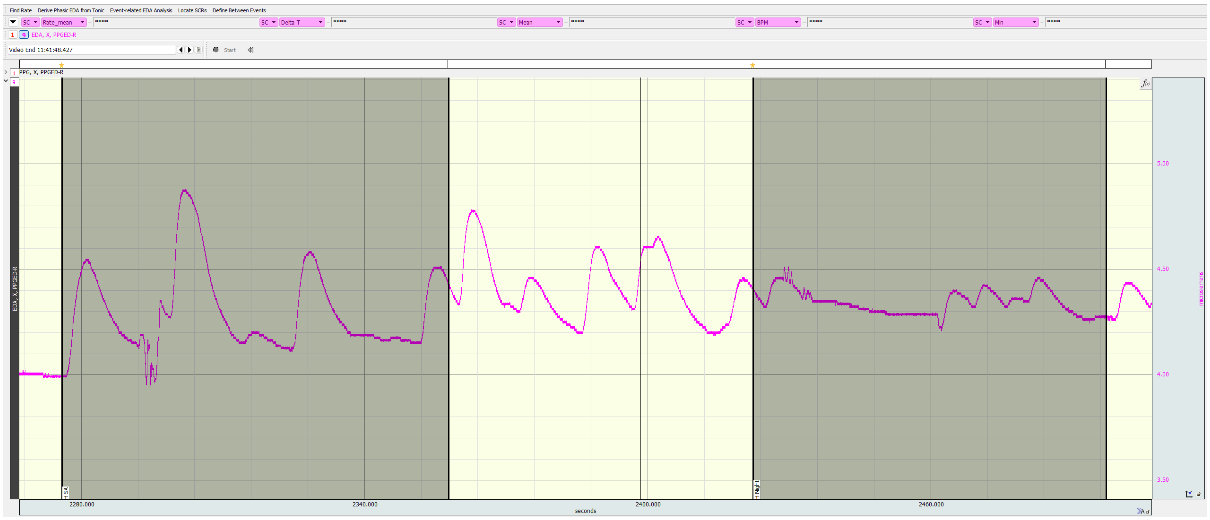
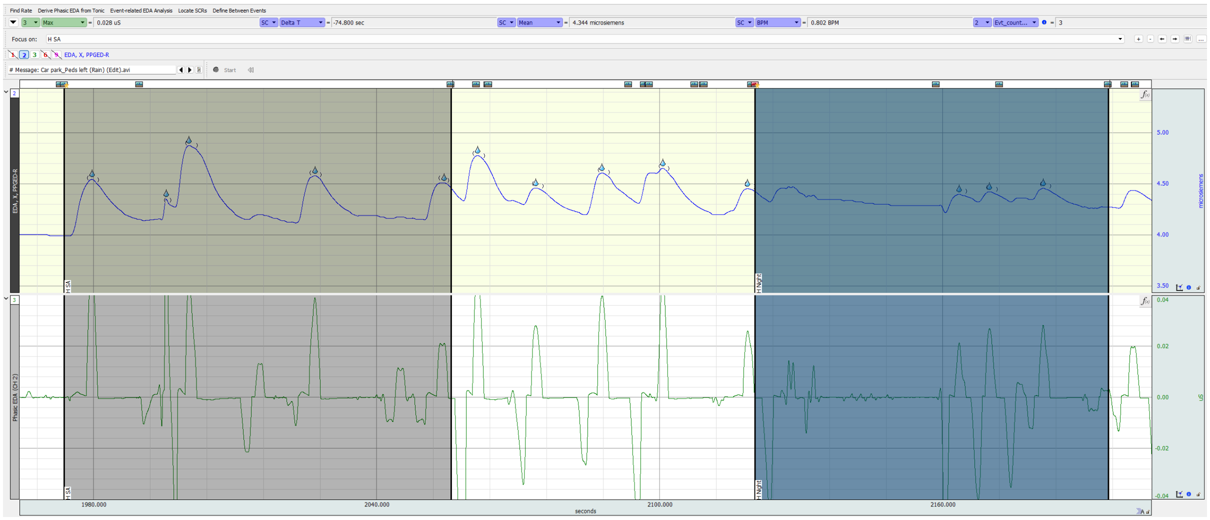


Figure 8: *Example of a cleaned EDA signal from the same events of the same participant with SCRs extracted from the tonic EDA signal.*



Driving simulator

Driving simulators have been widely used in the field of driving research (Bobermin et al., 2021; Wynne et al., 2019; Martín-delos Reyes et al., 2019) and provide detailed and objective information about speed, acceleration, position, lane changing, headway, braking, driving distance, responses to hazards, foot and hand position, among others (Cao et al., 2022). Driving simulators have the advantage of recording driving behaviour in real-time under demanding conditions without putting drivers and other road users at risk. This is important for driving anxiety studies as it would be unethical for anxious driver to be tested in the real environment which could expose them to anxious or threatening stimuli within the driving environment (e.g. Fischer et al., 2020). There are three main types of simulators: full-scale, desktop, and portable simulators. Full-scale simulators provide the closest experience to real driving and are often built using an actual car or a built-up cab, such as the National Advanced Driving Simulator (National Advanced Driving Simulator, 2020) or SimDYN, SimPULSE or SimELITE systems (AVSIMULATION, 2024). Such simulators often feature motion platforms, which provide motion in multiple degrees of freedom to enhance the realism of the driving experience. With such specifications, these simulators could provide the closest feeling of true realism, especially when a lack of motion could lead to heading error or lane violations (Greenberg et al., 2003). With high-end driving simulators, there is a possibility of developing simulator sickness which could have an impact on driving performance (Reinhard et al., 2019; Helland et al., 2016). "Low-cost" desktop simulators are also available, such as SimEASY and SimFLEX systems, which includes a seat, steering wheel, and three flat-panel LCD displays. Although these low-cost options do not have motion bases, they are portable and easy to set up. The choice of driving simulator depends on the study's aim, and low-cost simulators often use the same software as more sophisticated ones. However, Park et al. (2005) compared low-cost and a medium-cost driving simulators on training effectiveness. They found that although there were no differences in collision rates, there were differences in handling behaviours (i.e. braking and steering), which were largely affected by the difference in controls and differences in lane position, vehicle speed, time-to collision, and simulator sickness ratings based on the graphical display. This demonstrates that sophisticated simulators may be more applicable for detailed analysis.

While driving simulators have been criticised for their validity (Reimer et al., 2006), studies have found that real driving behaviour and behaviour during simulator studies are not significantly different (Godley et al., 2002; Underwood et al., 2011). However, it is the relative validity (similar patterns of behaviour e. g. whether people drive faster on certain roads) which is often established. For example, when combining eye-tracking and driving simulation, Chan et al. (2010) found that novice drivers glanced for longer periods of time inside the vehicle, and the eye fixation patterns were similar to real-world driving studies. In Study Four (Chapter 6), a Carnetsoft Driving Simulator (Carnetsoft BV, Groningen, Netherlands) was used to assess driving behaviour in anxious and non-anxious drivers across two routes. This 3D desktop simulator, equipped with three 23-inch monitors offering a 210° field of view, included a Logitech G29 steering wheel, pedals, and a shifter for realistic control. Adjustable seating and pedals ensured driver comfort, while force feedback simulated vehicle dynamics, allowing for the measurement of acceleration, braking, and steering inputs. The driving simulator featured Carnetsoft software that was used to develop the virtual environment. Both routes used CGI (Computer-Generated Imagery). It is recommended by Carnetsoft to use one of the 15 ready to use virtual environments as they are pre-connected to a graphical and logical database. Due to the recommendations, two of the 15 pre-designed routes provided by the Carnetsoft software, were chosen to be the "Anxious" and "Non-anxious" routes. Both routes had clear weather conditions and visibility. For more information on the routes, please see the design section of Chapter 6, p. 193)

Ethics

All the studies in this thesis were carried out in accordance with the School of Business Law and Social Sciences Ethical Committee, Nottingham Trent University (See Appendix A).

For study three, face-to-face experimentation had to commence during COVID-19. Therefore, COVID-19 specific protocols and risk assessment had to be put in place for this study. A NTU COVID-19 face-to-face protocol was followed (Appendix D). Face masks for the researcher and participants had to always be worn during testing. The protocol also included cleaning procedures of equipment and surfaces after each participant had completed the study. Specifically for this study, the researcher would also be wearing nitrile gloves due to placement of equipment (e.g. the biopac) on the participant. For more information see protocol for safely undertaking laboratory-based Galvanic Skin Response research under current COVID-19 restrictions (Appendix E).

Informed consent to participate in the studies were obtained from all participants (See Appendix A). Only the researcher and their doctoral team had access to the data collected within this thesis. In order to anonymise the collected data every participant was given a unique identifying code. Data collected from participants was kept separately from participants' personal details in order to ensure anonymity and confidentiality.

Participants were told that they were able to withdraw their data until the point of data analysis. After which any personal data (as defined by the Data Protection Act, 1998) would be destroyed, and only anonymised raw data and summary data retained.

This procedure was explained to the participants in the information sheet, prior to the studies (See Appendix A). The consent forms confirmed that participants understood the procedure. Participants were informed that following analysis, summaries of non-personal data (demographics, responses in hazard perception test results) may be retained long-term as part of a larger data set and used for publication (unless they had asked for their data to be removed). After each experiment, participants were debriefed (See Appendix A).

Chapter 3: How does driving anxiety manifest?

More than one-third of drivers experience anxiety while driving, with nearly half (43%) of these individuals reporting that their anxiety negatively impacts their driving ability, according to new research on 1,441 UK motorists from Aviva (2023). The report indicates that residents of London (44%), the east of England (44%), and Yorkshire and the Humber (38%) are the most likely to report being anxious drivers, whereas those in the Northeast are the least likely (23%). Drivers who primarily use minor connecting roads (32%) or drive in urban areas (31%) are especially susceptible to driving anxiety. Interestingly, only 7% of those who do most of their driving on motorways report feeling anxious.

However, driving anxiety is a prominent issue not only in the UK but also in many other countries. Research conducted in New Zealand and France provided insightful statistics that underscore the prevalence and significance of anxiety-related challenges in driving contexts. Taylor (2018) reported that around 55% of their participants experienced mild forms of driver anxiety. Similarly, Fort et al. (2023) conducted a study with a sample of 5000 French adults where 37.6% of drivers reported having mild driving anxiety, 30% had moderate driving anxiety, and 32.4% reported experiencing severe driving anxiety. It is evident that a considerable proportion of drivers encounter obstacles when engaging in driving due to anxiety-related concerns. Driving-related anxiety encompasses a diverse spectrum of experiences, varying from mild discomfort to severe distress, often prompting avoidant behaviours that can ultimately lead individuals to cease driving or even avoid being passengers altogether (Fischer et al., 2020; Hempel et al., 2017; Taylor, 2018). Moreover, anxious driving can have consequences for road safety, and it is recognised as a relevant factor that may affect an individual's ability to operate a motor vehicle safely. According to the most recent information provided by the Driver and Vehicle Licensing Agency (DVLA) in the United Kingdom, it is obligatory for individuals to inform the DVLA if they experience anxiety while driving (DVLA, 2023). This regulatory provision demonstrates the significance of accurately assessing and managing this condition to safeguard both the wellbeing of the drivers themselves and the road users they interact with. However, only two-fifths (39%) of individuals who state that anxiety impacts their driving have informed the DVLA about it and 16% of these individuals were unaware that they were required to report this information (AVIVA, 2023).

Anxiety is defined as a pervasive and multifaceted emotion characterised by tension, worried thoughts, and physical changes (Kazdin, 2000). As one of the most common mental health conditions worldwide (World Health Organization, 2017), anxiety manifests in various forms and can have a profound impact on individuals' daily functioning and quality of life (Kessler et al., 1999; Wittchen et al., 1994; Hoffman et al., 2008). One of the main ways anxiety can be conceptualised, is a persistent and excessive apprehension regarding future events (Sussman et al., 2016). By constantly worrying about future events, it can transcend from momentary distress, becoming a chronic state that disrupts individuals' thought processes, emotional regulation, and behavioural responses (Beaudreau & O'Hara, 2008; Castaneda et al., 2008; Cisler & Koster, 2010; Mahoney et al., 2016). Furthermore, anxiety can often co-occur with other mental health conditions, such as depression (Starr & Davila, 2012) or Attention-Deficit/Hyperactivity Disorder (D'Agati et al., 2019), further complicating the diagnostic picture and amplifying the associated burden.

Anxiety can have far-reaching consequences, leading to a diverse array of anxiety disorders that affect various aspects of our lives. One such consequence is its impact on driving and the motivation to get behind the wheel. Driving anxiety is a specific anxiety disorder characterised by intense worry or panic specifically related to driving a vehicle (Taylor, 2018). It may manifest when drivers perceive uncertainty or limited control over a particular situation, often arising from factors like other drivers' behaviour or the complexity of the driving task involved (Dittrich, 2021). Some examples of such situations are driving on narrow roads, high speed, or heavy traffic where drivers feel unable to control the situation and may cause harm to oneself or others while driving (Dittrich, 2021; Ratering et al., 2024). Individuals with driving anxiety also experience physiological symptoms while driving such as increased heart rate, sweating, trembling and even panic attacks which can negatively impact their driving experience and motivation to drive (Barnard & Chapman, 2016, 2018; Hidalgo-Muñoz et al., 2021).

Driving anxiety not only impacts everyday life, making simple tasks like picking up children from school or commuting to work more challenging, but it also compromises driving safety. Many anxious drivers report feeling less confident in their driving abilities and believe they commit errors while driving (Kenow & Williams, 1992; Taubman-Ben-Ari et al., 2004). In fact, research has suggested that driving anxiety can contribute to an increase in driving errors (Taylor et al., 2007). When faced with hazardous situations, anxious drivers may exhibit poor capacity to manage the danger effectively, leading to even heightened anxiety and inadequate coping mechanisms if they are unable to respond appropriately (Hill & Boyle, 2007). This shows that both, the objective errors and subjective perception anxious drivers have of their driving ability should be studied as low levels of confidence can have an impact on driving behaviour ultimately leading to errors (Gwyther & Holland, 2014). Furthermore, anxious drivers tend to critically evaluate their own driving performance more frequently than others, which can result in decreased self-confidence (Brozovich & Heimberg, 2011; Goodman et al., 2021).

The diagnosis and classification of driving anxiety have been subject to ongoing debate and conceptual complexities, as highlighted in the literature (Hidalgo-Muñoz et al., 2021; Elphinston et al., 2023). One aspect of this debate revolves around the inconsistent terminology used to describe driving anxiety in research and clinical contexts. The definition of driving anxiety often overlaps with those of driving phobia or driving fear, even though the behaviour displayed can differ in each case (Jeon et al., 2014). Typically, individuals with driving phobia avoid driving altogether while anxious drivers still drive but may steer clear of specific situations that trigger their anxiety (Blanchard et al., 1994). It is crucial to distinguish between driving phobia and driving anxiety to enable a clearer understanding of how driving anxiety manifests and its underlying roots.

The term "fear" is often used in situations where driving anxiety may stem from specific events such as being involved in road collision or encounters with aggressive drivers (Jeon et al., 2014). These situational factors can evoke a fear response (bottom-up) that impacts the individual's driving behaviour and objective sense of safety. These processes are driven by external stimuli or the immediate environment and will typically evoke a response by all individuals independently if they are anxious or not. Driving anxiety, however, is often associated with cognitive processes which involve evaluations and expectations of the driving scenario based on prior negative experiences (top-down) while driving (Sussman et al., 2016). This process underscores the significant role of expectations and previous experience with certain driving events. Such events do not necessarily involve or are related to a road collision but refer to specific situations that caused stress for the anxious driver. As a result, previous experience with stressful situations while driving can establish negative bias memory. This bias may lead to interpreting ambiguous stimuli as threatening, thereby perpetuating driving anxiety (Sussman et al., 2016). While anxiety is commonly characterised as an inwardly directed response to an imprecise, distant, or unrecognised threat, fear typically pertains to a specific, external situation or object that elicits a tangible apprehension (Bourne, 1990; May, 1950; Wolman, 1994). Efforts to differentiate anxiety from fear have centred on factors such as the stimulus triggering the reaction, the specificity of the response, and the proportionality of the emotional reaction (Levitt, 1980). Indeed, it is entirely possible for both driving fear and driving anxiety to exist simultaneously.

The confusion between driving phobia and driving anxiety, however, has generated a debate concerning the potential causes of driving anxiety. Most research consistently indicates that driving anxiety often originates after motor vehicle collisions (MVCs), which has been observed in driving phobia (Brom et al., 1993, de L Horne, 1993; Kuch et al., 1994; Taylor & Koch, 1995). For example, a study of motor vehicle collision victims revealed that after a one-year follow up from their collision, 37.6% of respondents indicated a fear of driving, 24.8% reported a fear of cars, 38.9% expressed nervousness and anxiety in general, and 30.2% had difficulty controlling anger (Vingilis et al., 1996). Having been involved in a collision makes the association between driving and negative experience more likely and typically drivers will be more prone to overestimate the possibility for a potential danger associated with certain driving scenarios that led to collision (Ledesma et al., 2010). However, the relationship between MVCs and driving anxiety appears to be more complex than initially assumed, as not all drivers discontinue driving after experiencing a collision (in contrast to what has been observed with driving phobia) (Taylor & Deane, 1999, 2000; Blanchard et al., 1995). While MVCs can be an underlying factor for driving anxiety they are not always the sole or primary cause for it. Driving anxiety can arise from various factors, including cognitive and situational aspects such as fear of loss of control, social evaluation, negative driving experiences, perceived threat on the road, or even a general predisposition to anxiety (Ehlers et al., 1994; Taylor et al., 2000; Taylor et al., 2007). In fact, Fort et al. (2023) reported that drivers who experience driving anxiety typically show symptoms of generalised anxiety. Anxious drivers exhibit similar symptomologies, including excessive worry, catastrophic thinking, restlessness, irritability, and physical manifestations (American Psychiatric Association, 2013; Craske, 1999; Stein et al., 2009). The overlapping symptom profiles and cognitive biases raise intriguing questions about the relationship between generalised anxiety and driving anxiety. However, only a limited number of studies have focused specifically on studying the underlying reasons for driving anxiety and no studies (to the author's knowledge) have provided an understanding of individuals' lived experiences concerning driving anxiety. Considering the ongoing debate regarding the origins and complex nature of driving anxiety, there is a need to approach the topic anew by delving deeply into the lived experiences of those directly affected. This approach is crucial for gaining a better understanding of the origins, mechanisms, and underlying reasons behind this phenomenon.

The current study

This study seeks to address the limited research on the origins and impact of driving anxiety by offering an in-depth exploration of anxious drivers' lived experiences. The primary objective is to unravel the factors that give rise to driving anxiety and the specific triggers that exacerbate it, supported by specific examples. To achieve this, a qualitative approach was employed, as it allows for a comprehensive exploration of participants' lived experiences and their personal perceptions of these encounters. Existing studies have predominantly relied on questionnaires and quantitative measures, which may not fully capture the nuances and complexities of these experiences, including the specific examples that could enhance our understanding of how driving anxiety develops and, more importantly, how it is sustained. Considering that driving anxiety does not necessarily originate as result of being involved in a collision, delving into specific personal experiences with driving anxiety will provide a better understanding of the phenomena.

Additionally, the study will thoroughly investigate participants' perspectives on how their driving anxiety impacts their driving performance. Driving anxiety can affect individuals differently and each person may have a unique understanding of their experience

(Ang et al., 2019). Hence, it is essential to first examine this experience from the drivers' viewpoint before approaching it in a more objective manner. By examining and analysing each aspect of this experience, the study aims to identify commonalities and gain a comprehensive perspective on driving anxiety's impact on individuals' driving behaviour.

Method

Participants

A total of 15 participants (3 males, 12 females; $M_{(age)} = 28$; $SD_{(age)} = 10.9$) completed the study, however one participant (male) was removed due to unusable data as the interview was too short and did not reach saturation. Therefore, the final sample was comprised of 14 participants (see Table 1), which aligns with prior qualitative research suggesting that 8-12 participants are required for adequate data saturation (Guest et al., 2006). All participants identified themselves as anxious drivers with some participants demonstrating a history of diagnosed generalised anxiety. Driving experience was determined by years since driving test and milage. Participants who had been driving for more than three years and drove at least 1000 miles annually were classed as experienced drivers.

Table 1: *Demographic information of participants interviewed in study one illustrating the sex, age, area and driving experience* (*experienced vs. novice).*

Participant	Sex	Age	Area	Driving experience
Lily	Female	64	Leicester	Experienced
Narina	Female	25	Nottingham	Novice
Kate	Female	25	Prefer not to say	Novice
Rosie	Female	26	Nottingham	Experienced
Catherine	Female	24	Lincoln	Novice
Charles	Male	30	Prefer not to say	Novice
Laura Hill	Female	24	Prefer not to say	Experienced
Connor	Male	24	Nottingham	Experienced
June	Female	36	Prefer not to say	Experienced
Eleanor	Female	29	Prefer not to say	Experienced
Limetrea	Female	22	Prefer not to say	Novice
Julia	Female	31	Nottingham	Experienced
Indiana	Female	19	Knutsford	Novice
Caroline	Female	24	Nottingham	Novice

Participants were recruited through a volunteer sample. A post was shared on social media which provided an overview of the study including the interview schedule (Appendix F). Those who were interested in taking part were advised to contact the researcher for further details. Participants were once again informed about the study and provided with a formal participant information sheet and consent forms (Appendix A). All interviews took place via Microsoft Teams to adhere to the safety measures implemented due to COVID-19. None of the participants received compensation for their participation.

Design

A qualitative approach utilising semi-structured interviews, was adopted to gain a deeper understanding of the underlying reasons for driving anxiety and what potential scenarios may sustain it. As outlined in Chapter Two, a qualitative approach supported participants to voice their experiences and interpretations of driving anxiety (Alderfer & Sood, 2016; Willig, 2008).

Interview question development

An interview schedule was developed specifically for the current study (Appendix F). The literature review included in the introduction highlighted the uncertainty surrounding the root causes of driving anxiety and its relationship with generalised anxiety. The interview schedule aimed to tackle this issue by including questions related to participants' experience with generalised anxiety and their perception regarding the origins of their driving anxiety. Participants were specifically queried about the circumstances that initially triggered their anxiety while driving, as well as their emotional responses and subsequent behavioural patterns during such instances.

To gain insights into participants' perspective on how their driving anxiety impacts their driving behaviour, interview questions were designed to explore the focal points of anxious drivers, how they think anxiety impacts their driving behaviour and whether catastrophic thoughts distract them from the driving task. As a result, it will be possible to explore and assess potential negative cognitive biases.

Finally, considering the broader impact that driving anxiety can have on driving behaviour and beyond the act of driving itself, it becomes relevant to investigate whether individuals affected by driving anxiety continue to drive or perceive that their anxiety has put their life on hold. By posing questions that explore these aspects during interviews, researchers can gain insights into the extent to which driving anxiety influences individuals' daily lives and functioning. Understanding whether driving anxiety leads to avoidance or cessation of driving can provide valuable information regarding the practical implications of this condition.

Procedure

The current study complied with The British Psychological Society's Code of Ethics and Conduct (British Psychological Society, 2021). The study gained ethical approval from the School of Business Law and Social Sciences Ethical Committee, Nottingham Trent University (2021/98).

Written consent was emailed to participants prior to the interview and provided voluntarily, and any queries were addressed during informed consent. Once participants agreed to take part in the study, they were invited to an online Teams meeting. The duration of the interviews oscillated between 30 - 90 minutes. Each interview started with a description of the aims of the study. Participants were asked once again to provide verbal consent to participate in the study and have their voice recorded during the interview. Demographic questions such as sex, age, location and driving experience were asked prior to the interview questions.

At the end of the interview, the researcher provided a debrief form (Appendix A). The interviews were audio recorded and transcribed verbatim. Overall, the interview schedule for the anxious drivers had 13 main questions with all having sub questions and data was collected until saturation.

Data analysis strategy

Thematic analysis (TA) adapted from Braun and Clarke (2006) was chosen as the analytical approach. TA is the most suitable method for this research due to its flexibility and the ability to identify patterned meaning within data. These patterns are then grouped in themes to provide an understanding of the connection to the research topic (Braun & Clarke, 2006). Thematic analysis has been shown valuable in previous transport research (Alyavina et al., 2020; Gössling et al., 2016; Liu et al., 2020; Pettigrew et al., 2020).

All sessions were transcribed verbatim. The data was analysed and coded following the six steps for thematic analysis (Braun & Clarke, 2006; See Table 2).

Table 2: *Six-step process of thematic analysis* (*Braun & Clarke, 2006).*

PHASE	STAGE	DESCRIPTION
1	Familiarising with data	Transcripts were familiarised through repeated reading.
2	Generating initial coding	A line-by-line coding strategy was used, taking notes of thoughts, key words, point of views and attitudes. For this study this was done for each data item first.
3	Searching for themes	Once the initial coding list was identified, the codes were developed into working subthemes for data item (Level 1). Once subthemes had been created, the subthemes were combined to create overarching subthemes for the dataset (Level 2).
4	Reviewing themes	Once subthemes were identified at level 2, they were grouped into overarching themes. This is the recursive process where subthemes and themes were refined and checked against the initial codes within the dataset.
5	Defining and naming themes	Further refinement allows the themes to be place in an order which works within the narrative of the study and clear definitions of the themes develop.
6	Reporting the findings	A selection of compelling extracts is selected, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

The six-step process was completed using NVivo Pro Software which allows researchers to streamline the analysis process through a node system. Within NVivo, researchers imported the transcripts and familiarised themselves with the data in accordance to step one. Initial codes where then developed in accordance with step two and are known as 'child-nodes' within the NVivo Software. Once the child-nodes are coded, these codes form into the initial subthemes known in NVivo as 'parent-nodes'. NVivo Pro facilitated steps two to five through the categorization of relationships by linking together different nodes, thus providing easier referencing for the researchers.

Results and discussion

The thematic analysis generated four key themes: 'The role of generalised anxiety,' 'Stressors on the road', 'The alternative reality of attention' and 'The mitigation of driving anxiety'.

The first theme included two sub-themes such as everyday anxiety and its impact on daily life before moving into a driving context and common symptomology associated with anxiety, such as catastrophising.

The second theme centred on factors contributing to stressors while driving, with an underlying tone of social anxiety. The sub-themes encompassed scenarios such as the impact of social judgment on anxiety maintenance, the erosion of self-confidence among anxious drivers, and the impact of other drivers' behaviour.

The third theme scrutinised the ramifications of driving anxiety on driving proficiency, particularly in relation to attention. Participants, fearing errors, constructed alternative realities through imagined scenarios which led to the sub-theme of selective attention. The second theme included hypervigilance due to the consist worry participants expressed in paying attention to everything happening in the driving environment.

The final theme elucidated how drivers endeavour to mitigate driving anxiety. Notably, experience played a role, as novices and experienced drivers employed distinct strategies to avoid certain driving scenarios or to use distraction methods in order to alleviate their driving anxiety.

Table 3 depicts the number of times each theme and sub-theme was discussed by each one of the participants.

Table 3: *Themes and sub-themes identified during the interviews. The shaded areas in the table represent the number of times each theme (and sub-theme) were discussed by each participant.*

Superordinate theme	Subordinate Theme	Lily	Narina	Kate	Rosie	Catherine	Charles	Laura Hill	Connor	June	Eleanor	Limetrea	Julia	Indiana	Caroline
Role of Generalised Anxiety	Everyday Anxiety			■	■	■	■		■		■	■			
	Catastrophizing	■	■			■	■		■	■	■			■	■
Stressors on the road	Unpredictability of other drivers	■			■		■				■				■
	Social judgement					■			■	■					
	Lack of confidence	■	■						■				■		
Alterative reality of attention	Hypervigilance	■				■					■	■			
	Selective Attention										■		■	■	
Mitigation of driving anxiety	Avoidance		■					■			■	■			■
	Distraction				■	■					■	■			

The role of generalised anxiety

Everyday anxiety

At the outset of each interview, participants were asked whether they identified themselves as individuals experiencing anxiety. The majority of participants reported instances of anxiety in various everyday situations which did not involve driving and identified themselves as generally anxious individuals.

> *I think the short answer is yes in mainly in social situations or… yeah social situations, stressful stuff, exams, this sort of thing* (*Limetrea)*

During the interview, Limetrea mentioned experiencing anxiety in non-driving related situations, particularly related to her role as a student. She expressed anxiety about being socially outcast and worrying about her education. It is important to acknowledge that the focus of this study is on driving anxiety and its impact on driving behaviour, and thus, it does not delve into all the everyday situations where anxiety may occur. However, it is worth noting that anxiety can manifest in various contexts and is not limited to driving situations. Limetrea's concerns are common in relation to the broader scope of anxiety experiences among young adults (Goodwin et al., 2020).

Other participants, such as Eleanor, had an official diagnosis of generalised anxiety which was being clinically treated.

> *I have been diagnosed with generalised anxiety disorder aaand pretty much since puberty have been on various medications to umm… like treat that I've always been like a very like umm… I guess kind of A-type personality like umm… very high achieving and like busy all the time an anxious type of person* (*Eleanor)*

Some participants even clearly stated that their anxiety could manifest in various forms and lead to driving anxiety. For instance, Charles observed that his anxiety had the potential to extend to situations that involved driving or social interactions:

> *I'm diagnosed with anxiety like uhh… so… and I guess that just kind of extended out to the driving pretty much or like just social settings or whatever all that kind of goes with it I guess* (*Charles)*

Similarly, Rosie attributed her driving anxiety as a manifestation of her generalised anxiety:

> *I do have a general- a diagnosis of … generalised anxiety umm… but I definitely think driving is one of the things that manifests itself as* (*Rosie)*

Both participants consciously highlighted the link between generalised anxiety and driving anxiety, suggesting that generalised anxiety may manifest and extend to driving anxiety. Generalised anxiety can manifest in various forms and contexts, such as social anxiety or public speaking anxiety. The confirmation of official diagnoses among these participants further supports this understanding. While specific events such as motor vehicle collisions and negative experiences while driving or being a passenger can act as triggers for driving anxiety, it appears that such anxiety may already be latent in some individuals, making them more susceptible to develop driving anxiety after such negative experiences (Weinberg et al., 2022).

Catastrophising

The manifestation of certain cognitive distortive processes which are also observed in generalised anxiety further supported this observation. Some of the participants reported a tendency to often anticipate the worst-case scenario when facing certain driving situations, regardless of its low likelihood or its neutral nature.

> *It's not that I'm ever worried about like making a small mistake I'm worried about something unexpected happening like a semi trying to get over because they don't see me or a pedestrian running out into the road or someone turning in front of me without having space to turn and me rear ending them umm… but it's more bigger things and I worry about* (*Eleanor)*

This tendency typically refers to a cognitive distortion, known as catastrophising, where individuals excessively exaggerate the potential outcomes of a situation or event (Ellis, 1962; Beck et al., 1979, Flaskerud, 2022). In the context of driving, individuals with catastrophising propensity may overestimate the danger a neutral event can involve which will inevitably impact their perception and expectations of the outcome of such event. This pattern was exemplified by the narrative of Connor:

> *If you just kinda sit there in silence you hear like knocking noises that you never heard before which are perfectly normal and it'll be there like "Ok what the hell is that?" I had one earlier where it was like dirt under my tyre and I thought "Oh God is the tyre gonna fall off?" or something* (*Connor)*

When Connor heard a noise emanating from his car, he immediately attended to the auditory stimuli, quickly reaching a catastrophic conclusion. Based on the attentional control theory, due to his anxiety, Connor displayed impaired goal-directed attention by focusing on stimulus-driven attention (Eysenck et al., 2007). In this example, the goal-directed attention would be getting to his destination. The car should be a means to get to his goal. However, the auditory stimuli has overwritten his goal-directed attention so instead of getting to the destination, a catastrophising thought develops based on the auditory stimuli highlighted by *"Oh God is the tyre gonna fall off?"*, potentially leading to a major accident. This catastrophic thinking triggered an increase in Connor's anxiety levels, causing his focus to shift from a neutral problem-solving evaluation to an overwhelming fear of a disastrous outcome (Eysenck et al., 2007). Consequently, Connor's ability to concentrate on the road and make rational decisions became compromised as his mind became consumed by these anxious thoughts (Garner et al., 2011).

Stressors on the road

Unpredictability of other drivers

The previous theme suggested that generalised anxiety may play a role in the manifestation of driving anxiety. While participants exhibited anxiety across various aspects of their lives, they pointed out driving as the main anxiety-provoking factor. Driving is a complex task that requires good awareness of the driving environment and certain ability to multitask (Culot et al., 2021; Eysenck et al., 2007). However, in such environments, there are moments which are not in a driver's control, for example, other drivers' behaviour. The unpredictability of other drivers and their potential for unexpected manoeuvres seems to create a sense of confusion, intimidation, and nervousness among the participants. By being unable to predict the behaviours of other drivers in the immediate driving environment, this lack of control seems to contribute toward maintaining their driving anxiety. Rosie reported that mistakes made by other drivers increase her anxiety:

> *People you know indicating one way and doing the complete opposite and just so those of little things and that is the unpredictability about it … I think my anxiety is much more about not knowing what's going to happen in terms of other drivers* (*Rosie)*

According to Rosie's perception, the mistakes of other drivers had a ripple effect on the overall driving environment, making it increasingly challenging to anticipate and predict the behaviour of other drivers. The inability to predict, coupled with the potential consequences of errors made by other drivers, further intensified the anxiety Rosie experienced. This highlights the significance of the perceived control over the driving situation, the fear of uncertainty (typically manifested in generalised anxiety) and the impact it has on driving anxiety. The inability to anticipate and control the actions of other drivers creates a heightened sense of vulnerability and uncertainty, which increases and maintains the anxiety levels (Cocks et al., 2015).

Other situations that have been quoted by some of the participants to introduce uncertainty is close proximity of other drivers. Participants perceive that such behaviour can increase the likelihood of a potential collision due to inappropriate actions or manoeuvres from either party involved. The uncertainty arising from the possibility of the other driver miscalculating their next movement and the potential risk of collision leads to an escalation in the anxiety experienced by the participants. Lily captures how the uncertainty created by the proximity of other drivers increased her anxiety as she is worried about a potential collision.

> *I'm more aware about what the cars around me I'm more aware about you know whether I'm gonna hit a- whether you know if I'm passing a car how- but distance between me and the other car so my car I feel… quite close I don't like cars being near me and I don't like cars in front of me really close I'm just anxious of the fact that the cars are too close to me* (*Lily)*

Charles further describes how the presence of other vehicles in close proximity creates uncertainty, which influences his thoughts and perception of his own driving behaviour:

> *I start questioning like "is someone driving beside me" or something you know "are they getting too close" or if someone's in front of me "are they about to turn or may have met a stop light" and I forget how stuff works all of a sudden for instance… you know I can start increase my anxiety and then eventually I feel like I will just stop doing whatever I'm doing and then I'm in the middle of the road so that's that's problem* (*Charles)*

It seemed for both Charles and Lily, the close proximity of other vehicles around them made them believe that there was a higher chance of a collision occurring and showed certain doubts in their ability to manage the driving situation exemplified in their quotes "*I'm gonna hit", "forget how stuff works*". Lily highlighted two situations where proximity can lead to an increase in anxiety. Similarly, Charles also mentioned cars beside him or in front of him and verbalised his thought processes. For both participants, the uncertainty of another car beside them led to catastrophising thoughts and hypervigilance as they were worried the other driver would not see them and would hit them from the side. Both participants also expressed concern about the possibility of the car in front making an unpredictable manoeuvre, fearing that they might not be able to handle the situation and could end up colliding with it. While these scenarios could be common examples of everyday driving, participants find them stressful and tend to generate catastrophising thoughts related to these situations which maintains their anxiety and negatively impacts the level of confidence in their driving skills.

Lack of confidence

Anxiety typically has a negative impact on confidence (Kenow & Williams, 1992) and individuals with driving anxiety tend to report lack of confidence in their skills (Taubman-Ben-Ari et al., 2004). The process of social comparison and the fear of being negatively evaluated are common triggers for anxiety and can have an impact on drivers' confidence in their ability to drive (Buunk & Gibbons, 2006). Anxious drivers with high comparison orientation tend to often compare their driving behaviour with others (Gibbons & Buunk, 1999). Thus, anxious individuals may negatively evaluate their own performance more frequently than others, which could lead to a decrease in self-confidence (Brozovich & Heimberg, 2011; Goodman et al., 2021). Within the driving context one example is from Narina who often compares her driving ability to her partner who was driving:

> *Watching my partner going up that in the hill approaching going up it, made me anxious cause I'm like 'I wouldn't be able to do this' so I will have that negative*

thought of 'I wouldn't be able to do this' and then my partner was just like… fine he just went on with it he sailed through it… and he was just- I was just like 'I wouldn't be able to do that…' like Jesus Christ I know- that's when I realised like how bad my anxiety my anxiety could be (*Narina)*

It seemed that by observing her partner traverse the hill with no effort, Narina developed confirmation bias of her potentially limited driving ability to tackle hill situations. This is known as upward social comparison as the participant compared themselves to someone who they perceive to be better than themselves (Buunk & Gibbons, 2006). In this moment, Narina has a self-reflection moment during which the driving anxiety seems to negatively impact her confidence in her driving skills highlighted by *"I wouldn't be able to do that"*.

The same sentiment of comparing one's driving skills with a loved one is echoed by Lily.

I am more anxious when I've got my husband there because he is a good driver umm… I just feel that I'm not anymore (*Lily)*

Lily's driving anxiety had a significant impact on her self-perception as a driver, leading her to believe that she is now a worse driver than she was before experiencing driving anxiety. This comparison against her past self, highlights the negative influence of anxiety on her self-confidence in driving. Furthermore, Lily's anxiety also led her to compare her driving ability with that of her husband's, which further diminished her confidence. By evaluating her abilities twice, once against her past performance and the other against her husband's driving skills, Lily experienced a double burden of self-doubt and insecurity in her driving abilities. This social comparison and self-evaluation process is influenced by her anxiety, which may lead her to perceive herself as an inadequate driver compared to both her past self and her husband.

A final example is from Julia where she does feel confident in driving the car when she was on her own however if she was with someone else, her confidence decreased.

> *I do feel more confident when I'm by myself so if I made a mistake, I'm the only one in the car but usually when I have passengers in the car that made me more anxious because I don't want to make mistakes when they're in the car to hurt anybody and so on, so I am more confident and and doing less mistakes when I'm by myself that's what I realised* (*Julia)*

Julia's experience with driving confidence highlights an interesting aspect of driving anxiety. When she is driving alone, she feels more confident because there are no witnesses to her potential mistakes. This suggests that the presence of others as passengers adds a social dimension to her driving experience, leading to decreased confidence. In this social context, Julia perceives herself as being in a position of responsibility for her passengers' safety and well-being. This heightened sense of responsibility contributes to her anxiety, as she fears making mistakes that could potentially harm her passengers. The presence of others in the car creates a social pressure and evaluation that impacts Julia's self-perception as a driver, leading to a decrease in her driving confidence.

The current findings not only support the notion that driving anxiety impacts self-confidence in one's driving ability, but also demonstrates that this can occur through the observations mediated by a high social comparison orientation (Buunk & Gibbons, 2007). High social comparison orientation could intensify and maintain driving anxiety, further lowering the participants confidence in their own driving ability, which could lead to an increase in driving errors (Taylor et al., 2007). These examples emphasise the complex interplay between anxiety, social factors, and driving confidence. It also sheds light on the importance of considering the social context in which driving anxiety occurs and how it can influence drivers' feelings of competence and self-assurance while driving.

Social judgement

Social anxiety is manifestation of generalised anxiety, and it can also be linked to driving anxiety (Ehlers et al., 1994). Driving is a social behaviour as it involves the interaction and communication of drivers through a shared infrastructure (Bull, 2003). In the context of driving, this social dimension introduces specific factors that can maintain anxiety levels. The evidence presented in the previous sub-theme demonstrated that social evaluation and judgement on the basis of one's behaviour is a common trigger for anxiety in the driving context (Carleton et al., 2010). As a result, a common catalyst for driving anxiety appears to be the idea of being judged or negatively evaluated as a driver. This idea is manifested by June:

> *That is because of social anxiety, that connects to social anxiety like when I'm driving- when people are lining- if even one car or a few cars behind me I think that "I'm going too slow" even though I'm not "I'm going too slow, they are judging me right now, what am I doing wrong"* (*June)*

The relationship between social anxiety and driving anxiety is intertwined, with each reinforcing the other when individuals are on the road. The notion of being judged causes anxious drivers to become self-conscious, leading them to make judgments about their own behaviour. This self-evaluation, accompanied by thoughts of what they might be doing wrong (if anything), further contributes to their anxiety. This is also exemplified by Connor who believed he was being evaluated by other drivers based on their driving skills, leading to heightened self-consciousness and anxiety:

> *I was also feeling like people watch you in those situations umm… and judge your driving skills … I think in that [ambulance] situation my driving skill was probably quite crap umm… I think that was probably the back of my head I was thinking of like I've just pulled in front of somebody this is like me driving like a right knob head* (*Connor)*

The described situation evidently triggered Connor's anxiety, as the performed manoeuvre heightened his self-consciousness and instilled a fear of being judged by other drivers (Jann & Coutts, 2017). This equally can be observed in Catherine's quote as her anxiety increased when she felt judged by the other passengers:

> *I was driving with someone in the car I was focusing on like… not wanting to come across as a bad driver to the person in the car or to be like… "Oh God they're watching me"* (*Catherine)*

Catherine’s quote illustrates her desire to not be judged negatively by the passengers she is driving with. Her emphasis of “*not wanting to come across as a bad driver”* removes the focus from the driving task which is replaced by a worry about being judged by her peers (Mellings & Alden, 2000). Such worries can often cause drivers to focus on their own thoughts or other irrelevant events in the driving environment, causing them to miss important hazardous situations that require attention, which can lead to errors (Nassif & Wells, 2014).

The alternative reality of attention

Hypervigilance

This theme explored the self-perceived impact of anxiety on attention during driving. The link between generalised anxiety and attention has not gone unnoticed. Numerous theories propose that anxiety involves heightened vigilance towards potential threats. Individuals with elevated anxiety levels tend to quickly direct their attention and allocate cognitive resources towards stimuli that are perceived as threatening. This mechanism enhances the processing of information related to these threatening stimuli (Armstrong & Olatunji, 2012; Beck & Clark, 1997; Richards et al 2013; Williams et al., 1997). Heightened attention towards threat is particularly prominent among individuals with a predisposition towards high trait anxiety, especially when they are simultaneously experiencing elevated levels of state anxiety. The majority of participants reported that they tend to prioritise simultaneously all aspects of the driving situation in order to avoid making mistakes. This state is commonly referred to as hypervigilance or hyper-attentiveness. Eleanor's experience serves as an example of this phenomenon:

> *My anxiety if anything it makes me more hyper focused on what's going on around me and like umm… I… yeah if I'm anxious I'm checking my rear-view mirrors more than I normally would I'm umm… I'm paying more attention to is there “are there any pedestrians around, is there anyone trying to turn” things like that I think that if I'm more anxious I'm paying more attention…* (*Eleanor)*

Eleanor believed that her hypervigilance is helping her overcome the situation. Instead of engaging in a more efficient and adaptive allocation of attention, anxious participants find themselves consumed by self-generated worries which pushes their attention in different directions simultaneously (Nassif & Wells, 2014).

> *... Sometimes I'll have like invasive thoughts like "what if a kid runs out in the street or what if this semi driver next to me is tired and he doesn't see me and he hits-" you know umm…*(*Eleanor)*

Previous research has suggested that anxious and depressive populations have positive thought acceleration, processing a large amount of information in a short space of time (Pronin et al., 2008; Pronin & Wegner, 2006). In the context of driving, Eleanor's mind is constantly running through each aspect of the driving scenario, which, at first glance, may appear typical for any cautious driver. However, when these thoughts involve potential catastrophic outcomes, the hypervigilance contributes to overstimulating the likelihood of potential threats in the environment (Richards et al., 2013).

> *It was more like I tried to focus on everything and I ended up focusing on nothing *chuckles** (*Limetrea)*

Although it may initially appear as heightened focus on relevant stimuli, this constant shift of attention often proves counterproductive. Consequently, anxious drivers end up not attending to any stimulus in detail, and in their attempt to prioritise everything at once, they may overlook relevant hazardous scenarios (Korthouwer, et al 2021). By scanning the environment at a faster rate, there is a potential to misinterpret neutral stimuli and label them as hazards which could lead to overestimating the potential danger of neutral situations, thus ignoring actual hazards (Walklin, 1993).

Selective attention

Hypervigilance could also turn into selective attention especially when facing a demanding driving situation which can also impact the ability to spot relevant hazards. This has been observed in Julia's experience, who specifically mentioned parking as a prompt for her driving anxiety:

> *Sometimes thinking about that, say parking, makes me miss-judge other things like if there are people passing around because I would focus just on how to park correctly but at the same time you have to get aware of other things going around so by the time I started realising that I actually have to focus on the left, the right, people crossing the street and so on* (*Julia)*

Julia's driving experience provides a notable illustration of the impact of intense focus on a specific task, leading to a narrowed perceptual field. Her concentrated attention on the parking task becomes so all-encompassing that it hinders her ability to detect the presence of pedestrians in her vicinity. Similarly, Indiana's driving behaviour reveals a selective narrowing of attention to the immediate road environment, motivated by a desire to prevent potential damage to her vehicle. In doing so, Indiana's attention becomes overly fixated on micro-details of the road surface, potentially causing her to overlook broader environmental cues that could signal relevant hazards and safety concerns.

> *I'm constantly looking whether umm… I'm about to hit the curb or I'm about to hit the line* (*Indiana)*

Both Julia and Indiana's experiences emphasize the phenomenon of selective attentional tunnelling, where individuals concentrate their focus so intensely on one aspect of the driving task that they inadvertently neglect other critical information from their surroundings. In Julia's case, her intense focus on parking prevents her from processing pedestrians in her vicinity, which could compromise their safety. For Indiana, the excessive attention on avoiding damage to her vehicle may hinder her ability to respond to broader hazards on the road, potentially jeopardising her own safety. Several studies have reported similar findings, emphasising how individuals with driving anxiety may struggle to process and prioritise essential information directly relevant to their current driving situation (Briggs et al., 2011; Gotardi et al., 2019; Najmi et al., 2012). This suggested that anxiety-induced selective attention could hinder the ability to adequately perceive and process environmental cues, thus failing to perceive relevant hazards.

Mitigation of driving anxiety

During the interviews many participants admitted being aware of their engagement in catastrophising thoughts. This awareness suggested a conscious attention to their thought processes (See 'The alternative reality of attention', p. 91). Consequently, some of the participants shared their attempts to anticipate and actively avoid engaging in such thoughts, thus mitigating their anxiety in the process. They also shared specific techniques that help them reduce their anxiety while driving. A clear distinction between novice and more experienced drivers became obvious in their choice of anxiety mitigating techniques. Novice anxious drivers reported to typically avoid anxiety triggering driving situations, whereas experienced anxious drivers seemed to opt for distraction techniques.

Novice drivers and avoidance

Among novice drivers, a prevalent approach to managing driving anxiety involves avoidance of anxiety-inducing situations. One example of this was from Narina:

> *after I failed that test because of a hill that's when I started out trying to actively avoid hills umm… initially without me realising I was I was actively avoiding it initially was just like 'oh well this is just easier to do because it's clear of traffic going this way instead of the other route where the hill was' so it was umm… it was only really really later on when I started to realise actually no I am actively avoiding this hill I don't like the hill but that that experience in the test* (*Narina)*

Narina's recent experience of failing a driving test due to challenges related to driving on hills prompted her to develop a coping mechanism centred around avoidance rather than direct confrontation. Narina's strategy revolved around evading situations that triggered her anxiety, such as hills, by deliberately choosing routes or scenarios where she could circumvent those challenges. Narina's coping strategy was accompanied by a conscious effort to rationalise her avoidance behaviour which helped her realise she was actively avoiding this specific driving situation.

If the driving anxiety becomes too severe during the novice period, individuals may avoid driving altogether.

> *I have alternatives to get there umm… with my husband wanting to drive or be able to get buses it's so easy in everyday life to not have to drive it doesn't really make sense to me why I'd put myself in that position to be anxious if I didn't have to be … I get such anxiety from being behind the wheel with other ways of getting there it's not necessarily a priority for me to get that experience to stop the anxiety when I can stop the anxiety by just not driving in the first place* (*Caroline)*

For Caroline, driving is a significant source of her anxiety. Caroline recognises that by gaining experience in driving, she would be able to mitigate her driving anxiety (Culot et al., 2021). However, instead of trying to gain experience to tackle the anxiety in the long-term, access of alternative means of transportation, such as buses or having her husband to help provides a short-term solution to her anxiety. Therefore, Caroline prioritised avoiding anxiety over gaining the experience of driving. It is irrational for Caroline to put herself in a situation that causes significant anxiety when there are readily available alternatives. This demonstrates that the primary goal is to avoid the anxiety rather than confronting it through exposure.

Experienced drivers distract themselves.

Instead of avoiding specific driving situations, experienced drivers opt for distraction techniques to redirect their thoughts and mitigate the impact of their driving anxiety. One prevalent form of distraction reported by participants is the utilisation of music while driving. Catherine employed this technique to take her mind off the thought of driving a car:

> *It made the whole like driving experience about like me listen to music rather than about like me… like dealing with cars and like having to navigate like a big metal machine like I think that it became far more about like oh if I drive then I'll be able to like have my music and I can like sing and it be really fun and then it kind of like took the emphasis away from the fact that I was like having to drive a car* (*Catherine)*

Whereas Rosie used this technique to distract herself from driving through a potentially anxiety-inducing route:

> *I think it is very much about… where I'm going, what I'm doing more than anything… but like I said I do try- I listen to music a lot when I drive on my own because I think that, I find that helpful … Music was a really big thing to me it was like "I just wanna go out listen to music for an hour and sort of clear my head and get out the house" so kind of singing to music in the car *laughs* by myself is kind of what I was doing* (*Rosie)*

The established impact of music on arousal and mood is well-documented (Gabrielsson & Lindström, 2001; Krumhansl, 1997, 2002; Peretz, 2001; Schmidt & Trainor, 2001; Sloboda & Juslin, 2001; Thayer & Levenson, 1983). Many individuals frequently choose music as a method to modulate their mood (Gabrielsson & Lindström, 2001; Sloboda & Howe, 1992).

For anxious drivers, the act of listening to music serves to alleviate anxiety and cultivate a more positive mood. Music seems to help divert their thoughts from their anxiety, fostering a shift towards a more positive emotional state (Krause et al., 2023). By engaging in this strategic use of music, experienced drivers effectively manage their driving anxiety without resorting to avoidance behaviours. Such techniques can help divert the attention away from worrying thoughts, thus making their driving experience more positive (Groarke et al., 2020; Taruffi, 2021).

Concluding remarks

Summary of findings

The findings of the study generated four main themes that provided insights into the nature of driving anxiety: 'The role of generalised anxiety,' 'Stressors on the road', 'The alternative reality of attention' and 'Mitigation of driving anxiety'. Each one of these themes consisted of several sub-themes which contributed to a more comprehensive understanding of the experiences and challenges faced by individuals with driving anxiety.

The first theme underscored the role of generalised anxiety in driving anxiety. Most of the participants disclosed experiencing generalised anxiety disorder, which seemed to have branched into driving anxiety due to certain stressful scenarios experienced by the participants while driving. As a result, generalised anxiety could be seen as a potential precursor to driving anxiety, thus increasing the likelihood of developing the disorder.

The second theme delved into the factors that have been reported to contribute to the ongoing presence and intensification of driving anxiety through stressors on the road. Central to this theme is the prominent role played by the perceived lack of control that individuals experience while driving. A key aspect of this lack of control appeared to be rooted in the unpredictability of other drivers' behaviour on the road. It became evident that the inability to anticipate and regulate the actions of other drivers contributed significantly to the maintenance of driving anxiety and the low level of confidence in participants' skills to cope with the stressful situations.

Another factor closely linked to the lack of control was the feeling of being judged by other drivers and car's passengers. The social context of driving amplifies the anxiety experienced by individuals, as they not only contend with the challenges of the road but also grapple with the fear of being evaluated and criticised by others. The constant presence of potential judgment from other drivers seem to add an additional layer of stress and self-consciousness to the driving experience. The fear of social judgment appeared to further contribute to the low levels of confidence and the perception of poor driving skills for anxious drivers.

The low confidence in their driving skills seemed to be driven by a deep-seated need to avoid making errors which became clear with the third theme. This theme revealed information on the impact of anxiety on attentional processes during driving, with participants describing becoming fully engrossed in the driving situation. This intense focus and preoccupation with driving to ensure error-free performance seemed to lead to participants attending to the wrong cues due to the fast-paced nature of the alternative scenarios playing in their mind. Attending to multiple imagined scenarios could potentially impact the ability to attend to relevant real hazardous scenarios (Dijkstra et al., 2021).

The final theme addressed the mitigation of anxiety and highlighted the effect of experience on choice of mitigation technique. It was observed that novice drivers often tend to avoid situations that trigger anxiety altogether, while experienced drivers employ distraction techniques to distract their attention from the worrying thoughts and manage their anxiety.

Together, these four themes provided a comprehensive understanding of the multifaceted nature of driving anxiety, incorporating the role of generalised anxiety, the perpetuation of anxiety through lack of control and judgement, the impact of anxiety on attentional processes and some mitigation techniques employed by participants to alleviate the anxious thoughts.

Implications

This study expands on the knowledge of how driving anxiety manifests and its impact on drivers from both a social and individual perspective. Driving anxiety does not always stem from being involved in a traffic collision; it can often originate from prior struggles with an anxiety disorder or simply as an outcome of all different daily life issues (when there is not a diagnosed anxiety). This suggests that therapies targeting anxiety may be effective in mitigating driving anxiety. However, these therapies would need to be tailored to address behaviours specific to the driving context in addition to more general behaviours. Tailored therapies may involve exposing drivers to certain driving scenarios, which can be both risky and frightening for anxious drivers. Recently, virtual reality-based treatments have gained increasing interest due to the decreased cost of hardware, growing acceptability, and improved ease of access (Carl et al., 2019; Menelas et al., 2018). They offer several advantages including mitigating the common experience of patient aversion associated with in vivo exposure (Bouchard et al., 2017); reducing the risk of conducting exposure therapy on road (Bush, 2008); and improving the ability to control and tailor the environment to the needs of the patient (Knott et al., 2021).

Driving anxiety seems to be more common among younger drivers. As a results, driving instructor's may be able to tailor their teaching styles to support anxious drivers and advise on steps they can take to conquer their nerves. One of the main problems is the low confidence anxious drivers have in relation to their driving skills. Working on increasing their confidence could help decrease the anxiety. Driving instructors could focus on teaching a balance between confidence and competence. Drivers who suffer from performance anxiety will most likely not perform at their best due to a lack of confidence. They may have the necessary skills, but without confidence, they cannot fully utilise them. Conversely, a driver might feel very confident but lack the required ability to driver safely. In both scenarios, drivers are likely to fail—either because they cannot apply their skills effectively or because their overconfidence leads to mistakes.

This study is not without limitations. Of note, the sample was of convenience, relatively small and isolated to anxious drivers. Although the sample size was acceptable when conducting thematic analysis, the diversity in the sample was limited which suggests that there may be driver types that were not captured in the current study (Guest et al., 2006). Therefore, this study should be considered an explorative rather than exhaustive understanding of driving anxiety. While driving experience was balanced, the age of the participants was skewed towards younger drivers. Older drivers may have provided other insights into the cause, maintenance, and impact of driving anxiety through the lifespan.

Additionally, the sample was a mixture of individuals with and without generalised anxiety. Although the current study suggested that driving anxiety could be a manifestation of general anxiety, previous literature found that driving anxiety has also been associated with specific driving situations themselves without the addition of generalised anxiety (Ehlers et al., 1994; Taylor & Deane, 1999, 2000). This indicates that personal experiences with anxious driving situations can give rise to driving anxiety without an interaction with generalised anxiety. However, it is important to acknowledge that the conclusions from this study are based on the current sample, which did not seem to have severe generalised anxiety. Individuals with more severe generalised anxiety may be more susceptible to developing driving anxiety in these contexts compared to those without generalised anxiety (Stephens et al., 2020).

Conclusion

Driving anxiety may not always originate from collisions; it can stem from underlying anxiety disorders or everyday stressors. This type of anxiety specifically affects a driver's confidence in their driving abilities. Individuals may have the necessary skills to drive safely, but their anxiety could undermine their belief in their own competence, leading to a potential increase in stress and hesitation behind the wheel. This lack of confidence could cause drivers to second-guess their decisions, overreact to minor situations, or even avoid driving altogether, which further limits their opportunities to practice and improve their skills. Certain driving scenarios may appear to trigger driving anxiety more than others, with social judgment being particularly significant. Anxious individuals may become preoccupied with these anxiety-inducing scenarios, frequently anticipating negative outcomes. This preoccupation may have the potential to influence their attentional processes, leading to behaviours such as hypervigilance or visual tunnelling. Finally, anxious drivers reported using different strategies to manage their driving anxiety. Experienced drivers may use distraction techniques, while novice drivers tend to avoid specific driving routes.

Chapter 4: Relationship between driving anxiety and self-reported driving error

Summary of the results from the previous chapter

The aim of Chapter Three was to address the limited research on the origin and impact of driving anxiety on everyday driving by offering an in-depth exploration of anxious drivers' lived experiences. The primary objective was to unravel the factors that give rise to driving anxiety and the specific triggers that exacerbate it, supported by specific examples. To achieve this, a qualitative approach was employed, as it allows for a comprehensive exploration of participants' lived experiences and their personal perceptions of these encounters. Additionally, the study investigated participants' perspectives on how their driving anxiety impacted their driving experience and performance. Driving anxiety can affect individuals differently and each person may have a unique understanding of their experience. Hence, it was essential to first understand the personal experience of anxious drivers from their viewpoint before approaching the phenomena in a more objective manner. The drivers' perception of their driving performance will inevitably influence their driving behaviour, making it crucial to understand their subjective experiences thoroughly (Gwyther & Holland, 2014). By examining and analysing each aspect of this experience, the study aimed to identify commonalities and gain a comprehensive perspective on driving anxiety's impact on individuals' everyday driving.

A notable finding was that anxious drivers often evaluate their own driving performance as negative, leading to a decreased self-confidence in their driving skills. All participants believed they commit errors while driving more often than other drivers. Building upon the findings in the preceding chapter, the study in the current chapter was focused on assessing whether driving anxiety is associated with self-reported driving error. Some of the participants from the previous study reported committing a variety of driving errors including performance and attentional driving mistakes and lapses. As a result, the aim of the current study was to develop a model to test whether driving anxiety can predict driving error.

Introduction

In 2022, there were 135,480 road-related casualties of all severities in Great Britain (Department of Transport, 2023). Of these casualties, 30,229 (22.3%) were caused by drivers failing to look properly and 29,556 (21.8%) by inappropriate driving behaviour such as being careless, reckless or in a hurry (Department of Transport, 2023). Reports demonstrate that approximately 52% of drivers experience mild anxiety at the wheel whereas 16% experience moderate to severe anxiety whilst driving (Taylor, 2018). Recently within the UK, 5,614 motorists reported driving-related anxiety to the DVLA in 2022 with 2,189 (39%) reporting that anxiety affects their driving (AVIVA, 2023).

Anxious drivers can experience considerable distress while driving (Taylor, 2011; Koch et al., 2011), often leading to difficulty in maintaining focus on the driving task (Navon & Taubman-Ben-Ari, 2019). This difficulty has been attributed to their preoccupation with repetitive negative thoughts (cognitions) related to driving, causing them to become detached from the driving task (Love et al., 2022). These cognitions involve thoughts concerning threat or harm that can inflate the perceived risk either before or while driving (Koch et al., 2011; Zinzow & Jeffirs, 2018). The tendency to overestimate potential risk and negative outcomes was also evident in the findings in Chapter 3, particularly with the catastrophising thoughts reported by our participants. Ehlers et al. (2007) identified three main types of cognitions linked with anxious drivers. These were panic related cognitions, crash related cognitions, and negative social cognitions, which were all validated as different dimensions of the Driving Cognitions Questionnaire (DCQ). Panic related cognitions occurred when participants were overwhelmed, which caused them to become detached from the driving situation. Crash related cognitions were noticeable when participants held the belief that their lack of driving skills would result in a collision. Negative social cognitions emerged when individuals believed they were being judged by other road users. The first study of this thesis supported Ehlers et al.'s (2007) findings in Chapter 3 revealing that participants reported to experience all three types of cognitions. Other studies have also observed similar findings (e.g. Craft & Preslopsky, 2009; Hoel et al., 2010).

As driving is a complex and goal-directed behaviour, it relies on various higher-order cognitive processes (Groeger, 2013; Mäntylä et al., 2009). If these cognitive processes are compromised by irrational and catastrophic thoughts, then the driving behaviour could also be negatively affected, leading to driving errors. Some studies have identified a range of problematic driving behaviours (e.g., disorientation, slowing for green lights, driving significantly below the speed limit) among individuals who continue to drive despite feeling anxious (Koch & Taylor, 1995). Clapp et al. (2011a) further explored the impact of anxiety on driving behaviour by identifying three categories of anxious driving. These included anxiety-based performance deficits, exaggerated safety-cautious behaviours, and retaliatory hostile/aggressive behaviours which were all part of their newly developed Driving Behaviour Survey (DBS) as different dimensions.

Anxiety-based performance deficits suggest that driving-related worry can interfere with task-related demands, impairing driving performance and reducing overall safety (Matthews et al., 1998). For instance, Taylor et al. (2007) found that anxious drivers made more performance errors, such as using incorrect lanes and making inappropriate speed adjustments, compared to non-anxious controls. Exaggerated safety-cautious behaviours, such as maintaining excessive distances from other motorists, driving well below the posted speed limit, and reducing speed before intersections, are often seen as coping mechanisms that decrease immediate anxiety by enhancing perceptions of safety and control (Mayou et al., 1991; Taylor & Koch, 1995). While these behaviours can alleviate short-term distress, predictive models indicate they ultimately maintain anxiety by disrupting natural driving processes. Hostile/aggressive behaviours, including yelling, honking, and aggressive gestures toward other drivers, are also associated with anxiety. Anxiety-related driving aggression is particularly detrimental, as anxious-aggressive drivers tend to have low perceived driving skill, endorse risky driving behaviours, and exhibit high levels of accident involvement (Ulleberg, 2002).

In addition, Clapp et al. (2011b) assessed the convergent validity between their newly developed DBS, and the Driving Cognitions Questionnaire (DCQ: Ehlers et al., 2007). Their results suggested that the anxiety-performance deficits dimension of the DBS showed strong positive association with all three cognitions factors of the DCQ. This suggested that irrational cognitions were positively related to anxious driving behaviour.

Clapp et al., (2011a) related a third component to driving cognitions and anxious driving behaviour – driving avoidance. The level of driving avoidance in anxious drivers has been measured via different dimensions of general driving avoidance as well as avoidance of specific driving situations - dimensions included in the Driving and Riding Avoidance Scale (DRAS; Stewart & St. Peter, 2004). Their results suggested that driving avoidance was associated with anxious driving behaviour, but only in relation to anxiety-performance deficits and not the safety/caution dimension. However, DRAS did show a more favourable convergent validity with the DCQ (Taylor et al., 2021). While driving avoidance shows inconsistency in its relationships with driving anxiety, it is still important to be observed together with the other factors. Reduction in driving frequency and an increase in arranging alternative transport is frequently observed in anxious drivers (Baldock et al., 2006; Gallo et al., 1999; Taylor, 2018). This behaviour can be problematic as infrequent driving can prevent anxious drivers from practicing their driving skills, resulting in diminished control while driving and an increased risk of errors (Matthews et al., 1998). Anxious drivers genuinely believe that their anxiety negatively impacts their driving performance, leading them to avoid driving as a result of perceived performance deficits (Molnar et al., 2013).

The driver's ability to maintain attention is crucial for discerning relevant information required for effective decision-making, while simultaneously remaining poised to respond promptly to unforeseen circumstances. The evidence suggests that driving anxiety can have an impact on driving performance (Matthews et al., 1998; Shoham et al., 1984). Notably, individuals exhibiting heightened anxiety levels have demonstrated less efficient allocation of attention to target stimuli in comparison to their less anxious counterparts (Eysenck et al., 2007). Additionally, the capacity to inhibit distractions in stressful situations could be difficult for anxious drivers (Tsai et al., 2017). The impaired attentional control coupled with difficulty in supressing anxiety could lead to errors while driving (Tsai et al., 2017).

Driving error is defined as “the failure of planned actions to achieve an intended consequence” (Reason et al., 1990, p. 1315). However, driving errors could be either intentional or unintentional. For example, if the action deviates from what was intended, it is categorised as a slip error. In turn, if the intention itself is flawed, leading to an inappropriate action, it is classified as a mistake (Norman, 1983; Reason et al., 1990). Furthermore, driving error can also encompass different risk levels (Reason et al., 1990). An example of low risk is to miss a sign on a roundabout and exit on the wrong road. An example of intermediate risk would be unknowingly speeding, and an example of a high risk would be not checking mirrors before changing lanes. Anxious drivers often report to have committed similar errors which are usually self-inflicted (Fairclough et al., 2006), a finding supported by many quotes from participants in study one, where they described making comparable mistakes while driving (please refer to the result and discussion section, p. 81).

Anxious drivers have been associated with errors (Clapp et al., 2011b; Matthews et al., 1998; Taylor et al., 2007). Some errors that anxious driver have committed from previous studies are the using incorrect lanes and making inappropriate speed adjustments (Clapp et al., 2011a). As mentioned above, the importance of these errors is based on the intention of the driver. For example, if an anxious driver did not realise, they were driving too slowly because they did not see the speed sign change, this would be a slip error. However, if the anxious driver saw the speed sign change but chose to maintain a slow speed, this would be a mistake. Both types of error can be attributed to driving anxiety, but the way driving anxiety is impacting the behaviour is different. For example, the slip error could be due to the anxious driver attending to another stimulus (Gortari et al., 2019), whereas the mistake could be due to an ineffective coping mechanism (Mohamad, 2022).

Other types of error anxious drivers have been reported to commit are riskier in nature. Dula et al. (2010), found that higher levels of anxiety were associated with greater propensity toward dangerous driving compared to low or medium levels of anxiety. In the study high anxious drivers scored significantly higher on each of the subscales of the Dula Dangerous Driving Index (Dula & Ballard, 2003) which included aggressive driving, negative-emotional driving and risky driving. Other violations which have been associated with high driving anxiety have been running red lights and not stopping at stop signs. When measuring driving anxiety through the State-Trait Anxiety Inventory (STAI; Spielberger, 1970), riskier driving behaviour was identified in individuals high in trait anxiety with the explanation offered for this being cognitive overload in the highly anxious leading to unintentional violations, lapses and errors while driving (Shahar, 2009). However, Taylor et al. (2007) using a standardised on-road assessment, argued anxious drivers seem to make more driving errors rather than different types of error. However, it is important to focus the studies which measured self-reported errors because it is essential to understand anxious drivers perceptions of their errors.

While there is evidence indicating that anxiety can contribute to errors in driving performance, the literature remains scarce. Moreover, the existing studies have not made a distinction between different types of errors, particularly intentional and non-intentional errors. The Driving Behaviour Questionnaire (DBQ, Reason et al., 1990) is a multi-dimensional measure able to make this precise distinction between unintended errors and intentional violations. The efficacy of this measure has been demonstrated in various countries (Lajunen et al., 2004; Özkan et al., 2006) and among diverse driver groups (Bianchi & Summala, 2004; Conner & Lai, 2005; Dobson et al., 1998; Freeman et al., 2009; Martinussenet al., 2014; Rimmö & Hakamies-Blomqvist, 2002; Steg & Van Brussel, 2009; Sullman et al., 2002). The questionnaire not only has shown a good ability in identifying those drivers who are more prone to commit errors but also distinguished this propensity between younger less experienced drivers and older more experienced ones (Sucha et al., 2014). Exploring the relationship between driving experience and driving anxiety is important as certain differences in the driving behaviour of anxious novice and experienced drivers have been reported. Anxious inexperienced drivers tend to closely monitor other vehicles, while anxious experienced drivers are more focused on monitoring task-related goals, such as checking their speed (Gotardi et al., 2019). These findings highlight differing strategies employed by drivers based on their experience levels when dealing with anxious states. However, it was not within the aims of Gotardi et al.'s (2019) study to examine the moderating effect of driving experience between driving anxiety and driving error. Thus, it remains unclear whether more experienced anxious drivers would report fewer driving errors than their novice counterparts.

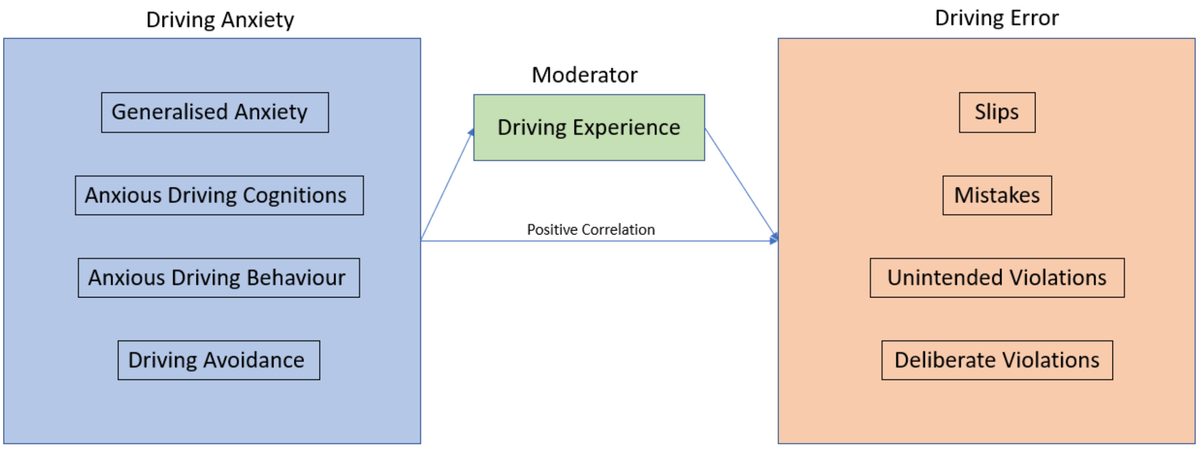
The current study

Though some studies have argued that anxious drivers engage in more risky driving behaviours compared to non-anxious drivers, the classification of their anxiety groups was solely based on scores from the STAI (Spielberger et al., 1970), without specifically considering the different dimensions of driving anxiety (e.g. Shahar, 2009). In order to establish a more robust distinction between anxious and non-anxious drivers, the current study assessed various behavioural indications of driving anxiety, alongside generalised anxiety. These were measured via The DCQ, DBS, DRAS, and Generalised Anxiety which demonstrates good reliability and convergent validity. The selected measures allowed for driving anxiety to be mapped to cognitive and behavioural components, thus providing a more holistic assessment of the driver groups (Taylor et al., 2021). As a result, driving anxiety was fitted as a predictor to self-reported driving error. More specifically the predictive model developed in this study aimed to assess whether the identified dimensions of driving anxiety can predict intentional and unintentional driving errors (See Figure 9). This distinction is important given the propensity of some anxious drivers to report more slips errors. Finally, the model also assessed whether driving experience moderates the relationship between driving anxiety and driving errors.

Hypotheses

It was hypothesised that driving anxiety would predict driving error, with higher scores in driving anxiety predicting a higher tendency to commit both unintentional and deliberate violations. Specifically, it was expected that higher scores in driving anxiety would predict more propensity to commit slips, mistakes, and unintended violations. Finally, it was predicted that driving experience would have a moderating effect between driving anxiety and driving error, with anxious and non-anxious experienced drivers reporting less driving errors than anxious and non-anxious novice drivers.

Figure 9: *Predictive model of driving anxiety and driving error.*



Method

Participants

In total, 384 participants took part in this study. Sixty-six participants were removed due to incomplete responses, leaving 316 participants. Experienced drivers were defined as those who had at least three years of driving experience and have driven actively during the previous two years (at least a 1000 miles per year). Participants who had less than 3 years of driving experienced were classed as novices independently of the mileage driven during these three years (McCart et al., 2009). As a result, the final sample was comprised of 249 participants after removing 135 participants who did not meet the above criteria. The final sample was comprised of 83 males, 163 females with 3 not disclosing their sex. For more information, please refer to Table 4.

In total, 156 individuals reported experiencing driving anxiety, while 93 participants reported no driving anxiety. This division was based on participants' self-reported driving anxiety, and subsequently validated through the driving anxiety scales selected for this study. For a detailed information on driving anxiety, experience and age, please refer to Table 4.

Table 4: *Means* (*M*), *standard deviations* (*SD*) *across descriptive variables for anxiety and experience for study two*

N = 249								
Descriptive variables								
Anxiety	**Anxious *n* = 156**				**Non-anxious *n* = 93**			
Experience	**Experienced *n* = 72**		**Novice *n* = 84**		**Experienced *n* = 66**		**Novice *n* = 27**	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Age	31.96	14.08	21.96	5.36	34.97	16.61	20.48	2.33
License in months	151.03	150.82	9.57	11.85	194.21	190.76	12.48	13.75
Miles per year	6532.78	4766.15	1848.57	2823.52	9242.42	5348.79	6051.85	10842.03

Design

A cross-sectional design featuring self-report measures, and an open-ended question was implemented for this study. The study was administered online via Qualtrics. The model included four predictor variables: anxious driving behaviour, negative driving cognitions, driving avoidance behaviour and generalised anxiety. The outcome variable was self-reported driver error (slips, mistakes, unintended violations, and deliberate violations), while driving experience was fitted as a moderator between driving anxiety and driving error.

Materials

Participants were first asked to provide demographic information related to their driving history. They were asked to provide their age, gender, driving experience and average miles driven during the previous year.

Several psychometric measures including the Driving Behaviour Survey (DBS; Clapp et al., 2011a), Driving Cognitions Questionnaire (DCQ; Ehlers et al., 2007), Driving and Riding Avoidance Scale (DRAS; Stewart & St. Peter, 2004) and the Generalised Anxiety Disorder Scale (GAD-7; Spitzer et al., 2006) were administered to participants to measure their scores in driving-related anxiety. The Driving Behaviour Questionnaires (DBQ; Reason et al., 1990) was used to measure driving errors (slips and mistakes) and violations, as it has demonstrated consistent results in a number of countries for the assessment of risky driving behaviour (Aberg & Rimmö, 1998; de Winter et al., 2015; Gupta et al., 2021; Lajunen et al., 2004; Martinussen et al., 2013). In addition, participants were asked to report whether there were specific driving situations that trigger their anxiety while driving.

All questionnaires in this study were selected based on their ability to measure a certain aspect of driving anxiety such a driving avoidance, driving panic, being judged by other drivers etc. The GAD-7 was included to control for differences between the anxious and non-anxious groups and test whether those drivers who reported to experience driving anxiety will also report high scores in generalised anxiety. It should be noted that the role of GAD-7 was to explore a possible correlation between generalised anxiety and the rest of the measures and not for diagnostic purposes. Each one of the measures, including its validity and reliability have been briefly described below:

Driving Behaviour Survey (DBS)

The DBS (Clapp et al., 2011) is a 21-item self-report scale used to measure three dimensions of anxious driving behaviour: anxiety-related performance deficits (e.g., '*I have difficulty merging into traffic'*) (7 items) , aggressive behaviour (e.g., '*I swear/use profanity while I am driving'*) (7 items) and caution behaviour (e.g., '*I slow down when approaching intersections even when the light is green'*) (7 items). Participants were asked to rate the frequency of such behaviours when faced with a stressful driving situation. All items were rated on a 7-point Likert scale, ranging from 1 (*never*) to 7 (*always*). Scores were averaged across all items, with higher scores suggesting elevated anxious driving behaviour. Good internal consistency was demonstrated for performance deficits (α = .77), hostility/aggression (α = .86) and exaggerated safety (α = .78) (Clapp et al., 2011). Test-retest reliability coefficients were satisfactory, with satisfactory or good factorial, convergent and discriminant validity (Clapp et al., 2011a; 2011b; Clapp et al., 2014; Taylor et al., 2021).

Driving Cognitions Questionnaire (DCQ)

The DCQ (Ehlers et al., 2007) is a 20-item self-report scale that was used to measure driving anxiety-related cognitions. The scale exhibits three distinct areas of measurement: panic related (e.g., *'I will tremble and not be able to steer'*) (7 items), accident-related (e.g., '*I will injure someone'*) (7 items) and social (e.g., '*People will think I am a bad driver'*) (6 items). Frequency of thought occurrence when driving was rated on a 5-point Likert scale, ranging from 0 (*never*) to 4 (*always*). Total scores were calculated (ranging from 0 to 80), with higher scores indicating increased negative driving-related cognitions. The DCQ has been shown to have good internal consistency, convergent validity (Lajunen et al., 2004; Martinussen et al., 2013), and an ability to discriminate between people with and without driving anxiety (Ehlers et al., 2007).

Driving and Riding Avoidance Scale (DRAS)

The DRAS (Stewart & St. Peter, 2004) is a 20-item self-report measure that was used to assess the frequency of driving and riding-related avoidance behaviour. A four-factor model was used which covered the subscales: general avoidance (e.g., *'I put off a brief trip or errand that required driving the car'*) (7 items), traffic avoidance (e.g., *'I avoided driving on busy city streets'*) (7 items), weather avoidance (e.g., *'I avoided driving the car because the weather was bad'*) (5 items) and passenger avoidance (e.g., *'I avoided riding in a car if I could'*) (5 items). Participants were asked to rate the frequency of such behaviours across a period of seven days. Responses were rated on a 4-point Likert scale that ranges from 0 (*rarely or none of the time – less than 1 day*) to 3 (*most or all of the time – 5-7 days*). Total scores (between 0-60) were calculated through the sum of the items, with higher scores suggesting greater travel avoidance behaviour. The scale shows a high internal consistency (α = .92) (Stewart & St. Peter 2004), with a good test-retest reliability, as well as evidence for convergent and divergent validity (Blachnio et al., 2013; Taylor et al., 2018; Taylor & Sullman, 2009).

7-item Generalised Anxiety Disorder Scale (GAD-7)

The GAD-7 (Spitzer et al., 2006) is a 7-item self-report scale that was used to measure the frequency of Generalised Anxiety Disorder (GAD) symptoms over the last two weeks (e.g., '*Feeling nervous, anxious, or on edge*'). Responses are rated on a 4-point Likert scale, ranging from 0 ('*not at all*') to 3 ('*nearly every day*'). The total score (between 0-21) was calculated as the sum of the 7 items. Scores between 0-4 indicate no/minimal anxiety, 5-9 demonstrate mild anxiety, 10-14 moderate and 15-21 is classed as severe anxiety. The GAD-7 shows strong internal consistency (α = .92), good test-retest reliability (r = .83) and good convergent validity, reflected through correlations with: The Beck Anxiety Inventory (r = .72) and the Symptom Checklist-90 (r = .74) (Spitzer et al., 2006). The GAD-7 also demonstrates good reliability, construct, and factorial validity with general populations (Donker et al., 2011; Löwe et al., 2008)

Driver Behaviour Questionnaire (DBQ)

The DBQ (Reason et al., 1990) is a 50-item self-report scale used to measure driving error. The scale explores four subsections of aberrant driving: slips (e.g., *'realise that you have no clear memory of the road you have been travelling on'*) (21 items), mistakes (e.g., *'brake too quickly on a slippery road'*) (9 items), unintentional violations (e.g., *'unknowingly travelling faster than the legal limit'*) (3 items), and deliberate violations (e.g., *'overtaking a* *slow-moving vehicle on the inside lane'*) (17 items). Respondents were asked to rate how frequently they had produced said behaviours within the past year. Responses were rated on a 5-point Likert scale that ranges from 1 (*never*) to 5 (*nearly all the time*). Scores of all participants were averaged across each subscale, with higher scores indicating greater frequency of driving error. The DBQ is shown to be internally consistent with Cronbach's Alpha of .79 (α = .79) (Reason et al., 1990). Over several studies, the DBQ has demonstrated good construct (Martinussen et al., 2013; Niezgoda et al., 2013), factorial (Martinussen et al., 2013) and external validity (Helman & Reed, 2015).

Open question

One open-ended question was added to explore the situations which lead to instances of driving anxiety. Participants were asked to indicate any specific driving situations that make them feel anxious. The reason for including this question was to explore and obtain an understanding of what specific scenarios could potentially trigger driving anxiety while comparing situations to study one (see Chapter 3). Many participants described specific scenarios during their interviews for the previous study, but commonalities were not explored in detail. The aim was to assess whether there were common scenarios that can make drivers more anxious and whether these could be defined in different categories.

Procedure

Ethical approval for this study was obtained by the School of Business Law and Social Sciences Ethical Committee, Nottingham Trent University (2021/98). Data was collected online via link to a Qualtrics survey advertised on various social media platforms. Participants were invited to click on the link if they wished to take part in the study. They were presented with an information sheet and were asked for consent to participate. All participants were asked to confirm they were at the age of 18 or older. Each participant was asked to provide a unique identifier.

Following consent, all participants were directed to the demographics section, where they were asked to provide information about their driving history and driving anxiety. The survey then proceeded with each one of the questionnaires. The original questionnaires were designed for offline use therefore the instructions were amended to allow for online use. For example, instead of circling the chosen response, the participant would have to click the response instead. Certain questionnaires also had specific instructions which were time sensitive. For instance, the DRAS was interested in travel avoidance in the last seven days whereas the GAD-7 was interested in general anxiety in the last two weeks. All specific instructions were provided to the participant. Finally, the different questionnaires followed a specific order to avoid participant fatigue, with the longest scale in the middle of the survey and the shortest at the end (Ben-Nun, 2008). After completing the questionnaires, participants were asked to answer the open-ended question and describe whether there were any specific driving situations that made them feel anxious. Participants were asked to provide as much detail as they wished with specific examples. At the end of the survey, participants were debriefed.

Data analysis

To determine the internal consistency of each scale, a reliability analysis was conducted. In addition, several parametric (independent samples t-test and Welch's t-test) tests were conducted to test for differences in scores for each scale between the anxious and non-anxious groups.

A correlation analysis was then carried out to determine the concurrent validity between the different driving anxiety measures. This was followed by a moderated regression analysis to examine whether the cognitions and behaviours commonly associated with driving anxiety can predict self-reported driving errors and whether this relationship was moderated by driving experience. The predictor variables were anxious driving cognitions, anxious driving behaviour, driving avoidance and generalised anxiety, and the outcome was driving error through slips, mistakes, and unintentional and intentional violations.

Finally, an exploratory analysis was carried out to determine what specific driving situations trigger driving anxiety.

Results

Descriptive statistics:

Driving history

The sample was split into anxious and non-anxious drivers, with 156 participants (62.65%) experiencing driving anxiety and 93 (37.35%) reporting no driving anxiety. The initial sample split was first based on self-reported driving anxiety and validated later via the selected driving anxiety scales. Participants who reported to have held their license for one year or less were classed as non-experienced drivers, whereas participants who held their license for over three years with at least 1000 miles of driving per year were classed as experienced drivers. Drivers between these points were considered to be transferring between inexperienced and experienced drivers and were removed from the analysis. A t-test revealed a significant difference between the experience levels of both groups ($t(144.6) = 3.1$, $p < .01$) and miles per year travelled ($t(132.4) = 5.1$, $p < .001$).

Age was equally subjected to a t-test to test for differences between the anxious group ($M = 26.58$; $SD = 11.46$) and non-anxious group ($M = 30.72$; $SD = 15.48$). A significant difference was observed ($t(150) = 1.9$, $p < .05$). As a result, age was controlled as a co-variate during the analyses.

Questionnaires

For the anxious group, the scores on the DBS oscillated in the mid-range ($M = 3.49$; $SD = 0.71$), while the scores for the DCQ ($M = 31.60$; $SD = 17.35$), DRAS ($M = 20.03$; $SD = 15.40$) and GAD ($M = 8.62$; $SD = 5.83$) were observed to oscillate below the mid-point.

The scores for the DBQ (*M* = 91.68; *SD* = 30.32) were observed to oscillate between the low and mid-range.

For the non-anxious group, DBS oscillated between the low and mid-range (*M* = 2.79; *SD* = 0.78), while the scores for the DCQ (*M* = 13.77; *SD* = 13.64), DRAS (*M* = 7.88; *SD* = 11.74) and GAD (*M* = 5.05; *SD* = 5.61) were observed to oscillate considerably below the mid-point. The scores for the DBQ (*M* = 85.65; *SD* = 23.45) were observed to oscillate between the low and mid-range.

The scores for each one of the scales were subjected to t-tests and compared across the anxious and non-anxious groups.

Means comparisons between the anxious and non-anxious groups across driving anxiety scales.

To compare the responses on each scale between the anxious and non-anxious groups, a series of independent sample t-tests were conducted. Table 5 below illustrates the means and standard deviations for the t-tests.

The values for asymmetry and kurtosis between -2 and +2 are considered acceptable to support normal univariate distribution (George & Mallery, 2019; Gravetter & Wallnau, 2014). All dimensions fit into this paradigm. The results are as follows:

For the GAD-7, the 2-tailed independent samples t-test was associated with a statistically significant effect $t(240) = 4.7$, $p < .001$. Cohen's *d* was estimated at .62 which suggested a moderate practical significance (Cohen, 1992). The anxious group obtained significantly higher scores than the non-anxious group.

For the DCQ, the Welch's *t*-test (Levene's Test for Equality of Variance $p < .001$) was associated with a statistically significant effect ($t(228.8) = 9$, $p < .001$), with the anxious group demonstrating significantly more negative driving cognitions than the non-anxious group. The Cohen's effect size value (d = 1.1) suggested a high practical significance (Cohen, 1992).

For the DBS, the 2-tailed independent samples t-test was also associated with a statistically significant effect $t(247) = 7.3$, $p < .001$. The anxious group demonstrated significantly more anxious driving behaviour than the non-anxious group. Cohen's d was estimated at .95 which suggested a high practical significance (Cohen, 1992).

Finally, for the DRAS, the 2-tailed independent samples t-test was associated with a statistically significant effect ($t(226) = 7$, $p < .001$), showing that the anxious group avoided driving significantly more than the non-anxious group. Cohen's effect size value (d = .86) suggested a high practical significance (Cohen, 1992).

Table 5: *Means (M), standard deviations (SD) for GAD, DCQ, DBS, DRAS and DBQ across anxious and experienced driver groups. Score ranges and alpha coefficients for all scales and subscales are included.*

N = 249										
Descriptive variables										
Anxiety	**Anxious n = 156**				**Non-anxious n = 93**					
Experience	**Experienced *n* = 72**		**Novice *n* = 84**		**Experienced *n* = 66**		**Novice *n* = 27**			
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Score range	Cronbach's Alpha
GAD-7 Total	8.82	6.01	8.44	5.68	4.25	5.52	7.08	5.43	0 - 21	.94
DCQ Total	30.06	16.99	32.92	17.64	10.48	8.34	21.81	19.74	0 – 80	.96
Panic-related	7.40	6.26	7.83	6.29	1.94	2.85	5.85	6.93	0 - 28	
Accident-related	12.54	6.86	13.10	7.71	5.09	3.84	9.48	7.85	0 – 28	
Social-related	10.11	5.65	11.99	5.97	3.45	3.26	6.48	5.76	0 - 24	
DBS Mean	3.54	.78	3.45	.65	2.81	.63	2.74	1.08	1 – 7	.86
Anxiety-related performance deficits	3.13	1.09	3.25	1.03	2.05	.78	2.32	1.12	1 – 7	
Exaggerated safety/caution behaviour	4.74	.87	4.80	.89	3.86	1.05	3.46	1.59	1 – 7	
Hostile/aggressive behaviour	2.75	1.28	2.32	1.06	2.52	1.13	2.44	1.37	1 – 7	
DRAS Total	18.17	14.10	21.72	16.41	4.86	6.40	15.42	17.58	0 - 60	.95
General avoidance	6.08	5.35	7.61	6.17	1.57	2.50	5.27	5.77	0 - 21	
Traffic avoidance	7.63	5.86	8.67	6.34	2.17	3.33	5.35	6.21	0 – 21	
Weather avoidance	4.14	4.37	5.56	5.07	.98	1.87	4.62	5.22	0 – 15	
Passenger avoidance	3.40	3.65	3.61	4.19	.91	2.17	3.73	4.80	0 – 15	
DBQ Total	99.46	31.47	85.01	27.79	85.65	20.87	85.63	29.26	50 - 250	.96
Slips/Lapses	45.10	14.32	39.05	12.91	35.41	8.11	36.56	12.91	21 – 105	
Mistakes	18.78	5.89	16.33	6.05	15.97	4.27	16.15	5.91	9 – 45	
Unintended violations	6.81	2.21	5.92	1.77	6.18	1.83	5.89	1.87	3 – 15	
Deliberate violations	28.78	12.05	23.71	9.48	28.09	8.98	27.04	10.76	17 – 85	

Correlations between the scores for each scale:

The concurrent validity between all driving anxiety scales was tested. Table 6 exhibits a statistically significant, positive correlation between all scales selected for this study.

Table 6: *Correlations between GAD -7, DCQ, DBS, and DRAS.*

	GAD-7	**DCQ**	**DBS**	**DRAS**
GAD-7	1			
DCQ	.547**	1		
DBS	.343**	.533**	1	
DRAS	.393**	.677**	.484**	1

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

Moderated linear multiple regressions

A series of moderated linear multiple regressions were calculated to assess whether driving anxiety can predict driver error through slips, mistakes, unintentional and deliberate violations. Driving experience was fitted as a moderator and participants' age fitted as a covariate. All values of all control variables, moderating variables, and predictors in their respective scales are shown in a table after each result respectively.

Driving anxiety and slips errors while driving

The overall association between all driving anxiety predictors and slips was significant, $F(10, 230) = 21.63$, $p < .001$. The Slips Model explained 46% (adjusted $R^2 = .46$) of the variability in driving slips. The scores on the GAD-7, DCQ, DBS and DRAS significantly predicted the scores on the slips subscale, suggesting a better than mean model.

It was found that anxious driving behaviour (DBS) significantly predicted slip errors indicating that the more anxious and aggressive driving behaviour participants display on the road, the more likely they are to make slip errors. None of the other predictors contributed significantly to the model.

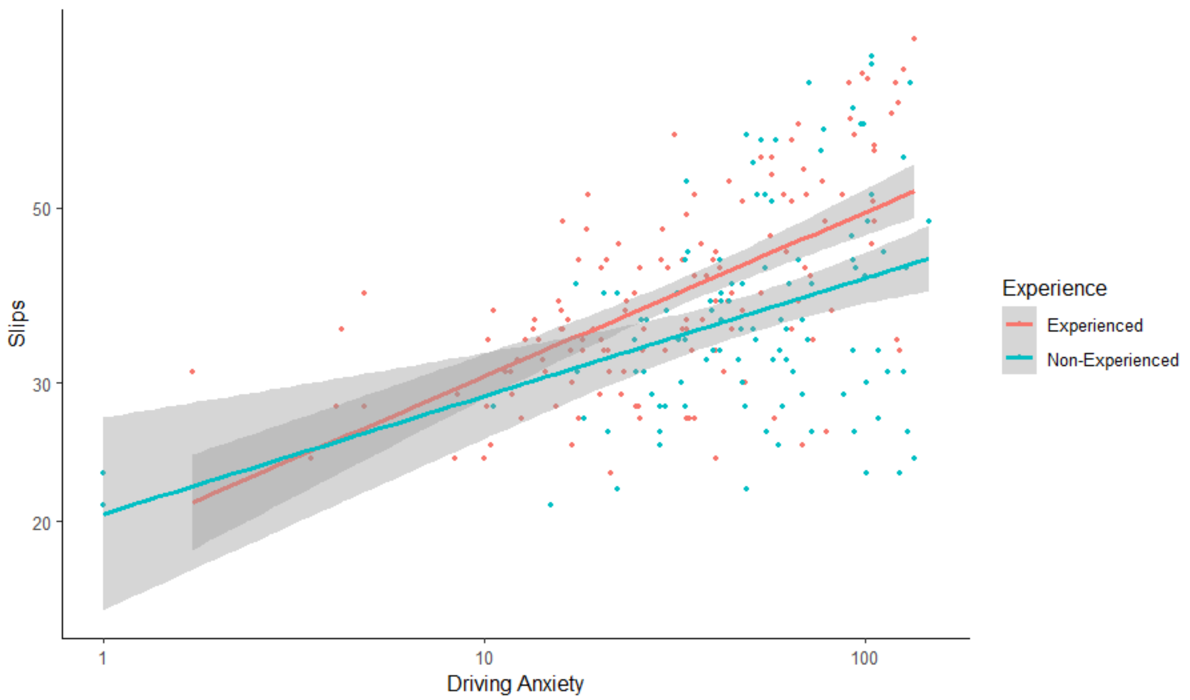
The moderating effect of experience on the relationship between driving anxiety and slip errors was not found to be statistically significant. This suggests that the strength and direction of the relationship between driving anxiety and slip errors do not significantly differ across different levels of experience. When controlling for age, it was found that age did not influence the relationship between the variables.

Table 7 illustrates the values of all control variables, moderating variables, and predictors in their respective scales for the Slips Model. Figure 10 exhibits the scatterplot of the slips model.

Table 7: *Summary of multiple regression analysis for the Slips Model.*

Variable	B	SE(B)	β	t	p	Tolerance	VIF
Intercept	6.70	4.73		1.42	0.16		
Age	0.02	0.06	0.05	0.36	0.72	0.580	1.725
GAD	-0.25	0.26	-0.76	-0.96	0.34	0.153	6.540
DCQ	0.03	0.08	0.06	0.41	0.68	0.156	6.413
DBS	9.23	1.53	0.59	6.05	0.001	0.236	4.235
DRAS	0.10	0.09	0.28	1.17	0.24	0.201	4.970
Experience	0.77	1.28	0.80	0.60	0.55	0.054	18.595
GAD*Experience	0.05	0.07	0.13	0.77	0.45	0.122	8.176
DCQ*Experience	0.04	0.03	0.20	1.33	0.19	0.104	9.649
DBS*Experience	-0.37	0.44	-0.45	-0.84	0.40	0.040	24.728
DRAS*Experience	-0.01	0.03	-0.23	-0.30	0.76	0.165	6.077

Figure 10: *Relationship between driving anxiety and slip errors across experienced groups.*



As the DBS contributed significantly to the model, a moderated regression of the DBS subscales was conducted alongside all other independent variable subscales. Each subscale dimension was observed individually, but only the DBS subscales are reported. Anxiety-based performance deficits ($\beta = 0.69$, $p < .001$) and aggressive behaviour ($\beta = 0.37$, $p < .001$) independently displayed a positive association with slip errors. Cautious behaviour did not significantly contribute to the model ($\beta = -0.14$, $p = .053$).

Driving anxiety and mistakes while driving

The overall association between all driving anxiety predictors and mistakes was significant, $F(10, 230) = 16.54$, $p < .001$. The Mistakes Model explained 39% (adjusted R^2 = .393) of the variability in driving mistakes. The scores on the GAD-7, DCQ, DBS and DRAS significantly predicted the scores on the mistakes subscale, suggesting a better than mean model.

It was found that anxious driving behaviour (DBS) significantly predicted mistakes indicating that the more anxious and aggressive driving behaviour participants display on the road, the more likely they are to make mistakes. All other driving anxiety scales did not significantly contribute to the model.

The moderating effect of experience on the relationship between driving anxiety and mistakes was not found to be statistically significant. This suggests that experience did not influence the strength and direction of the relationship between driving anxiety and mistakes. When controlling for age, it was found that age did not significantly predict mistakes.

Table 8 illustrates the values of all control variables, moderating variables, and predictors for the Mistakes Model. Figure 11 exhibits the scatterplot of the mistakes model.

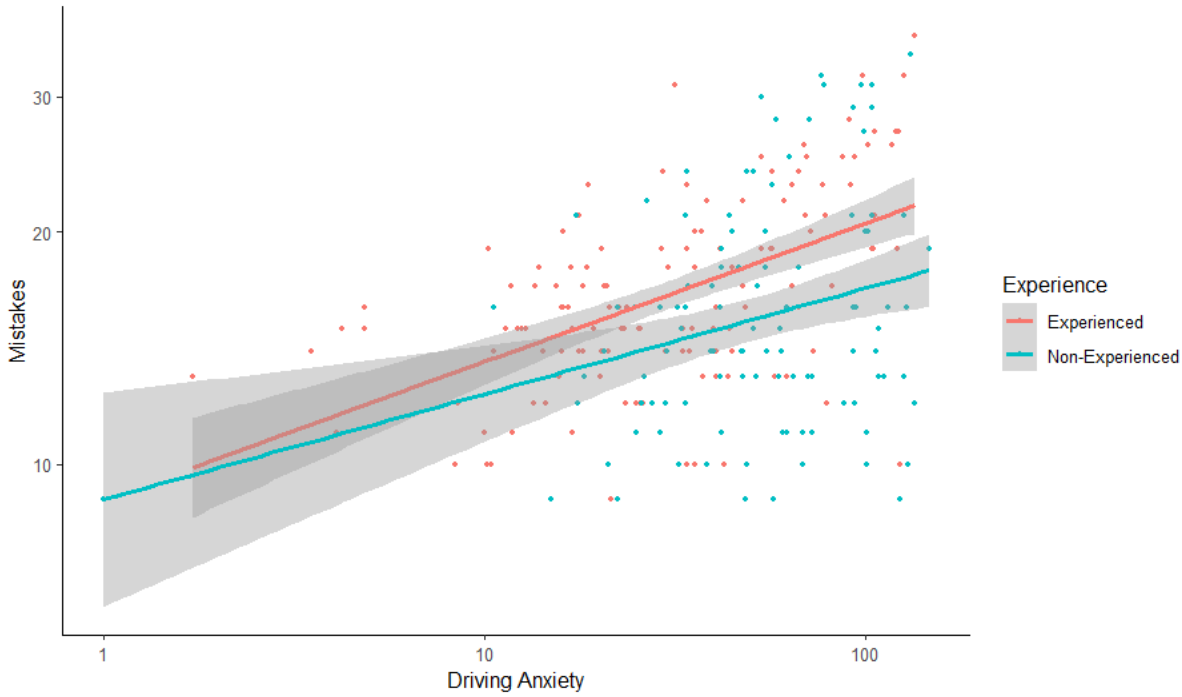
As the DBS contributed significantly to the model, a moderated regression of the DBS subscales was conducted alongside all other independent variable subscales. Each subscale dimension was observed individually, but only the DBS subscales are reported. Anxiety-based performance deficits ($\beta = 1.62$, $p < .001$) and aggressive behaviour ($\beta = .34$, $p < .001$)

independently displayed a positive association. Cautious behaviour did not significantly contribute to the model (β = -.03, p = .64).

Table 8: *Summary of multiple regression analysis for the Mistakes Model.*

Variable	B	SE(B)	β	t	p	Tolerance	VIF
Intercept	2.87	2.22		1.30	0.20		
Age	-0.03	0.03	-0.03	-1.17	0.24	0.580	1.725
GAD	-0.15	0.12	-0.16	-1.21	0.23	0.153	6.540
DCQ	0.02	0.04	0.16	0.43	0.67	0.156	6.413
DBS	4.14	0.72	0.32	5.78	0.001	0.236	4.235
DRAS	0.05	0.04	0.06	1.14	0.25	0.201	4.970
Experience	0.95	0.60	0.34	1.57	0.12	0.054	18.595
GAD*Experience	0.02	0.03	0.30	0.72	0.47	0.122	8.176
DCQ*Experience	0.02	0.01	0.14	1.69	0.09	0.104	9.649
DBS*Experience	-0.28	0.21	-0.15	-1.36	0.17	0.040	24.728
DRAS*Experience	-0.01	0.01	-0.14	-1.14	0.25	0.165	6.077

Figure 11: *Relationship between driving anxiety and mistakes across experienced groups.*



Driving anxiety and unintended violations

The overall association between all driving anxiety scales and unintended violations was significant, $F(10, 230) = 6.95$, $p < .001$. The Unintended Violations Model explained

20% (adjusted $R^2 = .20$) of the variability in unintended violations. The scores on the GAD-7, DCQ, DBS and DRAS significantly predicted the scores on the unintended violations subscale, suggesting a better than mean model.

It was found that anxious driving behaviour (DBS) significantly predicted unintended violations indicating that the more anxious and aggressive behaviour you display on the road, the more likely you are to make unintended violations. All other driving anxiety scales did not significantly contribute to the model.

The moderating effect of experience on the relationship between driving anxiety and unintended violations was not found to be statistically significant. This suggests that experience did not influence significantly the strength and direction of the relationship between driving anxiety and unintended violations. When controlling for age, it was found that age did not significantly predict unintended violations.

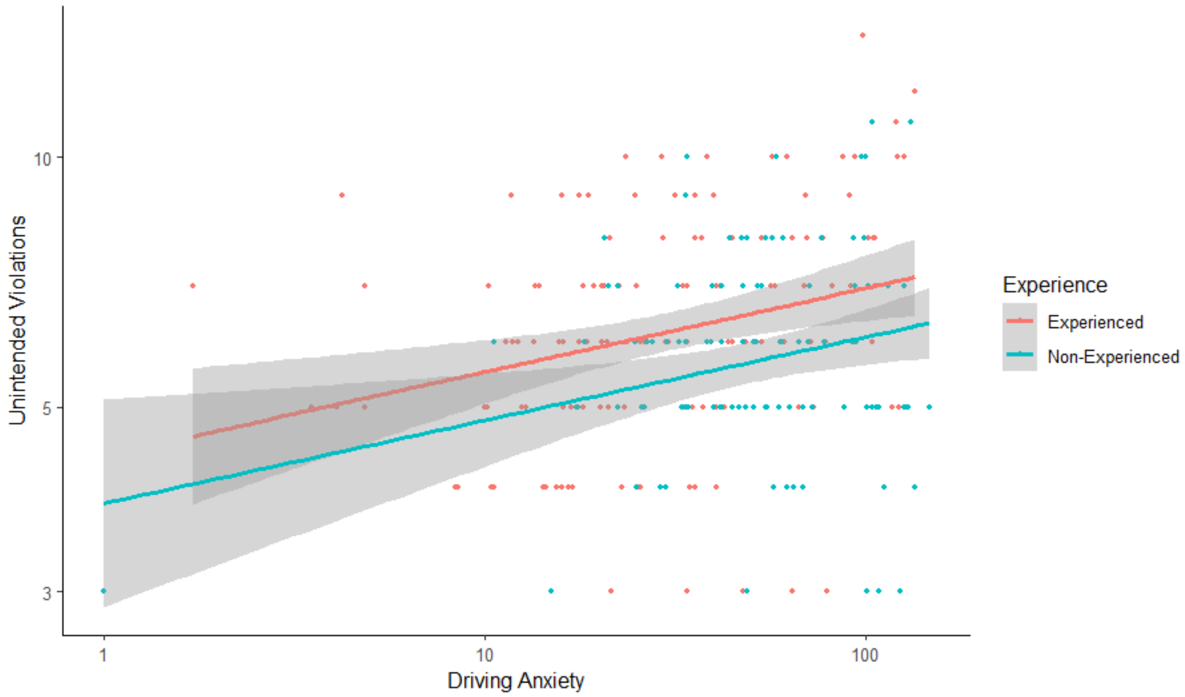
Table 9 illustrates the values of all control variables, moderating variables, and predictors in their respective scales for the unintended violations. Figure 12 exhibits the scatterplot of the Unintended Violations Model.

Table 9: *Summary of multiple regression analysis for the Unintended Violations Model.*

Variable	B	SE(B)	β	t	p	Tolerance	VIF
Intercept	2.36	0.89		2.67	0.01		
Age	-0.01	0.01	-0.02	-1.15	0.25	0.580	1.725
GAD	0.02	0.05	0.01	0.32	0.75	0.153	6.540
DCQ	0.00	0.02	-0.01	-0.16	0.87	0.156	6.413
DBS	1.10	0.29	0.46	3.86	0.001	0.236	4.235
DRAS	0.00	0.02	0.00	-0.15	0.88	0.201	4.970
Experience	0.34	0.24	0.05	1.41	0.16	0.054	18.595
GAD*Experience	-0.01	0.01	-0.03	-0.59	0.56	0.122	8.176
DCQ*Experience	0.01	0.00	0.24	1.32	0.19	0.104	9.649
DBS*Experience	-0.06	0.08	-0.04	-0.75	0.46	0.040	24.728
DRAS*Experience	0.00	0.01	-0.01	-0.31	0.75	0.165	6.077

As the DBS contributed significantly to the model, a moderated regression of the DBS subscales was conducted alongside all other independent variable subscales. Each subscale dimension was observed individually, but only the DBS subscales are reported. Anxiety-based performance deficits (β = .13, p < .01) and aggressive behaviour (β = .30, p < .05) independently displayed a positive association with unintended violations. Cautious behaviour did not contribute significantly to the model (β = -.001, p = .94).

Figure 12: *Relationship between driving anxiety and unintended violations across experience.*



Driving anxiety and deliberate violations

The overall association between all driving anxiety predictors and deliberate violations was significant, $F(4, 246) = 11.75$, $p < .001$. The Deliberate Violations Model explained 15% (adjusted R^2 = .15) of the variability in violations. The scores on the GAD-7, DCQ, DBS and DRAS significantly predicted the scores on the deliberate violations subscale, suggesting a better than mean model.

It was found that anxious driving behaviours (DBS) significantly predicted deliberate violations indicating that the more anxious and aggressive driving behaviour participants display on the road, the more likely they are to make deliberate violations. All other driving anxiety scales did not significantly contribute to the model.

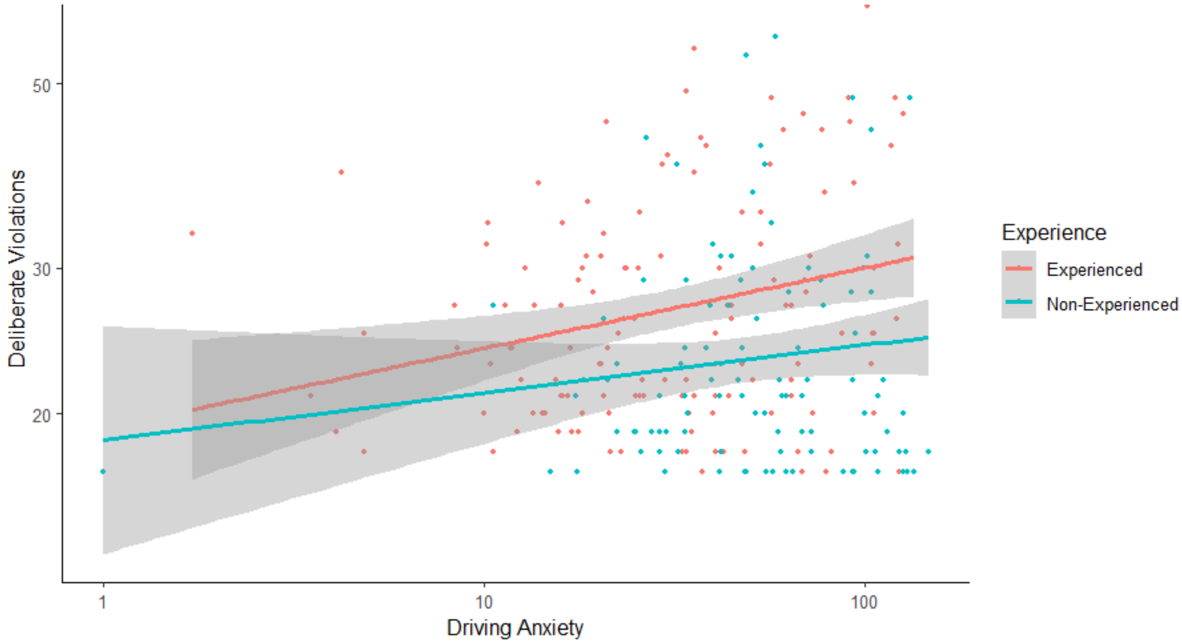
The moderating effect of experience on the relationship between driving anxiety and deliberate violations errors was not found to be statistically significant. This suggests that experience did not significantly influence the strength and direction of the relationship between driving anxiety and deliberate violations. When controlling for age, it was found that age significantly predicted deliberate violations. The results suggested that younger drivers were more likely to commit deliberate violations on the road.

Table 10 illustrates the values of all control variables, moderating variables, and predictors in their respective scales. Figure 13 exhibits the scatterplot of the Deliberate Violations Model.

Table 10: *Summary of multiple regression analysis for the Deliberate Violations Model.*

Variable	B	SE(B)	β	t	p	Tolerance	VIF
Intercept	14.33	4.72		3.03	0.01		
Age	-0.17	0.06	-1.13	-2.80	0.01	0.580	1.725
GAD	-0.19	0.26	-0.11	-0.74	0.46	0.153	6.540
DCQ	-0.04	0.08	-0.05	-0.42	0.67	0.156	6.413
DBS	3.97	1.53	0.57	2.60	0.01	0.236	4.235
DRAS	0.10	0.09	0.79	1.15	0.25	0.201	4.970
Experience	0.36	1.28	0.07	0.28	0.78	0.054	18.595
GAD*Experience	0.01	0.07	0.01	0.08	0.94	0.122	8.176
DCQ*Experience	0.02	0.03	0.20	0.60	0.55	0.104	9.649
DBS*Experience	0.33	0.44	1.16	0.75	0.45	0.040	24.728
DRAS*Experience	-0.02	0.03	-0.09	-0.65	0.52	0.165	6.077

Figure 13: *Relationship between driving anxiety and deliberate violations across experience.*



As the DBS contributed significantly to the model, a moderated regression of the DBS subscales was conducted alongside all other independent variable subscales. Each subscale dimension was observed individually, but only the DBS subscales are reported. Anxiety-based performance deficits ($\beta = .23$, $p < .05$) and aggressive behaviour ($\beta = .44$, $p < .001$) independently displayed a positive association with deliberate violations. Cautious behaviour did not significantly contribute to the model ($\beta = -.67$, $p = .25$).

Anxiety triggering driving situations

In total, 188 of all anxious drivers answered the open question. The majority of answers reported specific driving situations (161; 85.63%). The most common situations that lead to driving anxiety involved roundabouts (38; 20.21%) followed by high-speed roads (e.g. motorways) (33; 17.55%) and unfamiliar roads (25; 13.30%). Alongside this, 49 participants (26.06%) felt any type of congested road trigger their anxiety. Finally, 48 participants (25.53%) cited other road users as the main cause for their driving anxiety, particularly aggressive drivers, and tailgating.

Discussion

The aim of the present study was to assess whether driving anxiety could significantly predict intentional and unintentional errors while driving and whether this relationship is moderated by driving experience and age. A series of moderated regressions were conducted to assess the relationship between different predictors of driving anxiety and types of driving error (slips, mistakes, and intentional/unintentional violations). The findings suggested that, overall, driving anxiety significantly predicted self-reported driving error. Those drivers who reported to experience driving anxiety seemed to be more likely to report intentional and unintentional mistakes and violations while driving. Specifically, the strongest factors that contributed to each one of the individual models were anxiety-based performance deficit and anxiety-based aggressive driving behaviour. None of the other dimensions contributed significantly to the model.

In addition, the relationship between the predictors and outcome for each model was moderated by driving experience and age. Driving experience did not significantly moderate the relationship between driving anxiety and driving errors for any of the models, suggesting that anxiety can predict driving error independently of the level of driving experience. Similarly, age did not significantly influence any of the models except for the relationship between driving anxiety and intended violations. The results revealed that younger drivers are typically more prone to commit intended violations than older drivers independently of their levels of anxiety. This has already been observed in previous studies as younger drivers are typically overrepresented in traffic collisions as they are more prone to underestimate risk (Massie et al., 1995). Their tendency to overestimate their driving ability, coupled with the believe that they can control the driving situation often leads them to commit deliberate violations such as speeding or driving under the influence of alcohol (McKenna and Crick, 1991; Finn and Bragg, 1986; Brown, 1982).

While there was a good concurrent validity between the scales, not all the individual predictors contributed significantly to the model. The study focused on a variety of dimensions of driving anxiety in order to identify which specific factors of driving anxiety contribute to errors while driving. Previous studies that have linked anxiety to driving error did not report what specific aspects of driving anxiety can lead to what specific types of errors in driving performance (e.g. Pourabdian & Azmoon, 2013; Shahar et al., 2009; Wong et al., 2015) As driving anxiety is multi-faced construct and can vary between individuals, assessing its individual aspects provided a more holistic understanding of its impact on driving error. While anxiety-based performance and anxiety-based aggressive driving behaviour were found to significantly predict driving error, aspects such as driving avoidance, anxiety related cognitions and exaggerated safety behaviour did not significantly contribute to the model. Driving avoidance may have a more complex relationship with driving anxiety and driving error, overall, as previous studies have found mixed results in relation to the association between these variables (Clapp et al., 2011b). Avoiding to drive could contribute to a delay in gaining driving experience especially for novices, which could be related to lower levels of situational awareness and a higher proneness to commit errors (Gugerty, 1997). However, this does not necessarily translate to experienced drivers who already have developed good levels of SA (Wright et al., 2016). Although experience did not moderate this relationship significantly, previous studies have suggested that the relationship between driving avoidance and anxiety is not always linear (Clapp et al., 2011a), which in turn could have impacted the association with driving error.

Surprisingly, anxiety-based cognitions while driving did not significantly predict driving error. A number of studies have reported that catastrophising thoughts, as well as panic and stress-related thoughts can deviate drivers' attention from the current situation (in this case the driving task) which can lead to errors in performance (Goodwin et al., 2017).

Anxiety, characterised by heightened physiological arousal and a negative emotional state can interact with attentional biases (Bar-Haim et al., 2007). This interaction elevates sensitivity to errors and negative feedback, consequently interrupting the attentional control of goal-directed inhibition (Tobias & Ito, 2021). Notably, individuals exhibiting heightened anxiety levels have demonstrated less efficient allocation of attention to target stimuli in comparison to their less anxious counterparts (Eysenck et al., 2007; Tsai et al., 2017). However, as anxiety is a complex process characterised by many aspects such as heightened physiological arousal, negative emotional state, catastrophising and panic-related cognitions, it is possible that all these aspects interact in a complex way with attentional biases (Bar-Haim et al., 2007). While it has been observed that catastrophising thoughts can affect attention and lead to prioritising perceived threats, they do not aways result in actual driving errors (e.g. Stefanopoulou et al., 2014). In fact, such cognitions could encourage hypervigilance, thus increasing the attention to the driving environment (Richards et al., 2014). There has been mixed evidence with some studies reporting that anxious cognitions may impact the attentional mechanisms through increased bias of threat detection (Bar-Haim, et al., 2007) , while others suggested that anxious driving cognitions have a limited association with driving performance under both light and heavy cognitive load (Salayev, 2020). As a result, such cognitions might increase the anxiety but not necessarily have a negative impact on driving performance. Study one (see Chapter 3) reported that many participants admitted having committed driving errors due to focusing on what triggers their anxiety rather than on the driving task. However, it is possible that their subjective understanding of this experience can be different from their objective performance. Future studies should focus on exploring the impact of driving anxiety on the attentional processes while driving or while undertaking tasks where drivers will be required to actively explore the driving environment such as when looking for hazards. Similarly, anxious drivers could be asked to verbalise their thoughts during real driving/driving simulator while being eye-tracked to assess whether these cognitions indeed can lead to driving error.

While cautious driving behaviour did not significantly predict driving error, anxiety-based aggressive driving behaviour was observed to be an indicator for driving error. Previous research has observed a higher level of anxiety among drivers that display anger, and predictive models have proposed that anxiety can exacerbate aggressive reactions (Deffenbacher et al., 2000; Deffenbacher et al., 2003). Such reactions could be altering perceptions of risk (Fischhoff et al., 2005; Lerner & Keltner, 2001), placing an attentional premium on anger-related information (Parrott et al., 2005) and triggering further hostility and aggression (Baron & Baron, 1977; Berkowitz, 1993; Geen, 1998). Controlling anger can be challenging and can lead to a variety of risky behaviours (Mirón-Juárez et al., 2020; Sârbescu & Rusu, 2021). It is unsurprising that experience did not moderate the connection between anxiety-driven aggressive behaviour and driving errors. Despite its correlation with driving skills, the capacity to manage anger-based emotions and divert attention from them does not appear to be influenced by years of driving experience as developing driving experience is not considered an intervention for angry driving (Deffenbacher, 2016). The relationship between anger and anxiety seems to be stronger than the relationship between cautious behaviour and anxiety. Eboli et al. (2017) reported that when drivers feel gloomy, worried, nervous, or angry, they are inclined toward a more aggressive driving style which can help explain the lack of significant association between cautious driving behaviour and driving error. Anxious experienced drivers appeared to be more prone to speed and adopt an aggressive driving style if their anxiety was accompanied by feelings of nervousness.

The strongest contributor to driving errors was a deficiency in performance associated with driving anxiety highlighted by the subscale with within DBS. This implies that drivers who acknowledged the influence driving anxiety can have on various aspects of their driving performance were also more likely to report instances of committing driving error. This outcome is unsurprising, given that the dimension representing performance deficits is characterised by error-related behaviours similar to those in the lapses dimension of the DBQ. Essentially, both dimensions in these questionnaires encompass driving error-related behaviours and have been observed to predict each other. However, the DBS dimension arises from driving anxiety, while the DBQ dimension includes everyday driving lapses and mistakes. Consequently, the results suggest that anxiety-induced performance deficits can lead to a broader range of both intentional and unintentional errors.

Should an error occur, it would likely lead to additional distress and the activation of anxious thoughts (Magee & Teachman, 2012), further increasing the risk of committing errors while driving (Lee et al., 2020). Therefore, the presence of driving anxiety could undermine the effectiveness of experience in mitigating errors, as the focus shifts toward emotional state rather than the driving task (Tobias & Ito, 2021). As the prioritisation of the driving task is reduced, these results highlight that presence of anxiety may be noticed specifically through driving behaviour. As anxious thoughts and overly cautious behaviour on their own does not appear to have a substantial impact on driving errors, the concept of cyclical disposition may provide some explanation of how the combination of these factors with perceived performance deficits, can be indicative of an increased likelihood of committing driving errors (Magee & Teachman, 2012). For example, driving anxiety may lead to attentional tunnelling of intrusive thoughts and a mis-prioritisation of stimuli, potentially increasing the likelihood of further errors (Horrey & Wickens, 2007; Wickens & Alexander, 2009). This concept is cyclical because if the individual believes that anxiety can lead to error through performance deficit behaviour and then proceeds to commit driving errors, then the act of making an error could lead to further anxiety which would exacerbate further errors.

As there is an association between anxiety and error, with the possibility that error could lead to further anxiety, then it is important to identify the situations which would lead to the initial feeling of anxiety. Historically, driving anxiety has been based on road traffic collisions (Mayou et al., 1991; Taylor & Koch, 1995) however, more recent research has argued that this may not be the case (Hidalgo-Muñoz et al., 2021) and other onsets, such as having experienced stressful driving situations could lead to driving anxiety (Ehlers et al., 1994; Ehlers et al., 2007; Taylor et al., 2021). The frequency analysis of the current study revealed that complex roads emerged as the primary source of anxiety among participants, followed by other road users. It is important to note that the road types associated with anxiety tend to be those where other road users are present. The reason this is important is that Clapp et al. (2011b) identified that the performance deficits based on anxiety-related aggression are built upon situations that are perceived as threatening (Bucsuházy et al., 2019). Therefore, it could be argued that the identified situations would have the greatest impact on anxiety-related performance deficits. For instance, roundabouts are complex road junctions that require drivers to navigate multiple lanes and interact with other drivers continuously. Similarly, high-speed roads, such as dual carriageways and motorways, have fast-moving traffic surrounding the driver as well as other drivers merging from slip roads. Both road types have been linked to anxiety in previous research (Ratering et al., 2024). The reason both situations are highlighted is because it is a requirement for multiple drivers to share the road and perform merging manoeuvres. If drivers come across discourteous drivers while performing such manoeuvres, such as not yielding the right of way, this can be a source of physiological stress (Jones et al., 2021). The potential that such situations have the capacity to producing anxiety-related performance deficits gives credence to look at how such scenarios link and their influence on anxiety-related processes.

Limitations

The main limitation of the current study pertains to the unequal sample sizes between the anxious and non-anxious groups. This discrepancy in sample sizes is attributed to the nature of the study, which specifically focused on driving anxiety. It is plausible that individuals experiencing driving anxiety would have found the study more relevant and engaging, leading to a higher level of interest and participation compared to the non-anxious group (Keusch, 2013). Furthermore, the study was conducted online, which allowed for wider dissemination and potential sharing of the research among interested individuals. This may have further contributed to the overrepresentation of the anxious driver group.

Additionally, the sample exhibited an overrepresentation of women, which aligns with the trend of higher participation rates of women in online surveys compared to men (Smith, 2008). This gender imbalance is consistent with findings from other international studies on driving anxiety as driving anxiety has been reported more often by women than men (Fort et al., 2021; Taylor, 2018). Given these imbalances in both anxious drivers and gender representation, findings should be interpreted with caution.

Conclusion

The present study investigated the relationship between driving anxiety and driving errors, highlighting the significant predictive value of driving anxiety on both intentional and unintentional driving errors, and identifying that this relationship is not moderated by driving experience and age, except for intentional violations for the latter. Anxiety-based performance deficits and aggressive driving behaviours emerged as the primary contributors to driving errors, while aspects such as driving avoidance and anxiety-related cognitions did not significantly contribute to driving errors. However, due to the significance of the overall model, there is some credence to suggest that the predictors may link through the cyclical nature of anxiety and errors. This cyclical disposition may be linked to complex driving environments that involve interactions with other road users. Future research should delve deeper into the specific contexts and mechanisms through which driving anxiety impacts performance, such as through real-time monitoring and evaluation of attentional processes in anxious drivers within anxious driving environments.

Chapter 5: The impact of driving anxiety on the ability to perceive hazards

Summary of the results from the previous chapters

Study two aimed to determine whether high levels of driving anxiety could predict self-reported intentional and unintentional driving violations. The findings revealed that, overall, higher levels in driving anxiety significantly predicted self-reported driving errors. A positive association was found between driving anxiety and driving errors, with individuals exhibiting higher levels of driving anxiety committing more errors while driving.

As study two revealed a significant association between driving anxiety and self-reported driving errors, study three, discussed in this chapter, aimed to evaluate what process may be limited by driving anxiety to associate with driving error. One example of how anxiety may lead to errors could be through a limitation of a critical skill related to collisions, hazard perception. Additionally, since no significant link was found between anxious cognitions and self-reported driving errors, this study also sought to determine whether anxious drivers' eye movement behaviours appropriately allocate their attention to the right places at the right times, enabling them to effectively identify and avoid hazardous situations. Finally, in studies one and two, participants identified various driving situations that appeared to trigger and sustain driving anxiety. These scenarios were included in a video-based hazard perception test to evaluate whether anxious drivers have more difficulty detecting hazards in these situations. It was hypothesised that their attention might be focused on the situation that triggers their anxiety, making it harder for them to focus on the relevant stimuli - the hazard itself.

Introduction

The limited research on driving anxiety suggests that it can have an impact on both cognitive and behavioural aspects of driving performance (Clarke & MacLeod, 2013; Hidalgo-Munoz et al., 2023; Maloney et al., 2014). Previous research has demonstrated that initial negative cognitive biases can increase anxiety, and through a downstream effect, impact other areas of cognition such as attention (Bar-Haim et al., 2007; Hallion & Ruscio, 2011). According to theories such as the attentional control theory (ACT), anxiety can impair an individual's ability to selectively allocate attention to task-relevant information, which can negatively impact performance (Eysenck et al., 2007; Derakshan & Eysenck, 2009; Eysenck & Derakshan, 2011). The level of attentional control plays a crucial role in maintaining focus while driving as it allows individuals to selectively allocate attention to task-relevant information and filter out distracting information (Hölig & Berti, 2010). High levels of attentional control enable drivers to effectively concentrate on driving-related activities, while low levels can have detrimental effects on driving performance (Leung et al., 2022). For example, they may struggle with monitoring the driving environment or promptly responding to changes in road conditions.

Gotardi et al. (2018) investigated the interplay between anxiety, driving errors, and fixation behaviour during a high-anxiety condition that included a driving task performed in a competitive environment, ego-threatening instructions, performance evaluation, external video camera and traffic noises. They observed that drivers in this condition committed more speeding errors and collisions, suggesting a decline in driving performance. Their participants also exhibited more random visual scanning influenced by stimuli-driven attentional mechanisms (bottom-up), at the expense of top-down regulatory processes, thus compromising deliberate attentional control. In a subsequent study, Gotardi et al. (2019) also found an interaction between anxiety and driving experience. During a similar high-anxiety condition, the experienced drivers showed an increased number of shorter fixations towards the speedometer, while the inexperienced group showed an increased number of shorter fixations towards other cars. Their results suggested that inexperienced drivers with higher levels of anxiety may experience a shift of attention from more task-relevant stimuli to more threatening stimuli, such as other vehicles (potential sources of collisions). This indicates a larger role of the stimulus-driven attentional system and a reduction in the functioning of the goal-directed attentional system, which is responsible for maintaining focus on task-relevant information. This observation underscores the critical role of attentional control in driving performance and safety, especially under conditions of heightened anxiety. The findings from both studies conducted by Gotardi et al. (2018; 2019) are in line with the integrated model of anxiety and perceptual motor performance (Nieuwenhuys and Oudejans, 2012; 2017), and the model of ACT which suggests that heightened anxiety demands additional processing resources to inhibit attention shifts towards threatening or distracting stimuli.

There is evidence to suggest that anxiety can have an impact on driver's ability to process information, make decisions, and perform safely while driving (Gotardi et al., 2019; Hidalgo-Muñoz et al., 2023; Taylor et al., 2008). However, the majority of the evidence is inconclusive as there exists a divergence of views regarding the impact of anxiety on attention and perception while driving. Some studies have suggested that anxiety can result in an elevated state of vigilance and heightened sensitivity to potential threats (Fan et al., 2005; Posner, 2012; Posner & Rothbart, 2007), resulting in enhanced ability to identify hazardous situations (Mao et al., 2023). Other studies, however, have reported that individuals experiencing anxiety may engage in more extensive rumination on negative stimuli associated with the origins of their anxiety (Eysenck & Calvo, 1992; Grafton et al., 2016), leading to an extended processing time and prolonged attentional focus on stimuli triggering anxiety. Consequently, drivers might become more vulnerable to distractions both inside and outside the vehicle. For instance, they may hyper-focus on their gearbox if their anxiety is centred around concerns of stalling the car, or they may become excessively preoccupied with the behaviour of other drivers due to the fear of uncertainty of what will happen next on the driving scene. From this vantage point, anxiety could potentially divert the driver's attention, resulting in an extended response time when reacting to a potential hazard (Wong et al., 2015). To reconcile these divergent perspectives, one could argue that the heightened state of alertness experienced by an anxious individual may facilitate the identification of a threat (effectiveness) (Van Bockstaele et al., 2014), but the additional cognitive processing induced by anxiety may subsequently lead to a slower reaction time (efficiency) in responding to that threat (Bar-Haim et al., 2010). It is even possible that identified threat may not be the most critical one in the situation, but rather one that stems from the driver's anxiety (Ehlers et al., 2004; Miloyan & Bulley, 2019). Drivers experiencing anxiety tend to perceive the driving environment as more threatening. They may label neutral situations as hazardous, particularly if these are associated with previous negative experiences (Rossi & Pourtois, 2017; Yoon & Zinbarg, 2008). This heightened perception can manifest as hypervigilance, leading them to closely monitor every aspect of the driving environment (Beck & Coffey, 2007; Blanchard & Hickling, 2004; Zawilinski, 2020) or are primed to focus on elements based on their driving anxiety, potentially overlooking actual hazards (e.g. Lowe et al., 2019; Walklin, 1993). Thus, if anxious drivers must attend to an increased number of potential threats, there exists the possibility that their overall reaction times to each negative stimulus could be prolonged (Wong et al., 2015). Consequently, a controlled visual search process is essential for good hazard perception skills (Huo et al., 2020).

Hazard perception is a fundamental skill for safe and collision-free driving and holds a crucial role in the safe operation of motor vehicles (Horswill & McKenna, 2004). It has been defined as the ability of drivers to identify and anticipate potential hazards on the road or “read the road” (Mills et al., 1998). As vehicles navigate complex road networks, drivers are constantly faced with different driving situations, including the presence of other vehicles, pedestrians, varying road conditions, and dynamic traffic signals. Effective hazard perception involves not only identifying existing hazards but also predicting how they might evolve and providing the appropriate response to avoid potential accidents (McKenna & Crick, 1991; Ventsislavova et al., 2019).

The ability to perceive hazards is commonly assessed via a hazard perception test. For example, the UK and Australia have integrated a hazard perception test into their official driving assessment. Since its introduction in the UK in 2002, Wells et al. (2008) reported a 3% reduction in non-low speed collisions (where blame could be attached) after surveying over 40,000 learner and novice drivers on their post-test driving. Hazard perception in driving has attracted a lot of attention by many researchers since it was first studied by Pelz and Krupat (1974), and Spicer (1964). As a result, a considerable body of literature has provided evidence of the ability of the HP test to differentiate between safe and less-safe drivers (Horswill & McKenna, 2004; Wetton et al., 2011).

Assessing the ability to perceive hazards could be a useful way to explore the potential influence of anxiety on attention allocation while driving, and subsequently its impact on the perceptual process and prioritisation of relevant stimuli. However, very few studies have looked at the impact driving anxiety has on hazard perception performance. One of these studies was conducted by Barnard and Chapman (2016) who used hazard perception clips divided into three categories, (uneventful, hazardous and crash) to measure the impact of trait anxiety on hazard perception performance (of hazardous clips only). It was found that trait anxiety had no significant effects on the hazard perception scores of their participants. However, they did not report whether their participants had experienced driving anxiety or had prior encounters with situations specifically triggering anxiety, potentially influencing the direction of their attention. In a different study, Hoffman and Rosenbloom (2016) assessed the impact of implicit and explicit threat on hazard perception performance while controlling for trait anxiety levels. In addition, driving experience was fitted as a moderator to test the effects between both types of threat and hazard perception performance. Their findings revealed that overall participants' hazard perception scores were not affected by threat. However, they did observe that the presence of implicit threat resulted in novice drivers exhibiting more cautious driving behaviour compared to experienced drivers whose behaviour was less cautious. The concept that experience may moderate the impact of anxiety on hazard perception is novel, especially with Hoffman and Rosenbloom (2016) findings suggesting that experienced drivers could demonstrate less-cautious driving behaviour when exposed to threat. Typically, the driving literature reports that novice drivers are more prone to engage in risky driving behaviour (Zou et al., 2020), due to underdeveloped situation awareness (Scott-Parker et al., 2020) and lack of experience with potential risks within their driving environment (Pollatsek et al., 2006). This has been evidenced via their hazard search and eye movements as novices tend to maintain their gaze closer to their own vehicle and centrally within their field of view, a behaviour indicative of their less-developed hazard perception skills (Alberti et al., 2014; Crundall & Underwood, 1998; Konstantopoulos et al., 2010; Mourant & Rockwell, 1970). As the findings presented by Hoffman and Rosenbloom (2016) in relation to driving experience contrast the previous literature future studies should explore the relationship between driving experience and driving anxiety more closely for a better understanding of this relationship.

While there is some existing knowledge regarding the relationship between hazard perception performance and threatening situations, (albeit very limited), the effects of specific hazardous scenarios, typically associated with driving anxiety, on hazard perception performance remain unknown. To date, only AVIVA (2023) has pinpointed specific driving situations associated with driving anxiety. According to their findings, over half (51%) of drivers cited 'tailgating' as the primary source of their anxiety, followed by being undertaken (27%) and overtaken at high speeds (37%). This data was drawn from a census sample comprising 1,287 participants. The situations identified by AVIVA (2023) align with the findings from the previous two studies in this thesis, where the unpredictability of other drivers' behaviour was also recognised as a trigger for driving anxiety. Understanding which specific driving scenarios trigger driving anxiety is crucial, as research suggests that sources of anxiety can significantly distract individuals both within and outside the driving context (e.g. Walsh et al., 2009; Wong et al., 2015). Studies have shown that even conversations related to anxiety-triggering object (e.g. spiders) while driving can increase the likelihood of driving errors and lead to a notable decrease in the range of visual fixations among drivers (Briggs et al., 2011). As a result, studying whether similar effects occur among anxious drivers when confronted with anxiety-triggering driving scenarios is essential to gain a better understanding of their driving behaviour in such situations. However, conducting such studies can be challenging due to ethical considerations, resulting in a scarcity of research in this area. Previous studies have sought to gauge the effect of anxiety on hazard perception performance by inducing anxiety (e.g. showing high risk driving situations) rather than including a sample of participants reporting experiences of driving anxiety (Barnard & Chapman, 2016). However, these findings could only provide partial understanding of the impact anxiety can have on driving performance as the selected scenarios might not be linked to drivers' prior experience and expectations with such situations. While clinical, dispositional, and situationally induced anxiety may be linked with quicker detection of threatening stimuli, many anxious drivers may instead prioritise perceived potential sources of danger based on their past experiences (e.g. Öhman et al., 2001; Robinson et al., 2012; Robinson et al., 2011). This behaviour appears to be driven by top-down processing, as drivers may concentrate on the source of their anxiety while neglecting other potentially more serious hazards. Such maladaptive safety behaviour may negatively impact their driving performance (da Costa et al., 2014). This process underscores the significant impact that expectations and previous experience could have on assessing hazardous and non-hazardous driving scenarios. Previous experience with threatening situations while driving can establish implicit memory bias, influencing drivers to selectively scan their surroundings (Gugerty, 1997). Consequently, their attentional patterns may prioritise areas associated with prior traumatic experiences (Derakshan & Eysenck, 2009), resulting in interference through top-down processing, wherein ambiguous stimuli are labelled as 'threatening' (Sussman et al, 2016). These past experiences could hinder drivers' ability to identify new sources of potential hazards and diminish their performance in goal-oriented tasks, such as maintaining a consistent speed (Gotardi et al., 2019; Matthews, 2002). Therefore, directly addressing the source of driving anxiety can offer valuable insights into whether confronting such situations could indeed impair driving performance, particularly in terms of hazard perception.

To achieve a precise understanding of the impact of driving anxiety on hazard perception performance, the inclusion of a sample that specifically report experiencing driving anxiety is crucial. Thus, this study will include a sample of driving anxious participants which also addresses the limitations observed in previous studies. Furthermore, it will feature a hazard perception test tailored to include scenarios that have been identified to trigger driving anxiety in the previous two studies within this thesis. However, distinguishing between anxious drivers and non-anxious drivers poses a challenge. A majority of previous research have differentiated between anxious and non-anxious drivers using self-report methods, mainly using questionnaires (Shahar, 2009; Stephens et al., 2020; Taylor et al., 2018) such as the DCQ (Ehlers et al., 2007) and the DRAS (Stewart & Peter, 2004; see Chapter 4). Therefore, definitions of driving anxiety across studies can vary (Hidalgo-Muñoz et al., 2021). Some researchers advocate for defining study groups using more objective measures, such as EDA (Dula et al., 2010), rather than solely relying on self-reported questionnaires (Fort et al., 2023; Shahar, 2009). EDA is typically assessed through the measurement of SCR and has been effective in various domains, including emotion recognition, decision-making processes, and the study of anxiety (Boucsein, 2012; Figner & Murphy, 2011; Najström & Jansson, 2006; Picard et al., 2001; Rosebrock et al., 2016). For example, Kinnear et al. (2013) used SCRs to measure learner, novice and experienced drivers' psycho-physiological responses to hazardous situations on the road. They found that experienced drivers were three times more likely to produce SCRs in response to emerging hazards compared to novice and learner drivers. However, there has been conflicting results regarding the use SCR to measure anxiety in the driving context. While Schmidt-Daffy (2013) concluded that physiological measures effectively detected anxiety and aligned with participants' self-reported responses, Barnard and Chapman (2016) found that SCRs failed to distinguish between anxious and non-anxious drivers. Due to these mixed findings, the present study will use both physiological and self-reported measures to classify and differentiate between anxious and non-anxious drivers.

Overview of the study

The aim of this study was to assess whether driving anxiety has an impact on perceptual and attentional processes related to the ability to perceive hazards while driving. For this end, the study featured a newly developed hazard perception test that included a variety of hazardous situations. Hazard perception performance was measured via drivers' reaction times and fixations to hazards across three conditions - hazardous, non-hazardous and control. Both, hazardous and non-hazardous conditions included driving scenarios previously identified by participants as anxiety triggering such as roundabouts, busy city traffic or narrow roads. While the non-hazardous and control condition did not include any hazards, clicks to potential "hazards" were still recorded in order to assess the proneness of anxious and non-anxious drivers to identify hazards even when they are not present. In addition, the study evaluated whether drivers would be prompted to produce more SCRs, during the hazardous and non-hazardous conditions compared to the control condition. To define the driving anxiety groups, the anxious driver group reported to experience driving anxiety and both groups underwent pre-screening using the STAI (Spielberger, 1983), DCQ (Ehlers et al., 2007) and DRAS (Stewart & Peter, 2004). Additionally, their SCRs were recorded during the study. Finally, it was assessed whether driving experience could moderate the relationship between driving anxiety and hazard perception performance.

Considering the studies discussed in the introduction, it was hypothesised that anxious drivers would fixate on hazards faster but for longer duration than non-anxious drivers, and that they would exhibit slower reaction times to hazards. In addition, it was expected that driving experience will moderate the relationship between anxiety and hazard perception performance with novice anxious drivers performing worse on the hazard perception test compared to experienced anxious drivers and non-anxious drivers. Due to the conflicting findings regarding hypervigilance in driving anxiety, no predictions were made regarding participants' spread of search. However, it was hypothesised that anxious drivers would report more hazards than non-anxious drivers across all three conditions via extra responses to hazards. Finally, it was anticipated that anxious drivers would report higher rates of SCRs than non-anxious drivers during both hazardous and non-hazardous conditions.

Method

Participants

To determine sample size, a priori power analyses were conducted with R package ‘WebPower’. A statistical power of .80 was recommended to capture a medium effect size and is the recommend power value to avoid a Type II Error (Cohen, 1992). The analyses recommended a sample size of 44 participants. In total, 85 participants were recruited for this experiment, however the final sample size comprised of 65 participants due to failed eye calibration. The final sample was composed of 30 anxious drivers (experienced drivers = 14, novice drivers = 16) and 35 non-anxious drivers (experienced drivers = 17, novice drivers =

18). The sample was initially divided based on self-reported driving anxiety and subsequently validated through scores on STAI, DCQ and DRAS.

All of the drivers held a full driving licence. Participants with less than three years of driving experience were classed as novices while those with three or more years of driving experience were classed as experienced drivers (see McCartt et al., 2003). The anxious drivers group held their license on average for 8 years (In months: *M* = 96; *SD* = 117.36) whereas the non-anxious group held their license on average for 10.7 years (In months: *M* = 128.15; *SD* = 164.47). The anxious group travelled an average of 3023.07 miles in the previous year (*SD* = 4249.88) whereas the non-anxious group travelled an average of 4561.57 miles (*SD* = 4255.94). For a detailed breakdown of demographic information across driving experience and anxiety see Table **11**. The majority of participants were recruited from Nottingham Trent University by attending teaching sessions and through poster advertisements. Members of the public were also approached, and leaflets were posted through doors. Participants were entered into a prize draw to win 1 of 40 £10 Amazon vouchers.

Table 11: *Means and standard deviations of demographic information of the participants* (*n = 65*) *across both anxiety and driving experience groups for study three.*

***N* = 65**								
Descriptive variables								
Anxiety	**Anxious drivers *n* = 30**				**Non-anxious drivers *n* = 35**			
Experience	**Experienced *n* = 14**		**Novice *n* = 16**		**Experienced *n* = 17**		**Novice *n* = 18**	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Age	32.93	12.57	21.00	3.67	35.35	15.98	21.33	4.78
Licence in months	155.71	135.98	31.69	34.17	211.41	193.40	39.69	40.10
Miles per year	4149.43	4321.04	2011.25	4049.32	6647.06	3521.21	2591.94	4012.44

Design

A 2 (anxious vs. non-anxious) x 2 (experienced vs. novice) x 3 (hazardous vs. non-hazardous vs. control scenarios) design was implemented. The between measure components were driving anxiety and driving experience and the within measure component was hazardous condition. Driver's fixations to the hazards, reaction time, SCRs and anxiety ratings were measured as dependent variables. For the present study, a hazard was defined as an event that causes the driver to either slow down, stop or change direction relative to the driver's previous action (Muttart & Fisher, 2016). Both hazardous and non-hazardous conditions contained very similar anxious driving situations with the difference being that the hazardous condition included materialised hazards, while the non-hazardous did not. For instance, in a situation deemed anxiety-triggering and including a hazard, the camera car navigated through a roundabout where a bus joined at the same time without giving way. In a situation perceived as anxiety-triggering but without hazards, the driver entered a roundabout without any appearing hazards that would typically require an evasive manoeuvre (see Table 12). Finally, the control condition did not contain any hazards or anxiety triggering situations. Driving history and driving anxiety were assessed before the start of the experiment, while state anxiety was measured after the experiment to account for any anxiety induced by the experimental process itself.

Materials and apparatus

Hazard perception test

The hazard perception test developed for this study was comprised of 24 video clips. The footage was filmed in the United Kingdom and was edited in short hazardous and non-hazardous video clips with Adobe Premiere Pro (following the method developed by Ventsislavova & Crundall, 2018). The footage was filmed with a GoPro Hero 7 camera (for more information, see camera placement in Chapter 2, p. 60). Filming took place across a different time points and during normal everyday driving. The footage captured driving through cities, suburbs, and rural locations. All three conditions (hazardous, non-hazardous and control) included eight clips. The hazardous condition included materialised hazards during situations previously identified as anxiety triggering (see Chapters 1 and 2). The non-hazardous condition also included anxiety triggering driving scenarios but with not materialised hazards. The control condition did not include any stressful or hazardous situations (see Figure 14). Clips varied in length from 32s to 81s and each one of the hazardous clips included one pre-defined hazard with a clear onset and offset identified by our team of transport researchers (see Ventsislavova et al., 2019). All hazards were captured naturalistically. For descriptions of all video clips, see Table 12.

Figure 14: *Three screenshot examples of video clips representing the same anxious situation* (*high speed carriageway) with a hazard* (*top panel), without a hazard* (*middle panel) and a control condition* (*bottom panel). Graphic overlay and mirror information are also present. From top to bottom, situation 5, 13 and 17 on Table 12 for a detailed description of the situations.*

Table 12: *Description of the 24 hazardous, non-hazardous and control situations with the source of the hazard* (*where applicable), mirror information and clip duration of all clips.*

Anxious Hazardous Clips					
Clip Number	Content	Hazard	Time of Hazard (ms)	Duration of clips (ms)	Graphic overlay and mirrors
1	You are driving in busy traffic. A black car from the left cuts up in front of you, attempting to incorporate into your lane.	Black car on the left-hand side undertakes the camera car	18050	35000	No
2	You are driving in a heavy rain and heading towards a junction on your left-hand lane. A white car in the lane adjacent to you indicates to join the left-hand lane but misjudges traffic ahead pushing you to brake suddenly to account for the narrowing of the lane ahead	4x4 in right lane swerves around van but causes subject car to stop abruptly	11340	32000	No
3	You are driving at night. You reverse out of a car park bay and head towards the exit of the superstore. Around a right bend on the left-hand side, pedestrians start to walk past your car on the road	Pedestrians from the left crosses into the street	50070	74000	No
4	You are driving on an unfamiliar country road. Once there is an opening the black car behind suddenly overtakes you but then starts to brake immediately.	A black car overtakes you on a single road and then brakes after the overtake.	21310	39350	Yes
5	You are driving on a high-speed dual carriageway. From a merging lane, a large HGV vehicle tried to enter the dual carriageway, but you cannot move because the traffic on the outside lane is not letting you out. You have to emergency brake to let the lorry out of the merging lane.	HGV moves into the dual carriageway and subject car cannot move out of the way	28150	60360	Yes
6	You are moving towards a roundabout. Once in the roundabout, moving toward the third exit, a bus enters the roundabout and cuts you up.	Red bus cuts up subject car on roundabout	25000	39779	No
7	You are driving on narrow roads with parked traffic on both sides. You need to judge the gaps between the cars. As	Blue car come around the left bend causing	19000	67480	Yes

	you go around the bend, a blue car coming around the left-hand bend blocks your route, making you slow down until the blue car pulls into a gap.	the subject car to slow down.			
8	You are being tailgated and being forced to move into the roundabout by the car behind. immediately after the roundabout, a car on the left cuts in front of you.	Silver/Grey VW cut up driver on to the left-hand side of the roundabout	20000	81400	Yes
Anxious non-hazardous clips					
Clip Number	Content	Hazard	Time of Hazard (ms)	Duration of clips (ms)	Graphic overlay and mirrors
9	You are in a city, with lots of heavy traffic around you.	NA	NA	39000	No
10	You are driving in the rain with poor visibility.	NA	NA	35000	No
11	You are driving at night. You take a right turn and are immediately confronted by traffic.	NA	NA	40000	No
12	You are driving on an unfamiliar country road	NA	NA	43000	Yes
13	You are driving on a high-speed dual carriageway in the left hand lane with cars overtaking you in the overtaking lane.	NA	NA	75000	Yes
14	You are driving towards a roundabout. You enter the roundabout and notice that on the exit of the roundabout, vehicles are already braking for traffic ahead.	NA	NA	55000	No
15	You are driving through a suburban area. You need to judge the gap to overtake the teal bus ahead. There is plenty of space	NA	NA	51000	Yes
16	You are being tailgated by a black Volvo while entering a roundabout. The Volvo continues to tailgate you after the roundabout before overtaking using the overtaking lane.	NA	NA	46000	Yes
Control Clips					

Clip Number	Content	Hazard	Time of Hazard (ms)	Duration of clips (ms)	Graphic overlay and mirrors
17	You are driving down a single lane road with no traffic in close proximity. You drive through a traffic-controlled junction, but the light stays green.	NA	NA	42000	No
18	You are driving on a slow double lane road which merges into a single lane, although there is light traffic, it is not in close proximity. You merge with no issue. After you drive for a short while the road opens into a dual lane again.	NA	NA	46000	No
19	You are driving toward a traffic-light controlled roundabout. You follow the road around, without entering the main part of the roundabout. There is no traffic in close proximity once you leave enter the new road.	NA	NA	43000	No
20	You are driving on a dual carriage way with no traffic in close proximity.	NA	NA	46000	Yes
21	You are driving down a single lane road with no traffic in close proximity. After you drive for a short while the road opens into a dual lane.	NA	NA	69000	Yes
22	You are driving on a slow double lane road. There is no traffic in close proximity.	NA	NA	33000	No
23	You are driving on a double lane road which merges into a single lane. You drive on the single lane keeping a safe distance from the car ahead.	NA	NA	39000	Yes
24	You are driving on a slow double lane road. Although there is traffic in the overtaking lane, there is no indication of them moving into your lane. You are a very safe distance from the car ahead.	NA	NA	46000	Yes

Fixations and eye-movements

Eye movements were recorded using a binocular SMI eye tracker at a sampling rate of 500 Hz. A four-point calibration was performed, during which participants followed a dot until the infrared light successfully captured their pupils and calculated their gaze location. The clips were displayed on a monitor with a resolution of 1920 x 1080 pixels and a screen size of 49 cm x 29.5 cm. Data analysis was conducted using BeGaze software (for more information see Chapter 2, p.62).

For each hazard, an onset and offset points were defined. In order to capture fixations, areas of interest (AOIs) were created for both precursors and hazards. The section between the onset and offset points was defined as a hazard window, which was also defined as an area of interest (AOI) for drivers' fixations in the current study. To capture fixations on the hazards, AOIs were created to match all the hazard windows (see Figure 15 for an example). On occasion, the equipment was not able to capture some of the fixations, as they appeared as smooth pursuits due to the dynamic nature of the stimuli. Manual calculations were conducted for these smooth pursuits (for more information see Chapter 2, p. 63). In addition, fixed AOIs were also defined around the car mirrors where applicable (See purple AOIs in Figure 15). Only fixations higher than 80ms were considered for the analyses (Staub, 2011; Takeda et al., 2001; Wass et al., 2013).

Figure 15: *The screenshot depicts scenario 5 at the start time of the hazard (See Table 12). The moving AOI of the hazard covers the HGV and is highlighted in red. The fixed AOIs for the mirror overlay is highlighted in purple. Once the hazard window has ended the hazard AOI disappears automatically whereas the mirror AOIs remain.*

Skin conductance responses (SCRs)

To measure SCRs, the biosensor used in the present study was the Biopac MP160 Module alongside the Bionomadix Wireless Photo Plethysmogram and EDA transmitter was used as data acquisition hardware. The Bionomadix is a wearable device designed for continuous, real-time data acquisition. In order to capture SCRs, the device applied an external low voltage to the skin on the index and middle fingers on the left hand of participants (for more information see Chapter 2). Acknowledge software was used to capture raw EDA signal. The data was initially sampled at 2000Hz and was pre-processed through a low pass filter and median smoothing to remove any rapid transients (Greco et al., 2016; Kelsey et al., 2017). After the pre-processing, the waveform was down sampled to 62.5Hz before deriving the phasic from the tonic signal to produce SCRs (e.g. Ashton et al., 2019).

Psychometrics measures

Several psychometric measures including self-reported driving anxiety, the STAI (Spielberger, 1983), DCQ (Ehlers et al., 2007) and the DRAS (Stewart & St. Peter, 2004; Sullman & Taylor, 2010) were administered to participants to observe their scores in driving-related anxiety. The STAI was added to measure whether driving anxiety is linked to driving situations (state) or if anxiety was felt consistently while driving regardless of situation (trait). Each one of the measures, including its validity and reliability have been briefly described below. For more details about the driving anxiety-based questionnaires (DCQ and DRAS), see Materials section (p. 110).

Driving Cognitions Questionnaire (*DCQ)*

The DCQ (Ehlers et al., 2007) is a 20-item self-report scale that was used to measure driving anxiety-related cognitions. The DCQ has been shown to have good internal consistency, convergent validity (Martinussen et al., 2013), and an ability to discriminate between people with and without driving anxiety (Ehlers et al., 2007).

Driving and Riding Avoidance Scale (*DRAS)*

The DRAS (Stewart & St. Peter, 2004) is a 20-item self-report measure that was used to assess the frequency of driving and riding-related avoidance behaviour. The validation paper reported the scale to have high internal consistency (α = .92) (Stewart & St. Peter 2004). Test-retest reliability was also deemed acceptable, as well as evidence for convergent and divergent validity (Taylor et al., 2018).

State-Trait Anxiety inventory (*STAI)*

The STAI (Spielberger, 1983) is a 40-item self-completed questionnaire that aims to assess state anxiety which is a temporary state influenced by the current situation and trait anxiety, a general propensity to be anxious. Each subscales have 20 items each. Both parts are rated on a 4-point Likert scale with responses ranging from 1 (*not at all*) to 4 (*very much so*). On each part of the questionnaire, total scores are calculated, with higher scores indicating higher anxiety in their respective subscale. Scores of 20–39, 40–59, and 60–80 indicate low, moderate, and high anxiety, respectively (Spielberger, 1983). Regarding internal consistency, the state subscale scored 0.95 and the trait subscale scored 0.93 for cognitive and somatic anxiety (Grös et al., 2007). The inventory has also found good factorial (Bieling et al., 1998;

Ortuno-Sierra et al., 2016; Vigneau & Cormier, 2008), concurrent (Spielberger & Sydeman, 1994) and construct validity (Ortuno-Sierra et al., 2016; Spielberger, 1983; Spielberger & Sydeman, 1994).

Procedure

Ethical approval for this study was obtained by the School of Business Law and Social Sciences Ethical Committee, Nottingham Trent University (2021/383). Before the study, due to COVID-19, safety protocols were followed in line with the university standards (See Appendix E). After consenting to take part in the study, participants were provided with instructions and seated approximately 60cm away from the screen. They then viewed the on-screen instructions. Participants were asked to fill in a demographic questionnaire which included information about their age, sex, driver history. They were then asked to complete questionnaires related to their driving anxiety (DCQ, DRAS, STAI).

Once the questionnaires were completed, the physiological equipment was placed on the participant's non-writing hand. The researcher verified that the physiological equipment was capturing the SCR signals before starting the eye-tracking calibration. Once participants' gaze was calibrated, they had to remain completely still and calm for 1 minute to provide an EDA baseline. Once the baseline was collected, a practice trial and questions were shown to the participant to familiarize with the hazard perception task. Participants then watched a series of driving clips, all taken from the driver's point of view. They were asked to watch the videos as if they were the driver of the car and click the mouse button each time they think they have seen a hazard. After each clip they were asked to describe the hazard (if they thought one was present) and indicate how anxious they felt watching the clips via rating their anxiety levels on a scale from 1 to 7 (1 non-anxious at all, 7 very anxious). All participants took part in each one of the conditions. Both, the conditions and video clips in each condition were presented in a randomised order for each participant. Prior to each video clip, gaze drift was controlled for. The experiment lasted approximately 40 minutes. After the experiment, the physiological equipment was removed and participants were asked to respond to the state anxiety portion of the STAI, followed by a debrief.

Data analysis

Scores on each one of the driving anxiety scales were totalled and compared across the anxiety groups. A repeated measures ANOVA was conducted to measure the differences between pre- and post- experiment anxiety levels across the anxious/driver groups.

To assess the eye movements, two univariate ANOVAs were conducted to test for differences in visual attention and hazard perception between the different driver groups. The units that were measured were time to first fixation of the hazard and the total time spent fixating on the hazards. Three repeated measures ANOVA were conducted to measure spread of search across the driving scenario for each condition (hazard; non-hazard; control) across the anxious/driver groups.

For behavioural analysis, a univariate ANOVA was conducted to assess differences in reaction time to hazards among the different groups. Additionally, a repeated measures ANOVA was conducted to test whether some of the conditions received a higher number of additional clicks outside the hazard window .

To test for differences between the anxiety ratings across the different conditions, a repeated measures ANOVA was conducted comparing all anxiety/experienced groups.

Finally, to measure SCRs, a repeated measures ANOVA was conducted to measure differences between SCRs for the anxiety group and experience group for all conditions. The data units for the analysis were first extracted in micro-Siemens (µS) units. To calculate the units, the data was normalised by using a square-root transformation to correct for the presence of skew and kurtosis to ensure a repeated measure ANOVA was acceptable (Braithewaite, 2015).

Results

Scores on the driving anxiety questionnaires

The questionnaires administered prior to the experiment showed that the anxious group oscillated below the midpoint on both the DCQ (*M* = 34.36; *SD* = 11.80) and the DRAS (*M* = 19.53; *SD* = 13.16). The scores for state anxiety (*M* = 38.83; *SD* = 12.62) were observed to be low whereas the scores for trait anxiety were observed to be moderate (*M* = 50.23; *SD* = 12.00). The non-anxious group scored low on both the DCQ (*M* = 13.05; *SD* = 10.13), and DRAS (*M* = 5.11; *SD* = 6.74). The scores for state anxiety (*M* = 31.45; *SD* = 7.30) were observed to be low whereas the scores for trait anxiety were observed to oscillate between the low and mid-range (*M* = 39.49; *SD* = 10.12). For post experiment, the anxious group's state anxiety oscillated within the mid-range (*M* = 44.40; *SD* = 10.97) whereas the non-anxious state anxiety oscillated between the low range (*M* = 32.70; *SD* = 8.72).

To test for differences between the anxiety groups for their scores for each questionnaire, a series of t-tests were conducted. For the DRAS, a 2-tailed Welch's *t*-test was associated with a statistically significant effect $t(41.7) = 5.42$, $p < .001$. Cohen's *d* was estimated at 1.41 which suggested a high practical significance (Cohen, 1992). Therefore, the anxious sample (*M* = 19.53, *SD* = 13.16,) avoided driving significantly more than the non-anxious driving sample (*M* = 5.11, *SD* = 6.74). For the DCQ, the 2-tailed independent samples t-test was associated with a statistically significant effect $t(63) = 7.80$, $p < .001$. Cohen's *d* was estimated at 1.39 which suggested a high practical significance (Cohen, 1992). Therefore, the anxious sample (*M* = 34.37, *SD* = 11.81) demonstrated significantly more negative driving cognitions than the non-anxious driving sample (*M* = 13.06, *SD* = 10.13). For state anxiety, Welch's *t*-test was associated with a statistically significant effect $t(44.8) = 2.80$, $p < .001$. Cohen's *d* was estimated at .73 which suggested a moderate practical significance (Cohen, 1992). Therefore, the anxious participants (*M* = 38.83, *SD* = 12.63) presented significantly higher state anxiety than the non-anxious (*M* = 31.46, *SD* = 7.30) driving sample. For trait anxiety, the 2-tailed independent samples t-test was associated with a statistically significant effect $t(63) = 3.90$, $p < .001$. Cohen's *d* was estimated at .98 which suggested a high practical significance (Cohen, 1992). Therefore, the anxious sample (*M* = 50.23, *SD* = 12.00) scored significantly higher in trait anxiety than the non-anxious sample (*M* = 39.49, *SD* = 10.12).

When compared to the scores of state anxiety prior and after the experiment, the anxious group (*M* = 44.43, *SD* = 10.97) reported a significant increase in their scores on the state anxiety after the study ($F(1, 29) = 8.20$, $p>.01$, $\eta_p^2 = .22$), whereas there was no significant change in anxiety for the non-anxious group (*M* = 32.69, *SD* = 8.72; $F(1, 34) = 1.10$, $p = .30$, $\eta_p^2 = .03$).

Eye movement measures

Eye movement information was recorded and analysed via SMI Experiment centre and BeGaze software. Fixations recorded by the software that were less than 80ms were not included in the analyses on the basis of the assumption that they are not determined by conscious cognitive processes (Inhoff & Radach, 1998; Nuthmann, 2017; Staub, 2011; Wass et al., 2013). AOIs were allocated for each one of the hazards (starting with the hazard onset and finishing with the hazard offset).

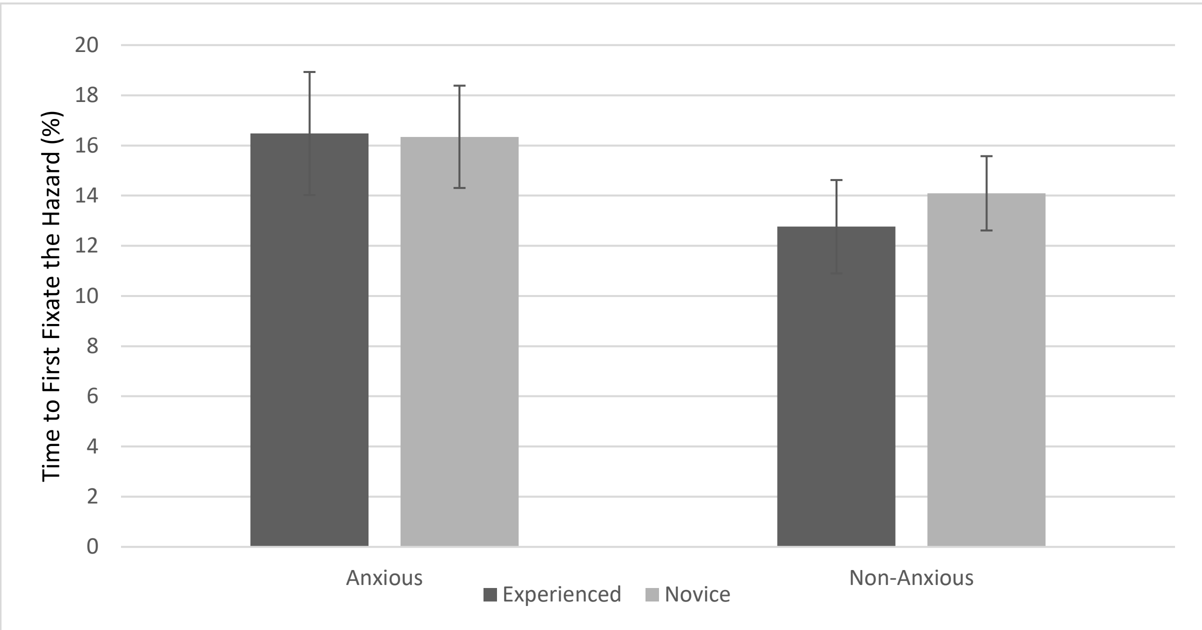
Fixations on hazards

The time taken to first fixate on a hazard was calculated by subtracting the time at which a first fixation fell within the hazard AOI and the time of the hazard AOI onset. To account for variation in hazard window length, this measure was recorded as a percentage of the hazard window at which the hazard was first fixated. For example, a fixation that landed on the hazard after one second of a four second hazard window, the score would be 25%. A score of 0% indicates a fixation at the very start of the hazard window, while a score of 100%

signifies no fixation on the hazard. Lower percentages indicate shorter times to first fixation on the hazard. The total time spent looking at the hazard was calculated considering the total proportion of time that drivers spent looking at the hazard. Then these fixations were converted into percentages by multiplying them by 100. Fixations were measured separately for each of the three conditions, levels of anxiety, and driving experience. Missing values (when participants did not fixate the area) were assigned the maximum 100%.

A 2 x 2 ANOVA was conducted to compare anxiety vs. experience as independent variables. The dependent variable was the time participants took to first fixate the hazard (only during the hazard condition). No main effect was observed for time to first fixate the hazard ($F(1, 64) = 2.40$, $p = .13$, $\eta_p^2 = .04$) between anxious ($M = 16.41\%$; $SD = 8.50\%$), and non-anxious groups ($M = 13.45\%$; $SD = 6.90\%$). Equally, there were no differences ($F(1, 64) = .10$, $p = .76$, $\eta_p^2 = .002$) between experienced ($M = 14.40\%$; $SD = 8.45\%$) and novice groups ($M = 15.20\%$; $SD = 7.20\%$) for hazard fixation. The interaction between anxiety and experience did not reach significance ($F(1, 64) = .14$, $p = .71$, $\eta_p^2 = .002$) (see Figure 16).

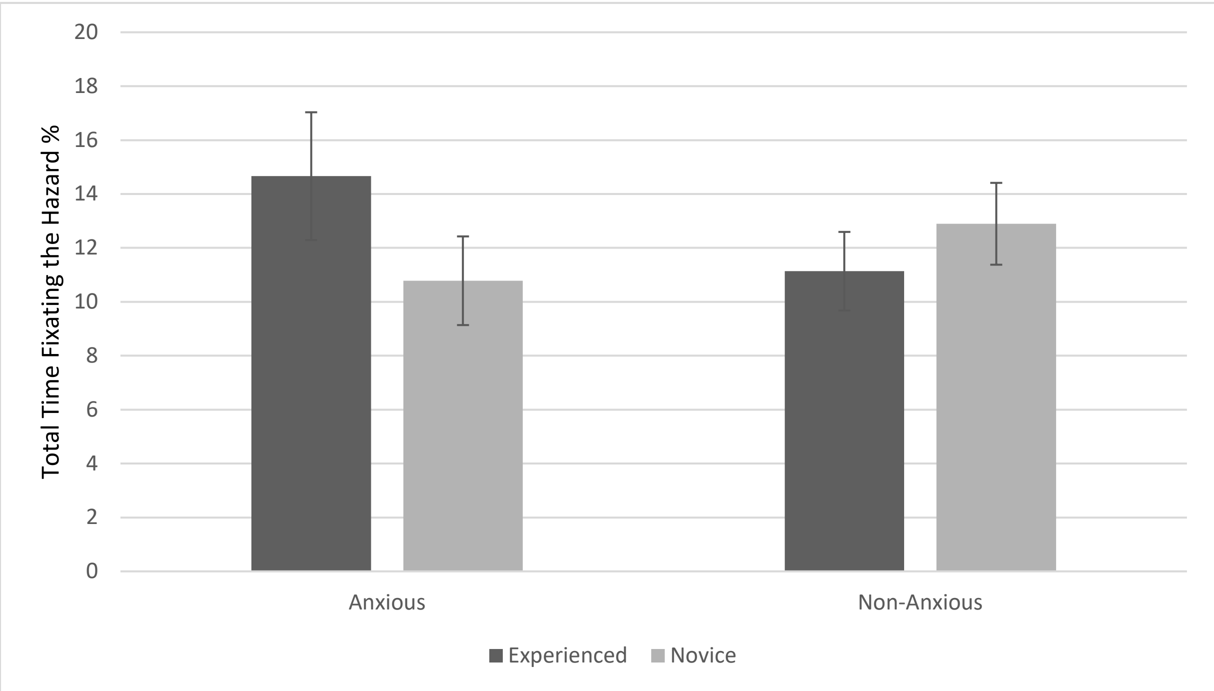
Figure 16: *Time to first fixate the hazard across anxiety groups and driving experience. Error bars refer to standard error of the mean.*



Total time spent looking at hazard

A 2 x 2 ANOVA was conducted to compare anxiety vs. experience as independent variables. The dependent variable was total time spent looking at the hazard (only during the hazard condition). There was not a main effect for the total time looking at the hazard ($F(1, 64) = .17$, $p = .69$, $\eta_p^2 = .003$) between anxious ($M = 12.59\%$; $SD = 7.84\%$), and non-anxious groups ($M = 12.03\%$; $SD = 6.21\%$). Equally, no differences were observed ($F(1, 64) = .38$, $p = .54$, $\eta_p^2 = .006$) between experienced ($M = 12.73\%$; $SD = 7.50\%$) and novice groups ($M = 11.9\%$; $SD = 6.50\%$). The interaction between anxiety and experience did not reach significance ($F(1, 64) = 2.60$, $p = .11$, $\eta_p^2 = .042$) (see Figure 17).

Figure 17: *Total time spent looking at the hazard across anxiety groups and driving experience. Error bars refer to standard error of the mean.*



Spread of search along the horizontal and vertical meridians

Repeated measures ANOVAs was conducted to test for differences in participants' fixations spread along the horizontal and vertical meridians, following the method reported by Crundall et al. (2021). The eye-movement data was analysed using three sections to capture dwell on different areas of the single-screen. The total time of each section was calculated using the total fixation time in each section and dividing it by the clip length before multiplying by 100. The total time spent looking at each left, centre and right sections AOIs was calculated for each condition (see Figure 18).

Figure 18:*Areas of interest defined for the left, centre and right section of the screen to capture spread of search during the visual scene*

Experimental conditions (hazardous vs. non-hazardous vs. control)

Hazard condition

For the repeated measures ANOVA to compare spread of search between the left, centre and right sections of the hazard condition video clips, the condition of sphericity was violated ($p < .001$) therefore GG was used. There was a main effect on spread of search between the left, centre and right sections of the hazard condition video clips ($F(1.08, 65.77) = 1033.71$, $p < .001$, $\eta_p^2 = .94$). Participants focused on the centre section the most (M = 54.78%; SD = 11.53%; $F(1, 61) = 1009.64$, p>.001, $\eta_p^2 = .94$), followed by the right section (M = 9.81%; SD = 2.91%) then the left section (M = 8.42%; SD = 2.75%; ($F(1, 61) = 18.54$, $p < .001$, $\eta_p^2 = .23$) during the hazardous condition.

There were no differences for the spread of search ($F(1, 61) = .08$, $p = .78$, $\eta_p^2 = .001$) between the anxious (M = 72.50%; SD = 15.00%) and non-anxious groups (M = 73.50%; SD

= 13.20%). There were no differences for the spread of search (F(1, 61) = 0.15, p = .90, η_p^2 = .001) between experienced (M = 72.80%; SD = 13.40%) and novice groups (M = 73.20%; SD = 14.60%). The interaction between anxiety and experience did not reach significance (F(1, 61) = 0.43, p = .84, η_p^2 = .001).

Non-hazardous condition

For the repeated measures ANOVA to compare spread of search between the left, centre and right sections of the non-hazardous condition video clips, the condition of sphericity was violated (p = .001) therefore GG was used. There was a main effect on spread of search of the non-hazardous condition video clips between the left (M = 6.59%; SD = 2.43%), centre (M = 54.88%; SD = 11.56%) and right (M = 6.68%; SD = 2.15%) sections (F(1.06, 64.93) = 1155.39, p < .001, η_p^2 = .95). There were no differences between the left and right sections (F(1, 61) = .06, p = .80, η_p^2 = .001) but a significant difference between the right and centre section (F(1, 61) = 1189.1, p>.001, η_p^2 = .95). This suggests that all participants seem to focus on the centre section rather than the side sections during the non-hazardous condition.

There were no differences (F(1, 61) = .01, p = .94, η_p^2 = .001) between the anxious (M = 68.00%; SD = 14.80%) and non-anxious groups (M = 68.30%; SD = 12.30%). No differences were observed between the experienced (M = 67.30%; SD = 13.90%) and novice groups (M = 68.90%; SD = 13.00%) either (F(1, 61) = .24, p = .63, η_p^2 = .004). The interaction between anxiety and experience did not reach significance (F(1, 61) = .001, p = .99, η_p^2 = .001).

Control condition

For the repeated measures ANOVA to compare spread of search between the left, centre and right sections of the control condition video clips, the condition of sphericity was violated (p = .001) therefore Greenhouse Geisser (GG) was used. There was a main effect on spread of search of the control condition video clips between the left, centre and right sections ($F(1.03, 62.86) = 1347.60$, $p < .001$, $\eta_p^2 = .96$). This suggests that participants focus on the centre section of the control condition video clips the most ($M = 63.19\%$; $SD = 12.80\%$; $F(1, 61) = 1300.06$, $p < .001$, $\eta_p^2 = .955$), followed by the right section ($M = 4.88\%$; $SD = 2.22\%$) then the left section ($M = 2.69\%$; $SD = 1.45\%$; $F(1, 61) = 91.23$, $p < .001$, $\eta_p^2 = .60$).

There were no differences ($F(1, 61) = .04$, $p = .84$, $\eta_p^2 = .001$) between the anxious ($M = 70.40\%$; $SD = 15.50\%$) and non-anxious groups ($M = 71.10\%$; $SD = 12.00\%$). There were no differences ($F(1, 61) = .12$, $p = .73$, $\eta_p^2 = .002$) between the experienced ($M = 70.20\%$; $SD = 14.70\%$) and novice groups ($M = 71.30$; $SD = 12.80\%$). The interaction between anxiety and experience did not reach significance ($F(1, 61) = .08$, $p = .75$, $\eta_p^2 = .001$).

Comparing centre sections for each experimental condition

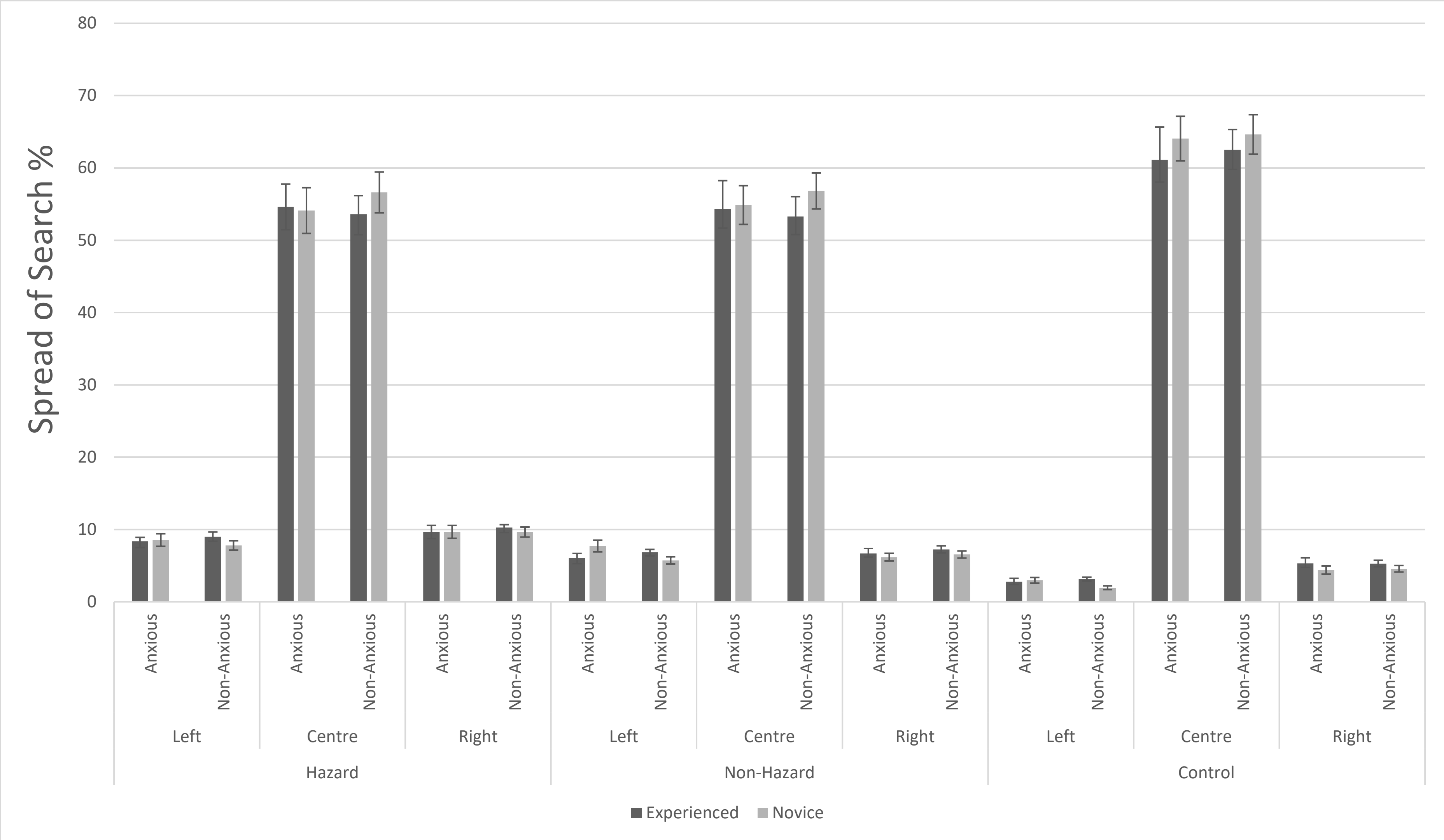
To explore the difference in spread of search for the centre section in each condition a within measures ANOVA was conducted. The condition of sphericity was upheld ($p = .08$). There was a main effect on spread of search between the central hazard section ($M = 54.78\%$; $SD = 11.53\%$), central non-hazard section ($M = 54.88\%$; $SD = 11.56\%$) and central control section ($M = 63.19\%$; $SD = 12.80\%$) sections ($F(2, 122) = 66.32$, $p < .001$, $\eta_p^2 = .52$). There was no difference between the hazard and non-hazard sections ($F(1, 61) = .02$, $p = .90$, $\eta_p^2 = .001$) however there was a difference between the non-hazard and control section ($F(1, 61) = 114.35$, $p < .001$, $\eta_p^2 = .65$). The higher the percentage of fixation within a section, the more time a participant spent looking within that section. The results show that as there is a higher percentage for the centre section in the control condition, compared to the centre sections of the hazardous and non-hazardous conditions, participants spent longer fixating on the centre control section. Therefore, as there were less fixations in the centre sections of the hazardous and non-hazardous conditions, this demonstrated more visual search for both the hazardous and non-hazardous condition, compared to the control condition.

There was no difference ($F(1, 61) = .06$, $p = .90$, $\eta_p^2 = .001$) between anxious (central hazard section: $M = 54.35\%$; $SD = 11.99\%$; central non-hazard section: $M = 54.63\%$; $SD = 12.43\%$; central control section: $M = 63.61\%$; $SD = 11.42\%$) and non-anxious groups (central hazard section: $M = 55.15\%$; $SD = 11.28\%$; central non-hazard section: $M = 55.10\%$; $SD =$ 10.9%4; central control section: $M = 63.61\%$; $SD = 11.4\%$).

There was no difference ($F(1, 61) = .12$, $p = .45$, $\eta_p^2 = .007$) between experienced (central hazard section: $M = 54.06$; $SD = 10.70$; central non-hazard section: $M = 53.76\%$; $SD = 11.90\%$; central control section: $M = 63.89\%$; $SD = 13.96\%$) and novice groups (central hazard section: $M = 55.43\%$; $SD = 11.75\%$; central non-hazard section: $M = 55.90\%$; $SD = 10.53\%$; central control section: $M = 61.37\%$; $SD = 11.74\%$).

The interaction between anxiety and experience did not reach significance ($F(1, 61) = .12$, $p = .74$, $\eta_p^2 = .002$). See Figure 19 for a comparison of spread of search between each condition and section across anxious and non-anxious groups and experience and novice groups.

Figure 19: *Spread of search for each condition across anxiety groups and driving experience. Error bars refer to standard error of the mean.*



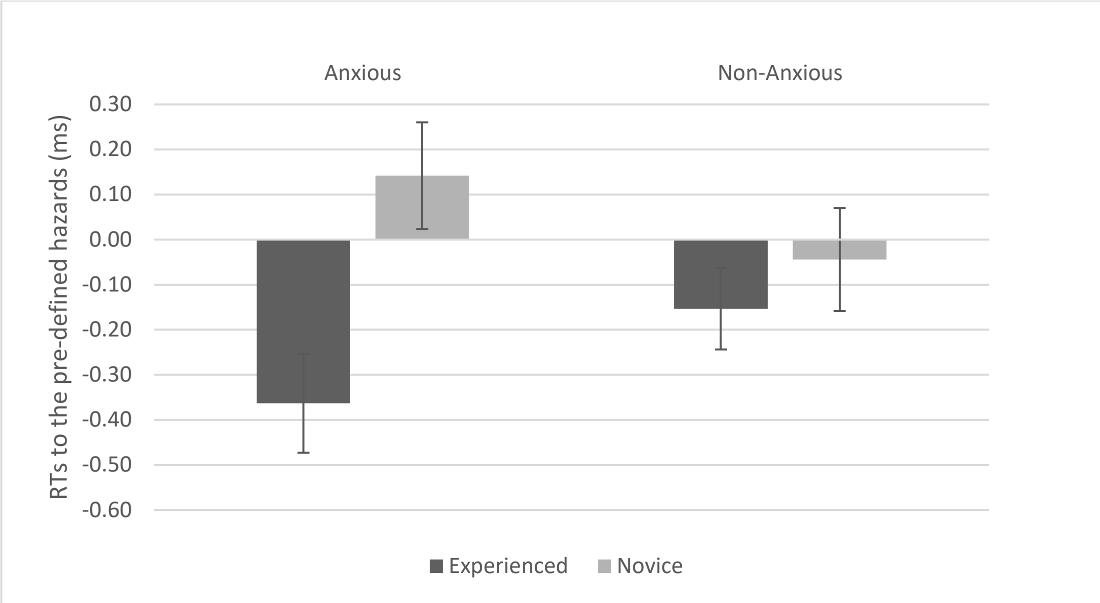
Behaviour responses to hazards

Reaction time to the pre-defined hazard

To calculate response times (RTs) for the hazards, the onset and offset times were defined for each clip (See Table 12). The hazard onset times for each clip were subtracted from the button-press times to determine the RTs. If participants did not respond during a particular clip, they were assigned a maximum response time equal to the hazard offset (McKenna et al., 2006). To minimize skewness in the data, a square-root transformation was applied. The transformed RTs were then standardised into Z-scores using the overall sample mean and SD for each hazard. This standardisation was necessary because the hazard windows varied in duration, and without it, some hazards might have a greater impact on the final mean than others (Wetton et al., 2010). Response times to hazards were analysed to find out whether non-anxious drivers would spot hazards quicker than anxious drivers.

A 2 x 2 ANOVA was conducted to compare anxiety vs. experience as independent variables. The dependent variable was reaction time to the pre-defined hazard (only during the hazard condition). There was not a main effect on reaction time to the hazards ($F(1, 64) = .26$, $p = .62$, $\eta_p^2 = .004$) between the anxious ($M = -.14$; $SD = .50$) and non-anxious groups ($M = -.11$; $SD = .42$). However, there was a significant difference ($F(1, 64) = 8.86$, $p < .01$, $\eta_p^2 = .13$) between the experienced ($M = -.28$; $SD = .46$) and novice groups ($M = .01$; $SD = .41$), with experienced drivers reacting faster to the hazards than novice drivers. The interaction between anxiety and experience was not significant ($F(1, 64) = 3.80$, $p = .06$, $\eta_p^2 = .06$) (see Figure 20).

Figure 20: *Reaction time to hazards across anxiety groups and driving experience. Error bars refer to standard error of the mean.*



Accuracy in hazard perception

Accuracy (i.e. the percentage of hazards that participants responded to within the hazard window) was also calculated. A button press response to indicate that there was a hazard within the frames of the time window was considered a hit. No main effect was found for anxiety (*M* = 76.70% for anxious drivers, *M* = 76.80% for non-anxious drivers) ($F(1, 64) = .03$, $p = .96$, $\eta_p^2 = .001$). However, there was a difference between the experience groups (*M* = 79.80% for experienced, *M* = 73.90% for novices), ($F(1, 64) = 2.80$, $p>.01$, $\eta_p^2 = .05$), with experienced drivers correctly identifying more hazards than the novice drivers. There was not a significant interaction between anxiety and experience ($F(1, 64) = 1.10$, $p = .28$, $\eta_p^2 = .02$).

Extra hazard responses

A repeated measures ANOVA was conducted to compare extra responses to hazard (i.e. responses to potential hazards above and beyond the predefined hazard window). As clips varied in duration time, the sum of these extra hazard responses for each participant was divided by the duration of the experiment creating a ratio measure of extra-hazard responses.

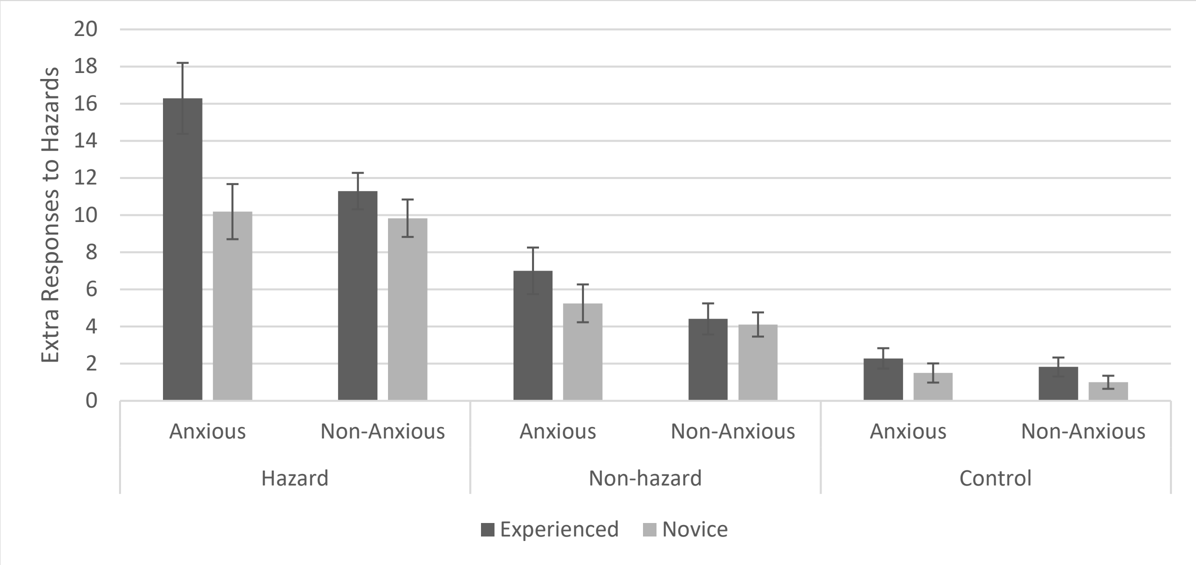
The condition of sphericity was violated (p = .001) therefore Greenhouse Geisser was used (GG). A main effect of condition was found for extra responses to hazards (F(1.71, 104.75) = 282.55, p < .001, η_p^2 = .82). This suggested there were differences between the hazardous, non-hazardous and control conditions when comparing extra responses to perceived hazards for all conditions. There was a significant difference of extra responses between the hazard condition (M = 11.69; SD = 5.81) and the non-hazard condition (M = 5.09; SD = 3.81) (F(1, 61) = 275.76, p < .001, η_p^2 = .82). Participants clicked more excessively in the hazardous condition than non-hazardous condition. There was also a significant difference in excessive clicks between the non-hazard condition (M = 5.09; SD = 3.81) and the control condition (M = 1.62; SD = 1.94) (F(1, 61) = 87.42, p> .001, η_p^2 = .59). Overall, participants provided a greater number of additional clicks for the hazard condition, followed by the non-hazard condition and finally the control condition.

No differences were observed between the number of clicks for the anxious group (M = 20.90; SD = 12.80), and the non-anxious group (M = 16.20; SD = 7.90; F (1, 61) = 3.94, p = .052, η_p^2 = .06). However, there was a significant difference between the experience groups (F (1, 61) = 4.90, p>.05, η_p^2 = .08), with the experienced drivers providing extra hazard responses more often (M = 21.20; SD = 11.40) than the novice drivers (M = 15.90; SD = 9.40). Although there were significant differences for the experienced group, there was not a significant interaction between anxiety and experience (F(1, 61) = 1.40, p = .23, η_p^2 = .02) (see Figure 21).

Anxiety ratings for each clip

After each clip, participants were asked to rate their anxiety levels using a 7-point Likert scale where, 1 indicating not at all and 7 indicating very anxious. A repeated measures ANOVA was conducted to compare the anxiety rating across the anxiety groups, experience

Figure 21: *Extra hazard responses across anxiety groups and driving experience. Error bars refer to standard error of the mean.*

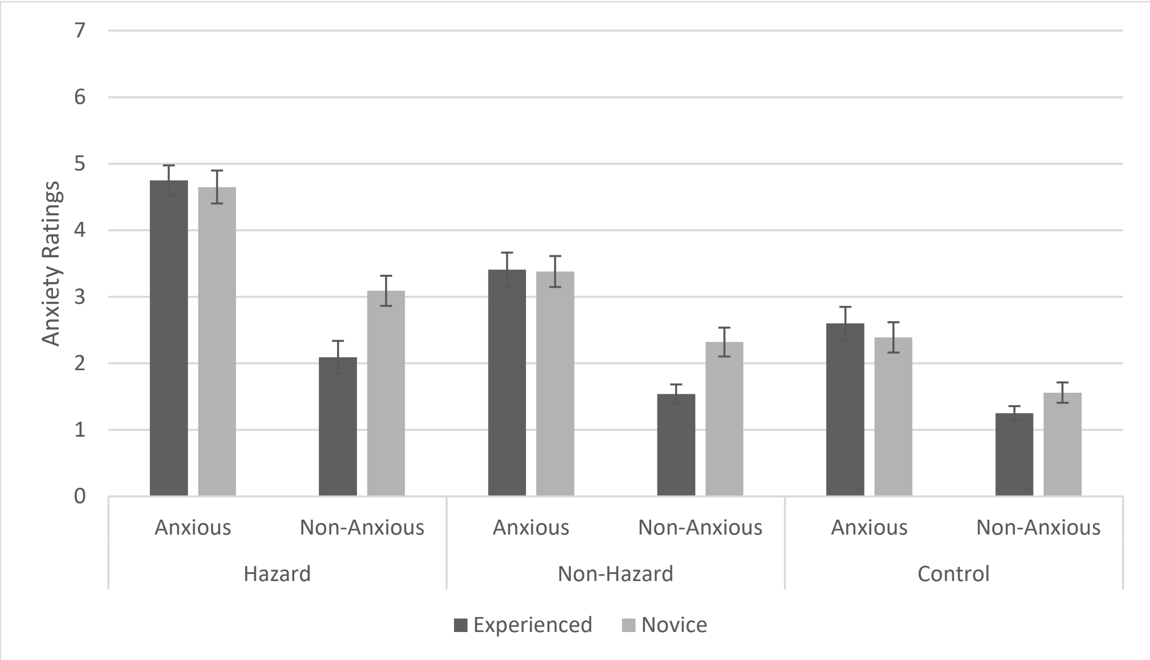


groups and experimental conditions. There was a main effect for anxiety ratings across the three conditions ($F(1.60, 97.57) = 223.19$, $p < .001$, $\eta_p^2 = .79$). The hazardous condition invoked more anxiety ($M = 3.57$; $SD = 1.46$) than the non-hazardous condition ($M = 2.6$; $SD = 1.15$; $F(1, 61) = 185.78$, $p < .001$, $\eta_p^2 = .75$), with the control condition demonstrating the lowest anxiety levels ($M = 1.9$; $SD = .92$; $F(1,61) = 111.49$, $p < .001$, $\eta_p^2 = .646$).

There was also a main effect for anxiety group. When comparing anxious (hazard: $M = 4.70$; $SD = .91$; non-hazard: $M = 3.41$; $SD = .92$; control: $M = 2.49$; $SD = .91$) and non-anxious groups (hazard: $M = 2.60$; $SD = 1.10$; non-hazard: $M = 1.94$; $SD = .86$; control: $M = 1.41$; $SD = .57$), the anxious group reported higher anxiety ratings than the non-anxious group ($F(1, 61) = 65.39$, $p < .001$, $\eta_p^2 = .52$).

There was no difference ($F(1, 61) = 2.30$, $p = .13$, $\eta_p^2 = .04$) between the experienced (hazard: $M = 3.29$; $SD = 1.64$; non-hazard: $M = 2.38$; $SD = 1.22$; control: $M = 1.86$; $SD = .97$) and novice groups (hazard: $M = 3.82$; $SD = 1.24$; non-hazard: $M = 2.82$; $SD = 1.05$; control: $M = 1.95$; $SD = .88$) between conditions. However, there was an interaction effect between the anxiety and experience groups ($F(1, 61) = 4.41$, $p < .05$, $\eta_p^2 = .07$) (see Figure 22). Further Bonferroni post-hoc correction analysis reported that novice drivers in the nonanxiety group reported significantly higher levels of anxiety compared to the experienced non-anxious drivers (p>.01). However, no differences were observed between experienced and novice drivers in the driving anxiety group (p = .69). Overall, anxious drivers collectively demonstrated higher anxiety levels than both non-anxious novice and experienced drivers, while experienced non-anxious drivers reported the lowest anxiety levels in comparison to all other groups.

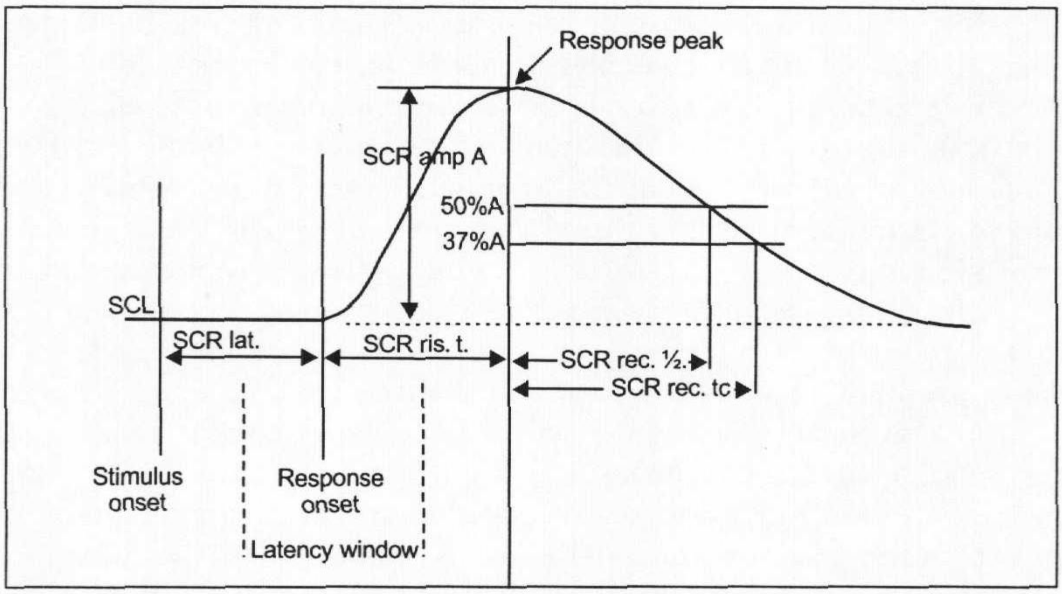
Figure 22: *Self-reported-anxiety ratings after each clip across anxiety groups and driving experience. Error bars refer to standard error of the mean.*



Skin conductance responses

EDA was used to measure anxiety responses during the experiment, following the method developed by Braithwaite et al. (2013). Prior to the analysis, a signal processing method was used to filter and clean the EDA data before converting it into SCRs. First, the EDA was filtered using a low-pass filter to eliminate high-frequency noise from the EDA signal. The cut off frequency was 1Hz (Mercado-Diaz et a., 2024). Once the low-pass filter was complete, a median smoothing was completed to remove any rapid transients. Then the signal was down sampled from 2000Hz to 62.50Hz before deriving the phasic from the tonic signal to produce SCRs. The cut-off point of an SCR created was 0.02 microsiemens (µS). Manual cleaning was then done to ensure all SCRs did not occur too quickly and followed the expected signal type (See Figure 23). Any SCRs which did not follow the correct signal type were removed before analysis. The data was normalised by using a square-root transformation to correct for the presence of skew and kurtosis to ensure a repeated measure ANOVA was acceptable (Braithewaite, 2015). See methodology for full cleaning procedure (p. 66).

Figure 23: *An example of the components of an SCR. Adapted from Martin & Venables (1980). Reprinted with permission.*

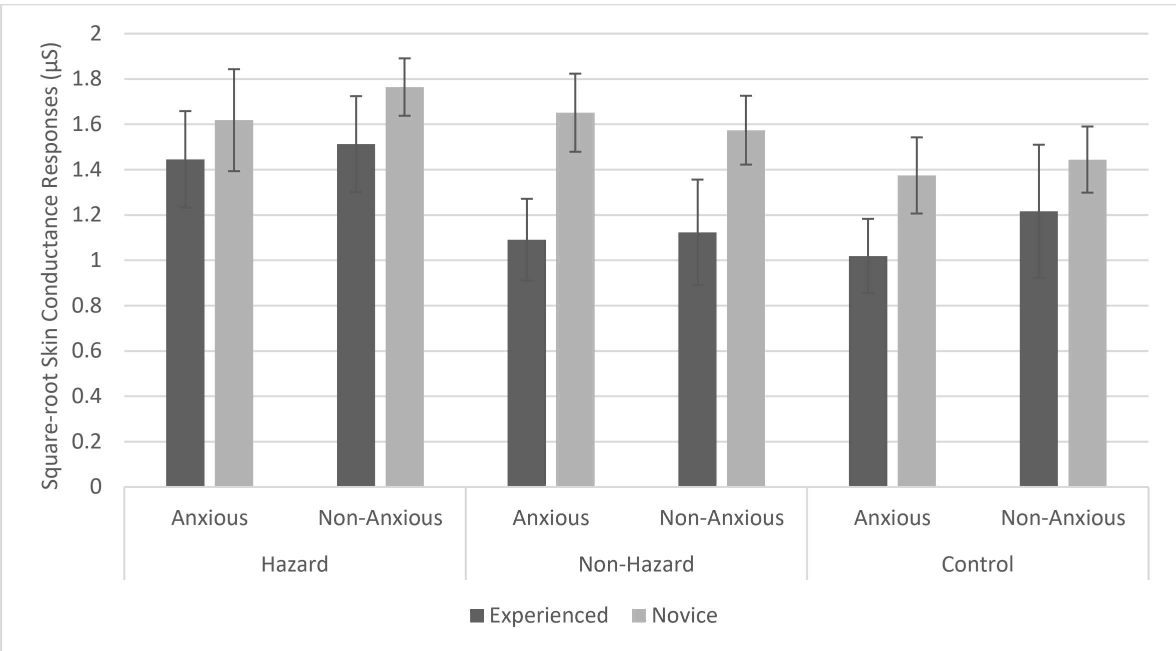


From the original 65 participants, 23 were excluded due to a poor EDA signal. The final sample was composed of 42 participants, with 21 classed as anxious drivers (experienced = 11, novice = 10) and 21 as non-anxious drivers (experienced = 8, novice = 13). There was a main effect of SCRs on clip condition ($F(2, 76) = 10.60$, $p>.001$, $\eta_p^2 = .22$). There was a difference between normalised SCRs in the hazard condition (M = 1.60 µS; SD = .61 µS) and the non-hazard condition (M = 1.38 µS; SD = .62 µS). However, there was not a difference in normalised SCRs between the non-hazard and control conditions (M = 1.27

μS; *SD* = .60 μS). This suggests that all participants reported more SCRs during the hazardous condition compared to the other two conditions.

When comparing the anxiety groups, there was no difference ($F(1, 38) = .19$, $p = .67$, $\eta_p^2 = .01$) between the anxious ($M = 4.1$μS; $SD = 1.7$μS) and non-anxious groups ($M = 4.4$μS; $SD = 1.6$μS). There was also no difference ($F(1, 38) = 3.97$, $p = .053$, $\eta_p^2 = .10$) between the experienced ($M = 3.7$μS; $SD = 1.8$μS) and novice groups ($M = 4.7$μS; $SD = 1.4$μS), although this was close to significance. Due to the significance value an exploratory independent sample t-test found that in the non-hazardous condition, there was a difference ($t(36.3) = -2.82$, $p < .01$; Cohen's $d = 0.61$) between experienced ($M = 1.1$μS; $SD = .61$μS) and novice ($M = 1.6$μS; $SD = .54$μS) drivers. This may suggest that novice drivers had more SCRs in the non-hazardous situation compared to the experienced drivers however, this finding should be interpreted with caution. The interaction between anxiety and experience did not reach significance ($F(1, 38) = .02$, $p = .87$, $\eta_p^2 = .001$) (see Figure 24).

Figure 24: *Normalised skin conductance responses* (*μS) across hazardous, non-hazardous and control experimental conditions split between anxiety groups and driving experience. Error bars refer to standard error of the mean.*



Discussion

This study had several objectives. The first one was to compare hazard perception performance across anxious and non-anxious drivers, considering their level of driving experience. For this end participants' hazard perception accuracy was assessed. The second aim of the study was to compare participants' eye movements during three different driving conditions (hazardous, non-hazardous and control) across anxiety and driving experience groups. Specifically, fixations on hazards and total time spend looking at the hazards was assessed. While fixations on the hazards was analysed only for the hazardous condition, participants' spread of search during each video clip was evaluated across all three conditions. In addition, extra responses to hazards and self-reported anxiety were assessed and compared across all three conditions. The final aim was to compare anxious vs non-anxious drivers' SCR responses across the different conditions.

It was hypothesised that anxious drivers would fixate on hazards faster but for a longer duration than non-anxious drivers, and they would also exhibit slower reaction times to hazards, although no predictions were made regarding their spread of search. In addition, it was expected that novice anxious drivers would exhibit poorer hazard perception scores compared to experienced anxious drivers and non-anxious drivers. However, it was expected that anxious drivers will report more hazards than the non-anxious group across all three conditions even when hazards when not present. Finally, it was expected that anxious participants would produce more SCRs across all conditions but especially during the hazardous and non-hazardous conditions.

Anxiety has no impact on visual attention

There were no significant differences between the anxious and non-anxious drivers in terms of the time taken to first fixate the hazard or the total time spent looking at the hazard. These findings indicate that anxious drivers neither exhibit superior ability to detect hazardous situations more quickly due to hypervigilance nor are they disadvantaged by taking longer to spot/process stressful situations. Instead, they appear to demonstrate similar hazard perception abilities to those of non-anxious drivers. Equally, no differences were observed between the experienced groups. While there is limited research on anxiety and hazard perception, it was at least anticipated based on previous findings that the experienced drivers would fixate hazards faster and spent less time dwelling on them compared to the novice drivers (e.g. Abele et al., 2018; Crundall et al., 2012). Several studies have reported that novices fixate on hazards slower than more experienced drivers (e.g. Chapman et al., 2007; Crundall & Underwood, 1998; Crundall et al., 2012; 2003) and exhibit longer fixation durations on hazardous objects (Chapman & Underwood, 1998). However, the current findings challenged much of the existing literature on eye movements. In fact, this is not the first time studies have failed to report significant difference between experienced groups in hazard fixation. Ventsislavova (2019) equally assessed time to first fixation a hazard and total time spent looking at the hazard and did not observe any differences between experienced and novice drivers in her study. In contrast, when participants were asked to click for the hazards, the results clearly showed that the experienced drivers were significantly faster in detecting the pre-defined hazards compared to the novices. They even reported a higher number of additional hazard responses across all three conditions. This suggests that while novices fixated at the hazards as swiftly as experienced drivers, they did not process and evaluate them as rapidly, as evidenced by their button clicks (e.g. Chapman & Underwood, 1998). The current results indicated that novice drivers may take longer to process hazards and appraise them. Interestingly, anxious experienced drivers reported higher mean score for hazard perception, despite the lack of a significant main effect for anxiety and interaction between experience and anxiety levels. The absence of significant differences between the anxiety groups indicates that driving experience appears to be the primary factor for distinguishing between good and poor hazard perception abilities.

Considering both, the hypervigilance and blockage that anxious drivers typically have been reported to experience in highly anxious driving situations, it was anticipated that their attention would be focused on the perceived threat, thus detecting it faster (e.g. LoBue et al., 2014). They were also expected to spend more time focusing on specific aspects of the driving scenario that could trigger their anxiety. However, it is not possible to observe cognitive distractions in the same way as visual and manual distractions. While anxious drivers have been observed exhibiting these behaviours, as well as rumination, worry and intrusive thoughts related the source of their anxiety (Taylor et al., 2021), this did not seem to affect their hazard perception performance, at least when compared to the non-anxious sample in this study. Typically, studies suggest that stress related cognitive distraction can impair driving performance especially when related to life stress situations as the attention is directed towards processing the emotion rather than the driving environment (Matthews, 2002). However, the demanding nature of the situations included in the current hazard perception test did not seem to impact the ability of anxious drivers to fixate the hazards in time. Moreover, upon closer examination of the data, participants exhibited a good ability to detect hazards. The average time to first fixate the hazard in the current study was approximately 14% into the hazard window, whereas in Crundall et al.'s (2012) study, hazards were typically fixated on at around 32% into the hazard window. Furthermore, in Crundall et al.'s (2012) study, the total time on target (dwell time on hazard) was 38.4% whereas for the current study the average total time on target for the total sample was 12.3%. This suggests that the participants in the current study were over twice as quick at detecting hazards compared to those in previous studies and three time as quick at disconnecting from the stimuli once attended to. In light of this, it is conceivable that while anxious drivers report mistakes while driving (Shahar, 2009), these may not be attributed to their hazard perception and attention abilities but rather to how these errors manifest in their actual driving behaviour (such as hesitating on a roundabout). It has also been suggested that such self-reported errors could be due to their low level of confidence in their driving skills (e.g. Björkman et al., 1993). Future research should aim to explore whether this phenomenon is valid and whether anxious drivers' subjective perception of their driving abilities can adversely affect their driving behaviour.

As for the visual spread of search, all participants regardless of their anxiety or experience levels, displayed a broader spread of visual search along the central part of the driving scenario. When comparing the spread of search across the three conditions (hazardous, non-hazardous, control), participants exhibited a wider spread of search during both hazardous and non-hazardous conditions, compared to the control condition. This indicates that participants recognised the hazardous and non-hazardous conditions as more demanding and requiring increased attention. This behaviour seems to be driven by a general inclination to scan for hazards based on the environment itself, rather than being solely influenced by their current anxiety levels (e.g., Muela et al., 2021). These findings, coupled with the observed differences in behavioural responses, suggested that the video clips possess the qualities to distinguish drivers based on their ability to identify stressful/demanding road scenarios and pre-defined hazards. Since we did not formulate predictions regarding the spread of search, one possible explanation for the lack of differences between the anxiety groups could be that anxious drivers are just as vigilant as non-anxious drivers, and the source of threat does not alter their eye movement behaviours compared to non-anxious drivers. Both groups could be equally vigilant, but they may differ in other aspects, such as how they process the information from the hazards once it has been observed (Eysenck & Calvo, 1992; Grafton et al., 2016), and in their decision-making processes. Future studies could delve further into this by assessing hazard appraisal and post hazard perception decision-making behaviour in anxious drivers.

Hazard perception accuracy and reaction time

Eye-movement data was complimented by the measurement of various behavioural responses to the hazard stimuli. It was hypothesised that anxious drivers would be slower at reacting to the pre-defined hazards compared to the non-anxious drivers. The findings revealed that there were no significant differences between anxious and non-anxious drivers in their ability to detect hazards, with both groups exhibiting a similar level of accuracy (76%). While previous studies have reported that anxiety may facilitate threat identification (Bar-Haim et al., 2007; Cisler & Koster, 2010; Eysenck et al., 2007; Mathews & Mackintosh, 1998; Mogg & Bradley, 2018, Mogg & Bradley, 2016; Öhman, 1993; Okon-Singer, 2018), it was anticipated that anxious drivers would still exhibit slower reaction times to hazards compared to the non-anxious group, attributed to the heightened cognitive demand posed by anxiety-triggering situations. However, anxious drivers performed as effectively as non-anxious drivers in detecting hazards, and driving experience did not interact with the anxiety levels. One potential explanation for these results is that although anxious drivers are perceived to make more mistakes while driving (Taylor et al., 2021), these errors may not necessarily be related to their ability to perceive hazards. Instead, these errors might manifest in their post-perceptual processes (decision making) and behaviours such as hesitating on a roundabout or stalling after encountering certain hazardous situations due to panicking. In other words, anxious drivers may struggle with translating their perception of danger into smooth driving actions, leading to hesitancy and panic-induced errors on the road (Taylor et al., 2021). Study two revealed that anxious drivers tend to score higher on self-reported driving errors and report heightened anxiety when confronted with stressful situations. Other studies have also reported similar findings (Pourabdian & Azmoon, 2013; Pourabdian et al., 2014; Shahar, 2009; Wong et al., 2015). However, based on the current findings, it appears that the subjective perception anxious drivers hold regarding their driving skills does not necessarily align with their objective hazard perception abilities and level of vigilance. Other types of driving behaviour related to decision-making post hazard perception may be more indicative in relation to differences between anxious and non-anxious drivers and therefore warrant further investigation.

The lack of differences could also be attributed to the varying degrees of stress elicited by each hazardous situation. Mathews and Mackintosh's (1998) original cognitive model suggests that strong danger cues are likely to capture attention universally, regardless of anxiety levels, whereas' weak danger cues may primarily attract the attention of individuals with heightened anxiety. The current study included scenarios characterised by a high level of stress and failing to identify these hazards in a real-world scenario would likely lead to a collision in the majority of cases (Ventsislavova et al., 2016; Yuan et al., 2018). Consequently, the hazards might have automatically captured the attention of all participants, regardless of their anxiety levels, thus minimising the expected performance differences between anxious and non-anxious drivers. To gain a better understanding of anxiety's sensitivity to threat perception while driving, future research could consider investigating "soft" hazards or cues with varying levels of threat (Yuan et al., 2018). Examining how anxiety influences the detection of less obvious or weaker danger cues may shed further light on the nuance between anxiety and hazard perception in driving contexts.

While no interaction was observed between driving anxiety levels and driving experience on hazard perception performance, experienced drivers significantly outperformed novices in detecting hazards. This is unsurprising considering the extensive evidence to support these results by previous studies. Experienced drivers typically detect hazards faster than novices due to their heightened ability to recognize and promptly respond to potential hazards (Malone & Brünken, 2016; McKenna & Crick, 1994a; Pollatsek, et al., 2006; Quimby & Watts, 1981; Scialfa et al., 2011, 2011; Smith, et al., 2009; Wetton et al., 2010). It should be noted that anxious experienced drivers reported the highest mean score for hazard perception, despite the lack of a significant main effect for anxiety and interaction between experience and anxiety levels. Experienced anxious drivers also reported more extra hazards responses although the effect was only significant for the levels of experience. As it was already discussed above, the results suggest that driving experience seems to be a more prominent factor for distinguishing between good and poor hazard perception abilities and not anxiety levels. However, future studies should not completely neglect a possible interaction between driving anxiety and driving experience, especially in relation to anxious experienced drivers.

SCRs and self-reported driving anxiety

To define and categorise the anxiety groups, self-report psychological measures were utilised, alongside the inclusion of skin conductance response measure. It was expected that anxiety levels would be significantly higher for the anxious group compared to the non-anxious group. All driving anxiety questionnaires and the state trait anxiety questionnaire reported that the anxious drivers scored significantly higher than the non-anxious drivers for driving anxiety and state-trait anxiety. However, no differences were observed between the anxiety groups in relation to their SCR in any of the three experimental conditions. While there was a higher number of SCRs recorded during the hazardous condition for all participants, no difference in SCRs was observed between the non-hazardous and control conditions either. This unexpected outcome may be attributed to the concept of diminished physiological flexibility, which pertains to instances where individuals with anxiety exhibit a narrower range of physiological responsiveness (Hoehn-Saric, 2007). In contrast, non-anxious individuals typically exhibit a robust initial response to stressors, followed by a relatively swift return to baseline levels when the perceived threat subsides (Hoehn-Saric & McLeod, 2000). It is plausible that diminished physiological flexibility represents a partial but ultimately insufficient attempt by the body to adapt to the enduring physiological alterations induced by anxiety (Burchfield, 1979). Furthermore, EDA could be capturing fear instead of anxiety. Schmidt-Daffy (2013) established that responding to a task demand often elicits the emotional response of fear, rather than anxiety due to bottom-up processing of the environmental stimuli. This interpretation aligns with the concept that a hazard, by its nature, is more likely to induce fear due to its immediate and tangible threat to the individual within the driving environment, necessitating an immediate response. Considering this perspective, it may be possible that the SCRs observed in the current study are related to emotional experience of fear. Further corroboration for this interpretation can be found in the work of Barnard and Chapman (2016), where SCRs were employed as a measure. In their study, crash clips exhibited a significantly greater escalation in SCRs compared to dangerous clips. This pattern of increase suggested that the observed skin responses may be a direct reaction to the heightened fear experienced while viewing these videos.

However, it is worth noting that skin conductance response is sometimes regarded as a measure reflecting non-specific general arousal (e.g. Scavone et al., 2020), and this could potentially contribute to the current results alongside Barnard and Chapman's (2016) study. Nevertheless, this body of evidence lends support to the notion that the presence of a general threat, such as a hazard in the driving context, has the capacity to trigger heightened physiological reactivity, in alignment with findings from prior research (Tomaka et al., 1993; Palomba et al., 2000). This has been evidenced by the high levels of SCRs reported by both, anxious and non-anxious participants especially during the hazardous and non-hazardous condition, with the control condition eliciting the lowest levels of SCRs.

Finally, participants were asked to assess their anxiety levels after viewing each video clip in all three conditions. The hazardous condition consistently received the highest anxiety ratings, followed by the non-hazardous and control conditions. Participants again detected the heightened stress and anxiety-inducing nature of both anxiety-triggering conditions evidenced by their ratings. This time there were significant differences between anxious and non-anxious drivers, with anxious drivers reporting higher anxiety levels than their non-anxious counterparts. This disparity between the levels of self-reported anxiety, alongside the absence of differences in SCRs, suggests a discrepancy between the subjective and objective measures. It should be noted, however, that the anxious drivers still reported a high number of SCRs, although these did not differ from those of non-anxious drivers. As a result, these findings imply that perceived anxiety may equally influence driving behaviour. In the previous study, anxious drivers reported experiencing mistakes and errors while driving, despite demonstrating comparable performance to non-anxious drivers on a hazard perception test (in the current study). Perceived stress from driving situations, along with personal stress factors, can influence one's perception of anxiety and their ability to cope with driving situations (Rowden et al., 2011). Anxiety has been observed to diminish confidence (Kenow & Williams, 1992), and individuals with driving anxiety often express doubts about their skills (Taubman-Ben-Ari et al., 2004), potentially leading to increased driving errors (Taylor et al., 2007). Anxious drivers when presented with a hazard appraise their capacity to handle the hazard, resulting in increased stress and poor coping if unable to respond to the hazard appropriately (e.g. Hill & Boyle, 2007). These findings underscore the significance of understanding drivers' subjective experiences, as their perception of anxiety will inevitably influences their behaviours on the road (Gwyther & Holland, 2014).

While no significant main effects were observed for driving experience, there was an interaction between driving experience and anxiety levels on self-reported anxiety. Both experienced and novice anxious drivers reported the highest levels of self-reported anxiety. However, novice non-anxious drivers exhibited significantly higher anxiety levels compared to experienced non-anxious drivers, aligning with the findings from study 2. Novice drivers typically report experiencing stress and anxiety during their initial months of driving, often due to the novelty of the experience or criticism from driving instructors (Hidalgo-Muñoz et al., 2021). While this initial anxiety may not immediately manifest as driving anxiety, it warrants attention to prevent it from evolving into a more serious issue for novice drivers.

Limitations

The study did not report which SCRs were based on certain hazards or events, as the MP160 had to be paired with an additional hardware known as the STP100D. Unfortunately, STP100D was unavailable during the current study, therefore synchronisation had to be performed manually. While it is possible to manually synchronise the EDA and video stimuli, it is impossible to measure which event-related SCRs was compared to regular SCRs. To overcome any bias, normalisation of the SCRs was conducted by square root transformations of SCRs (Braithwaite et al., 2013; 2015).

A final limitation was the use of a combination of video clips with and without mirrors. Mirrors were included in some of the clips to capture overtaking hazards, however, during the filming process, it was not always possible to set up the entire equipment to capture mirror information due to the extensive driving hours required, all conducted during normal driving conditions. Despite this, some anxiety-triggering video clips were retained although without mirrors because they closely resembled situations described by participants, which would have been otherwise discarded. Nonetheless, the analysis indicated no significant differences in fixations on mirrors based on clip condition, anxiety group, or experience level.

Conclusion

In conclusion, this study aimed to explore the relationships between driving anxiety, driving experience, and the attentional processes underlying hazard perception performance. The results suggested that anxious drivers are neither more vigilant nor slower at detecting hazards compared to non-anxious drivers. These results contradicted the expectation that anxiety would impair hazard perception performance due to heightened cognitive demands. The only differences observed were between experienced and novice drivers suggesting that the ability to perceive hazards is related to driving experience and does not seem to be impacted by the presence of driving anxiety. While anxious drivers often report a higher number of driving errors, the present results suggested that these errors may not be directly linked to their ability to perceive hazards or focus on relevant stimuli. Instead, these errors might arise during post-perceptual processes, such as decision-making, and manifest in behaviours such as hesitating at a roundabout or stalling after encountering certain hazardous situations due to panic. While there were no differences in skin conductance responses (SCRs) between the anxiety groups, anxious drivers consistently rated all hazardous situations as highly stressful compared to non-anxious drivers. This reveals a discrepancy between self-reported driving anxiety and objective measures. However, self-reported anxiety should not be underestimated, as the belief that one is anxious and unable to cope during a certain driving situation can still lead to errors during an actual driving performance, even if the driver possesses strong hazard perception abilities.

Chapter 6: The impact of driving anxiety on driving performance across stressful and less-stressful routes: A driving simulator study

Summary of previous findings

Study three compared drivers' hazard perception performance across hazardous and non-hazardous situations that have been identified to trigger driving anxiety. The study aimed to assess whether driving anxiety had an impact on perceptual and attentional processes relating to the ability to perceive hazards while driving, and whether anxious drivers exhibited a decreased ability to detect hazards in stressful situations compared to non-anxious drivers. The results revealed no significant differences between the anxiety and experienced groups in terms of the time taken to first fixate a hazard or the total time spent looking at a hazard. While no main effect was found for the different groups, participants differed in their visual spread of search across the different conditions. These findings suggested that the more demanding and stressful driving situations, regardless of whether a hazard was present, led to a broader spread of search for all participants.

There was a significant difference between experienced and novice drivers where experienced drivers were able to correctly identify a hazard within the hazard window more often than novice drivers. Using self-report, anxious drivers did find the anxious conditions with and without a hazard more anxiety inducing than the control conditions. This suggests that anxious driving situations can increase anxiety for anxious driving individuals.

The eye tracking and behavioural data seemed to differentiate from findings from study two which suggested that driving anxiety can lead to more driving error. Originally it was suspected that anxiety could reduce the efficiency of hazard perception skills and reaction time, leading to increased error. From the findings of study three this does not seem to be the case. As study two reported that anxious driver commits more driving errors than their non-anxious counterparts, it was hypothesised that perhaps driving anxiety has an impact on the post-perceptual decision-making processes which lead to errors while driving rather than the attentional processes pre-decision making. Therefore, the current study aimed to measure similar behaviours linked to different types of error found in the study two. For example, study two highlighted slip errors such as stalling and hesitation. Study two also highlighted violations related to speeding, which could have a detrimental impact on braking behaviours and safety leading to increased collisions.

While the eye tracking and behavioural data did not differentiate between anxious and non-anxious counterparts, anxious drivers did suggest that anxious driving situations did invoke anxiety based on self-report. Based on this data, two routes were used for the current study to investigate whether route type could also lead to increased driving error. For this study, a driving simulator with a driving cockpit (steering wheel, pedals and gearbox) was featured to driving performance on different simulated routes. Driving behaviours such as stalling, hesitation and collisions were measured. Furthermore, as it has been suggested that anxiety is linked to cautious driving behaviour (Clapp et al., 2011; Schmidt-Daffy, 2013), to test for differences between anxious and non-anxious drivers, common behaviours such as speeding and braking were captured across stressful and less-stressful driving scenarios.

Introduction

Although there are no official statistics, driving-related anxiety may pose risks to safe driving. A recent study by Traficante et al. (2024) found that spatial anxiety, which is the apprehension experienced during tasks involving spatial thinking, was negatively associated with driving performance (Lawton, 1994, Ramirez et al., 2012). Specifically, higher levels of spatial anxiety were linked to more frequent driving lapses - brief moments of inattention that may increase the likelihood of collisions (e.g. Trick et al., 2004). The study also showed that poor driving self-regulation partly explains the connection between spatial anxiety and driving lapses. This suggests that individuals with higher spatial anxiety may struggle with regulating their driving, leading to more frequent lapses and potentially unsafe driving behaviour (Klauer et al., 2005). Traficante et al.'s (2024) study highlighted similar results to those in study two of the current thesis, which linked driving anxiety to driving error in the form of slips, where an action deviated from what was intended and driving violations such as speeding (Norman, 1983; Reason et al., 1990). Study two found that only anxious driving behaviours were significant to driving error whereas study three found that perceptual processing was not affected by driving anxiety. Therefore, there is an interest in measuring driving anxiety's impact on post-perceptual processing to determine whether this can impact driving performance.

While the consistent relationship between the negative impact of anxiety on task performance has been well-established in the broader literature (Shi et al., 2019), the consistency of findings in the field of driving has been less robust. For example, it has been found that anxiety's impact on decision making can potentially lead to anxious drivers having increased hesitation when facing certain driving situations compared to non-anxious drivers. This hesitation is evidence that there is a negative impact on post-perceptual processing as correct driving behaviour is being delayed. Schmidt-Daffy (2012) highlighted this effect when investigating the impact of driving anxiety on goal conflict using a driving simulator. The goal conflict arises from the driver's simultaneous need to reach their destination quickly while also driving safely, which typically requires a slower speed. Schmidt-Daffy (2012) proposed that these two behaviours - driving quickly to reach a destination and driving safely - are connected through the Behavioural Inhibition System (McNaughton & Gray, 2000), which can be influenced by emotions such as anxiety. The study found that in conditions of low visibility and high goal conflict, anxious drivers exhibited increased hesitancy when trying to reach maximum speed, although this effect was relatively small (Schmidt-Daffy, 2012). It could be that anxious drivers were struggling to choose between driving fast to get to the destination and driving safely to avoid any potential dangers. These findings illustrate a delay in decision making processing. However, the simulator used within Schmidt-Dafty (2012) has methodological limitations via the utilisation of arrow key presses which required consistent taps every 1500ms. This method diverges from real-world driving, where acceleration and deceleration are controlled by pedals, thus reducing the immersion of the driving scenario. By using a more immersive measurement such as pedals to control the velocity, then the effect size may have been stronger. Additionally, the arrow keys corresponded to specific speed settings (40, 60, 80, 100) and a brake function, with no keys assigned for turning. This setup created an impression of driving on a straight road, rather than navigating a complex environment like a city. A city environment would be more like the real world, particularly when these environments having been linked to driving anxiety previously (Scott-Parker et al., 2018, Taylor et al., 2018). Even if a city environment was not used, similar roads such as the ones used in Schmidt-Daffy's (2012) research still require some level of steering. Therefore, the measurement of speed hesitancy may be constrained by these design limitations.

While anxious drivers may be observed to hesitate while driving, this may be due to the lack of confidence in decision-making (Taubman-Ben-Ari et al., 2004; Taubman-Ben-Ari et al., 2016). As a result, anxious drivers may struggle to make quick decisions (e.g., merging into a junction) or perform highly precise actions due to their lack of confidence in their driving skills and competencies (e.g. Freuli et al., 2020; Slavinskienė & Endriulaitienė, 2024; Useche et al., 2019). The reason for hesitation at junctions is primarily due to attention required for other traffic (cars, cyclists, pedestrians), as well as the surrounding environment (traffic signs, traffic signals, the shape of the road, yielding rules, traffic regulations, etc.) (see also Scollon & Scollon, 2003). For uncontrolled junctions there may also be some element of turn taking or negotiation among drivers (Haddington, 2010). Study One of this thesis highlighted that anxious drivers struggle in social environments due to their lack of confidence in their skills (See Chapter Three), therefore any form of negotiation on the road may also reduce decision making efficiency. As anxious drivers have been identified as cautious drivers (Schmidt-Daffy, 2013), then their anxiety may lead them to stop more than other drivers in similar situations and may not continue the journey at the same rate as other drivers (Taubman-Ben-Ari et al., 2004). In these instances, this hesitation may be classified as a slip error, as anxious drivers do not intend to delay their actions (See Chapter Three). While this behaviour may not be high risk, it could confuse other drivers leading to disruption of traffic flow (Burns, 1998; Laurier, 2005). Studies have indicated that hesitation can vary, ranging from one second, up to three seconds, after a driver is required to proceed (Yuda et al., 2020; Zhao et al., 2015). This variability in hesitation can potentially influence the decision-making processes of other drivers. However, it should be noted that all the studies which have been used to discuss hesitation have not used anxious driving samples. Furthermore, the duration of driving hesitation has not been conducted on anxious drivers, but instead looked at the effects of aging on foot pedal response (Yuda et al., 2020) and the impact of experiencing an exit-lanes for left-turn junctions for the first time. Therefore, investigating hesitation behaviours among anxious drivers is warranted to determine if there is a reduction in driving performance when using familiar junctions.

Apart from hesitation, anxious driving behaviour has also been linked to stalling behaviour (See Chapter Two). A stall refers to a sudden stopping of the engine turning, usually brought about accidentally (Schultz, 1979). Similarly to hesitation, this type of behaviour has also primarily been observed at junctions as a stall typically occurs when a driver needs to pull off from a stationary position. A stall often happens when the driver fails to find the biting point or selects the wrong gear of the car (Wardlaw, 2014). Stall errors have also been associated with driving anxiety, although this association is primarily based on self-report studies, including driving questionnaires and interviews. Scott-Parker (2015) identified anxiety as a common emotional response among novice drivers. Hashempour and Mehrad (2014) recognised anxiety as a prevalent emotion that impairs learning processes. Scott-Parker (2015) specifically highlighted that anxious novice drivers often experienced stalling, especially during the early stages of learning to drive. Therefore, disruption in learning linked to anxiety may have long-term consequences on skill acquisition. If anxiety can interfere with the development of essential driving skills, such as smooth clutch control or gear shifting then there may be an increase frequency in driving errors like stalling. If anxiety persists during the learning phase, it is possible that novice drivers may not develop these skills as efficiently or as effectively as they would in the absence of anxiety. As a result, the foundational skills necessary for confident driving may be weaker, potentially affecting their future driving performance and safety. However, Scott-Parker's (2015) findings remain limited on whether stalling behaviour is based on anxiety or inexperience. Therefore, an evaluation between anxiety and experience needs to be conducted to determine which factors have the more significant impact on stalling behaviour or whether both anxiety and inexperience are required to produce stalling as a driving error.

From both hesitation and stalling behaviour, a common situation where the behaviour is more frequently produced are junctions. Junctions are crucial connection points between multiple traffic routes, adding complexity to the environment (Zöller et al., 2019). By being the connection point between multiple routes junctions also have a higher chance of increased traffic and differences in traffic flow (Abdurakhmanov, 2022). Bauer and Harwood (1996) observed that traffic volume emerged as the primary factor affecting collision data across a variety of at-grade intersections. Typically, in high traffic volumes, drivers are expected to exercise greater caution and reduce their speed to allow more time for reaction to hazards. However, excessive caution and driving too slowly can disrupt the natural flow of traffic. It has been highlighted in previous studies of this thesis that heavy traffic situations can induce anxiety. Therefore, anxious drivers may opt to drive slower or excessively slow compared to their non-anxious counterparts (Peng et al., 2016), which can be perceived as dangerous by other drivers (Stephens et al., 2019). While anxious drivers typically fit into the cautious driving archetype which historically mitigates risk, paradoxically this archetype may increase the likelihood of driving errors. For instance, a study by Lim et al. (2022) delved into the perceived risks associated with behaviours characteristic of cautious driving. They conducted an online survey to explore the relationship between trait anxiety, anxious driving behaviour and perceived road safety risks. They identified two primary factors linked to excessive caution: "Hesitating at an intersection" and "Holding up other vehicles" (e.g. sudden braking). While anxious drivers did not perceive these behaviours as risky, they are viewed as such by other road users and can provoke anger (Lim et al., 2022). Anger has been linked with unsafe driving behaviour (Deffenbacher et al., 2000; Deffenbacher et al., 2003; Fischhoff et al., 2005; Lerner & Keltner, 2001). For example, Mann et al. (2007) found that perpetrators and victims of road rage had a significantly higher risk of collision involvement than did those without road rage experience. If anxiety can lead to anger, then it is possible for an unsafe driving environment to develop. However, as it has been found that anxious drivers have similar hazard perception skills than non-anxious drivers (See Chapter Five), and tend to driver slower, in a driving simulator, where anxiety does not lead to anger amongst other road users, anxiety should not have an impact on collisions.

Overview of the study

To address the limited research concerning the impact of driving anxiety on driving performance, this study aimed to further investigate this relationship. Anxious and non-anxious drivers drove two routes using a driving simulator. One of the driving routes included a range of anxiety-inducing situations identified in prior research (Scott-Parker et al., 2018, Taylor et al., 2018) and earlier studies within this thesis (see Chapters Three and Chapter Four). Driving performance was evaluated and compared via, specific driving behaviours such as stalls, hesitation, speeding, braking and collisions. It was hypothesised that anxious drivers would have a higher likelihood to commit stalls and hesitate longer at junctions and intersections than their non-anxious counterparts. It was also hypothesised that anxious drivers were less likely to speed compared to the non-anxious drivers. Because anxious drivers were less likely to speed it was hypothesised that anxious drivers would be less likely to perform sudden braking behaviours compared to their non-anxious counterparts. It was predicted that driving anxiety would have no impact due to a cautious driving style. Considering Scott-Parker's (2015) findings, differences between experienced and novice drivers were also expected, with a possible interaction between experience, anxiety. It was expected that anxious novice anxious drivers would have the weakest driving performance and it was expected that the non-anxious experienced drivers would have the best driving performance.

Method

Participants

A sample of 40 participants was estimated based on previous general driving simulator studies (Guo et al., 2021) as well as driving anxiety studies (Gotardi et al., 2019). For example, with a sample of 40 participants, Guo et al. (2021) achieved partial eta squared (η_p^2) scores between 0.22 and 0.43 throughout their results, indicating a large effect size (Fritz et al., 2012). Likewise, when looking at anxiety's specific effect on driving performance through speed and collisions, Gotardi et al. (2019) achieved η_p^2 scores between 0.11 and 0.14, indicating a medium to large effect size (Fritz et al., 2012). For the current study, 206 people in total expressed interest in taking part in the current study by completing the pre-screening driving anxiety questionnaire. Of these 206 people, 143 were not able to take part in the driving simulator portion of the study. The most common reason for this was not being able to travel to the university. Thus, the final sample was comprised of 63 participants. The initial sample split between anxious and non-anxious drivers was based on self-reported driving anxiety and subsequently validated by scores on several driving anxiety scales used in previous studies of the thesis. It should be noted that none of the participants who reported experiencing driving anxiety were diagnosed with any form of clinical anxiety disorder. All drivers held full UK driver licences. Novice drivers were participants who had driven under one year, regardless of mileage, and from one to three years if their milage was under 1000 miles per year. Drivers with over three years of licensure and at least 1000 miles per year were classed as experienced drivers (see McCartt et al., 2003). Nine participants were excluded for not meeting the milage criteria. As a result, the final sample size was of 54 participants: 28 anxious drivers (experienced = 14, novice = 14) and 26 non-anxious drivers (experienced = 13, novices = 13).

The anxious group held their license on average for 8.64 years (*SD* = 13.10) whereas the non-anxious group held their license on average for 7.96 years (*SD* = 12.21). The anxious group travelled an average of 4479.28 miles in the previous year (*SD* = 4363.77) whereas the non-anxious group travelled an average of 5267.30 miles (*SD* = 3271.05). The majority of participants were recruited from Nottingham Trent University by poster or lecture and workshop session advertisements. Participants were compensated for their time with a £10 Amazon voucher. See Table 13 for a detailed breakdown of participants' demographic and driving experience information.

Table 13: *Means and standard deviations of the demographic values for the participants for study four.*

Anxiety	**Anxious drivers *n* = 28**				**Non-anxious drivers *n* = 26**			
Experience	**Experienced *n* = 14**		**Novice *n* = 14**		**Experienced *n* = 13**		**Novice *n* = 13**	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Age	36.86	15.51	20.29	2.20	33.38	15.78	19.07	0.95
Licence in years	16.07	15.35	1.21	1.31	14.53	14.67	1.38	1.26
Miles per year	5847.87	4868.60	3110.71	3436.91	6807.69	2839.73	3726.92	3014.31

Design

This study collected a variety of measures across different driving scenarios to measure and compare driving performance between anxious and non-anxious drivers.

Firstly, to measure driving behaviour between junctions a 2 (anxious vs. non-anxious) x 2 (experienced vs. novice) x 2 (anxious route vs. non-anxious route) mixed factorial design was implemented with stalling, collisions and hesitation at junctions as dependent variables. Junction positioning within the software were represented via path numbers. For example, for the anxious route, the first T-Junction was based on path number 27 (see Figure 25). To ensure all driving behaviours were captured sufficiently, data were captured +/- 10 metres from each path number. Therefore stalls, collisions and hesitations behaviour was observed within a 20m radius of the junctions. Both collisions and stalling behaviour were measured in a binary format (presence vs. absence). As there is no concrete definition of hesitation driving behaviour (e.g. Amick et al., 2007), parameters were set according to the established by previous research - a range of one second (Zhao et al., 2015) and three seconds (Yuda et al., 2022). Thus, ‘excessive’ hesitation was measured within these parameters. For the current study hesitation was captured when a driver was driving below two km/h, after two seconds have elapsed when the driver should have moved off from a junction. This allowed the software to capture hesitating behaviour such as crawling or stop starting.

Second, to measure driving behaviour during specific driving situations a 2 (anxious vs. non-anxious) x 2 (experienced vs. novice) x 4 (complex junctions vs. gap judgement vs. heavy traffic vs. tailgating) mixed factorial design was implemented on the anxious route. For this design, only driver's speed and braking behaviour was measured. The scenarios in the anxious driving route were equally represented with path numbers. However, some anxious scenarios were repeated. For example, gap judgement appeared in two parts of the route, so both instances were combined to assess gap judgement.

As the speed limit of each route was different (see Overview of the study, p. 190) participants speeding and braking behaviours were only measured on the anxious route. Speeding was measured based on whether a participant broke the 30KPH speed limit. Speeding was measured using a binary format. If the participant's speed was higher than 30KPH then they would score a "1". If the participant's speed was less that 30KPH, they would score a "0". The binary scores were measured every 100ms. The outcome was the predicted probability of speeding per driving situation.

Hard braking was measured by deceleration force based on the following formula:

[Deceleration (*g*) = (Final Velocity(*m*) – Initial Velocity(*m*)) / Time(*s*)]

In Eastern countries, threshold rate of 0.3g has been used for describing and categorising deceleration events in emergency braking (Naito et al., 2009), whereas Western countries set their hard braking threshold as 0.5g (Hill et al., 2019). As the current study was based in the UK, the threshold of 0.5g was be used. Therefore, hard braking was measured when a participant applied a force of 0.5g or more while braking during an anxious situation. The variable was measured in a binary format (Not using 0.5g of braking force = 0, using 0.5g or more of braking force = 1) across all anxious driving situations.

All participant completed a practice drive to familiarise themselves with the controls of the simulator for 10 minutes. After the practice drive, participants were sequentially assigned to one of the two routes (anxious vs. non-anxious). For example, participant A with driving anxiety would be driving the anxious route first then after a 2-minute break, they would drive on the non-anxious route. Participant B with driving anxiety would drive the non-anxious route first then after a 2-minute break, drive on the anxious route. Participant C with no driving anxiety would driving the anxious route first then after a 2-minute break, they would drive the non-anxious route. Participant D with no driving anxiety would drive the non-anxious route first then after a 2-minute break, drive the anxious route. This was done to ensure there was no bias between anxiety group and route choice. Furthermore, the route choice was blind to the participant. After both the drives, the researcher would ask which route the participant thought was the anxious or non-anxious route. Only after the response would the researcher provide the answer of which route was the anxious route. This would allow confirmation on anxious route design.

Self-report demographic and anxiety data were collected via questionnaires in Qualtrics. Driving history and driving anxiety data were collected prior to the experiment. In addition, state anxiety was measured post experiment to control for anxiety levels after taking part in the experiment.

Driving stimuli and equipment

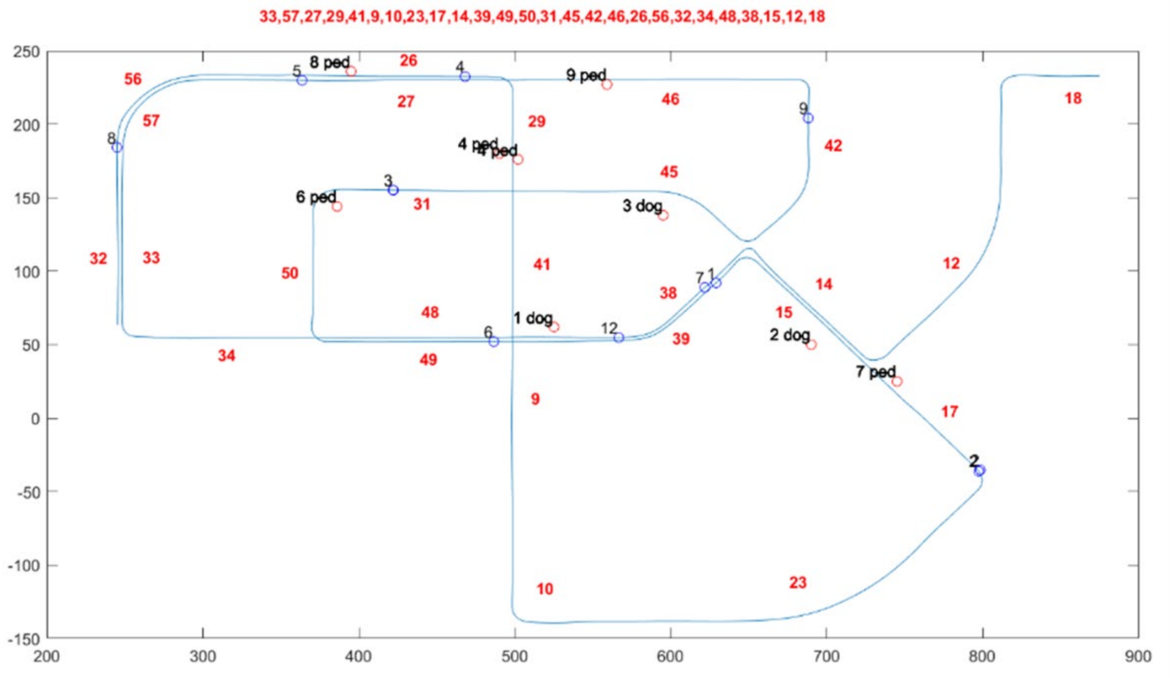
In order to observe and assess the driving behaviour of the participants, the study featured a three-dimensional desktop driving simulator with support for multi-monitor display of complex driving situations. The driving simulator consisted of three 23-inch monitors with a horizontal field of view of 210° and Logitech G29 Driving Force steering wheel, shifter, pedals, and speakers. Pedals and the driver’s seat were adjusted individually for comfort. The simulator was used to provide a realistic driving sensation by simulating vehicle dynamics including force feedback. and programmed to capture accelerating, braking and steering inputs while driving.

The driving simulator featured Carnetsoft software (Carnetsoft BV, Groningen, Netherlands) that was used to develop the virtual environment for both the anxious and non-anxious routes. Both routes used CGI (Computer-Generated Imagery). It is recommended by Carnetsoft to use one of the 15 ready to use virtual environments as they are pre-connected to a graphical and logical database. The graphical database is controlling the visualisation of the virtual world whereas the logical database hosts the data for the autonomous traffic to be used in their behaviour, for data sampling and analyses and for use in the script language in general. Due to the recommendations, the anxious and non-anxious routes were selected form two of the 15 ready-made routes.

Two of the 15 pre-designed routes provided by the Carnetsoft software, were chosen to be the "Anxious" and "Non-anxious" routes. Traffic 3 was named as the anxious route and night 2 was named the non-anxious route. See Figure 25 for a map of the anxious route and Figure 31 for a map of the non-anxious route. Both routes had clear weather conditions and visibility.

During both routes, a female voice over provided driving directions alongside the satellite navigation screen. For example, just before the junction, the voice would instruct the driver to "turn left" or "turn right". There were no other directions other than simple turn left or right instructions. Both routes took approximately 10-15 minutes to drive depending on the speed of the participant.

Figure 25: *Map for Traffic 3 with path numbers which is used as the anxious route for the current study. The red numbers at the top of the image are the path numbers in the order of the drive. The blue lines are the driving route. The axis will show the raw position of the driver within Carnetsoft software.*



Anxious route

Traffic 3 was chosen as the anxious route because the route included a range of anxious driving situations which were identified as anxiety triggering in previous studies in this thesis. For example, Traffic 3 had complex junctions in the form of traffic light situations where the driver had to decide whether it was safe to continue due to other vehicles in the vicinity. There were three traffic light situations in total, two where the driver had to turn left (path 14 and path 45) and one where the driver had to turn right (38). Figure 26 below depicts the first left turn at a traffic light which is linked to path 14.

Figure 26: *Example of a complex junction with traffic lights within the anxious route. The specific image is the first left turn at a traffic light which is linked to path 14.*

Another situation which was included was gap judgement, where the driver is on a narrow road and meets a bus driving in the opposite direction, which led to the driver having to decide whether to stop or continue driving. There were two gap judgement situations, both on a narrow sweeping corner meeting a bus (path 56 and 57). Figure 27 below depicts the first instance of gap judgement which is based on a right turn and linked to path number 56.

Figure 27: *Example of gap judgement Situation within the anxious drive. The specific image is the first wide right turn on a narrow road with a bus coming the opposite way. This situation is linked to path 56.*

There were also areas of heavy traffic while interacting with intersections where the driver either had the right of way or had to give way to the traffic (See Figure 28). There were two instances of heavy traffic (path 9 & 29). Figure 28 below depicts the first instance of a heavy traffic situation on a four-way intersection with pedestrians also crossing a zebra crossing. This situation is based on the path number 9.

Figure 28: *Example of heavy traffic situation in the anxious route. The specific image is first instance of a heavy traffic situation with cars on all four sides of a four-way intersection with a zebra crossing being used by pedestrians. This situation is linked to path 9.*

Finally, as tailgating was not part of the original route design, the scenario was programmed to add a red car to follow the driver while travelling towards a particular traffic light and was very close once the driver reached the traffic light to create tension (path 38) (note that the driver has to turn right when then is traffic with right of way) (see Figure 29).

Figure 29: *An example of tailgating within the anxious route where the red car is following the driver and is in very close proximity, adding pressure when the participants have to wait for all cars opposite to move before turning right at the traffic light.*

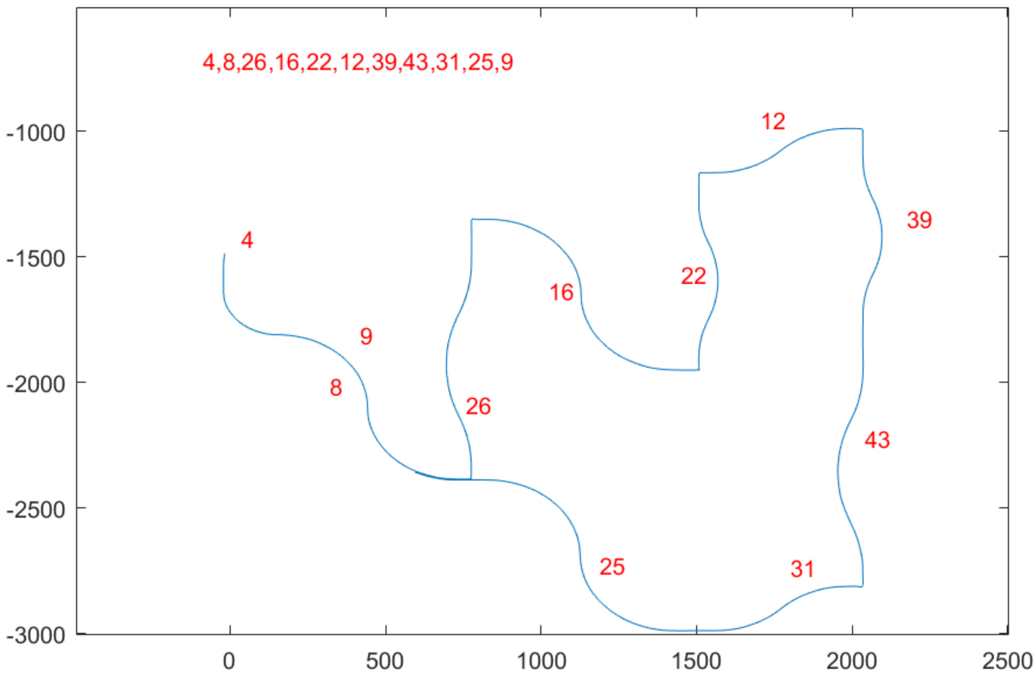
Within the anxious route, there were 19 junctions where stalling, collision and hesitations were recorded. Of the 19 junctions there were 2 T-Junctions, 8 give way junctions, 3 right of way junctions and 3 stop junctions and 3 traffic light-controlled junctions.

Non-anxious route

The non-anxious route was chosen due to being a generic and non-stressful drive through a rural setting with limited traffic and junctions (see Figure 30). Within the non-anxious route, there were 10 junctions where stalling, collision and hesitations were recorded. Of the 10 junctions there were 2 T-junctions, 1 give way junction, 5 right of way junctions and 2 stop junctions (see Figure 31 for non-anxious route map and path numbers). In total for both routes there were 29 junctions where stalling, collision and hesitation data were recorded.

Figure 30: *Example of the non-anxious drive through a rural environment with limited traffic and open environments.*

Figure 31: *Map of Night 2 with path numbers used for the non-anxious route for the current study. The red numbers at the top of the image are the path numbers in the order of the drive. The blue lines are the driving route. The axis will show the raw position of the driver within Carnetsoft software.*



Psychometrics measures

Several psychometric measures were used to assess the levels of driving anxiety of the participants. These included the DBS (Clapp et al., 2011), DCQ (Ehlers et al., 2007), DRAS (Stewart & St. Peter, 2004) and STAI (Spielberger, 1983). The questionnaires and their validity and reliability were already discussed in detail in previous chapters. Please refer to Chapter 4 for detailed information regarding DCQ, DBS and DRAS, and Chapter 5 for the STAI.

Procedure

The study was split into two parts. The first part was a pre-screening questionnaire which involved collecting demographic and driving anxiety data via a Qualtrics survey (https://www.qualtrics.com/en-gb/). Participants were invited to click on the link or scan the QR code if they wished to participate. All participants were asked to confirm they were aged 18 years or older. Each participant was asked to provide a unique identifier. They were then presented with an information sheet and were asked to consent to participate. Following consent, all participants were asked to fill in the demographic section which included information such as age, sex and driver history questions (date of driver's license, miles per year). The survey then proceeded with each one of the driving anxiety questionnaires. Questionnaires were following a specific order to avoid participant fatigue, with the longest scale in the middle of the survey and the shortest at the end (Ben-Nun, 2008). At the end of the questionnaire, the participant could click a link which sent the researcher a pre-written email stating that the participant had completed the pre-screening questionnaire and was waiting for a response from the researcher to organize a date and time to take part in the second part of the study. This first part of the study took 15 minutes to complete.

Subsequently, the pre-screening questionnaire was reviewed to determine which group each one of the participants should be assigned to (anxious-experienced, anxious-novice, non-anxious experienced, non-anxious-novice) before organising a time and inviting them to the lab. If participants contacted back the researcher, they were invited to the second part of the study involving the driving simulator.

For the second part of the study the participants were welcomed into the laboratory and asked to read the participant information sheet again and sign the consent form. This was to ensure the participants knew what to expect after a break between the two studies. After consenting to take part in the study, they were asked to complete the STAI. After completing the questionnaire, participants were guided to the driving simulator. The researcher then provided detailed instructions on its operation, including how to adjust the seat to ensure comfort throughout the experiment, how to use the brake and accelerator pedals, how to use the indicators and how to follow the satellite navigation system. After being told about the controls, the participant would complete a practice drive for ten minutes to familiarise themselves with the controls. During the practice drive, the participants would follow the pre-determined route with satellite navigation and make a series of left and right turns. To account for the speed difference of both the anxious and non-anxious route, the practice drive had slow sections and fast sections so the participants could test the controls at different speeds. During the practice drive the researcher made it clear to the participant that if there was a collision or the participant drove off the road, the simulator would spawn the driver back on the road a few metres behind their previous position. While the participant was proceeding with the practice drive, the researcher observed the drive to ensure all the driving simulator mechanics were tested such as accelerating, braking, steering and indicator use. The participant was also allowed to ask any questions they had during the practice drive. Once the practice was complete, the researcher clarified that if the participant would like to stop the experiment, they were able to do so without a reason. Once the participant was ready, they were assigned to one of the routes, (see Design section) and the researcher made notes on the progress of the participant during each of the routes. In between the routes, participants were able to have a break and step out of the driving seat if needed. Once both routes were complete, the researcher asked which route was the anxious route, before the participant was directed back to the laptop to complete the state section of the STAI again and read the debrief. The face-to-face portion of the study took 45 minutes to complete.

Data analysis

Statistical analyses were conducted using R 4.3.1 (R Core Team, 2023). To test the impact of anxiety on driving performance, mixed effects models via the lem4 package (Bates et al., 2015) were conducted using the reduced maximum likelihood (REML) approach. The REML uses a likelihood function calculated from a transformed set of data, so that unspecified parameters have no effect (Dodge, 2006). Multi-level modelling analyses are more sensitive to data dependency and reduce Type I errors compared to common practices such as ANOVA (Yu et al., 2022). This is due to multi-level modelling analyses allowing for the inclusion of random effects, which are not of direct interest, however they may lead to correlated outcomes (Fisher, 1919). For hesitations linear mixed effects modelling with fixed slopes to determine the best fit of the data were used for this analysis. All other models used a binomial logistical regression mixed effects modelling. Model comparisons used likelihood ratio tests were employed to identify the optimal fit for the data. The process began with the simplest model, an intercept only model containing only constants and no fixed effects. Subsequently, each main (fixed) effect was added sequentially, and the resulting model was compared to its predecessor. Interaction effects were also evaluated in this step-by-step approach. To explore differences between the two routes, three analyses were conducted (stalls, collisions and hesitations) with each analysis comparing two models: an intercept model with no fixed effects and random intercepts for participant and junction number, and either a fixed model or a three-way interaction model adding anxiety, experience, and route type dependant on best data fit. To test driving behaviour only during the anxious route, two analyses (speeding and braking) were conducted with each analysis comparing two models: an intercept only model with no fixed effects and random intercepts for participant and junction/path number, and a three-way interaction model adding anxiety, experience, and driving situation type. After the models were created, Bonferroni corrected post-hoc comparisons were conducted, dependent on design, using estimated marginal means (Lenth et al., 2023) and adjusted for familywise error.

Results

Questionnaires

Anxiety groups were split using their self-reported driving anxiety. The questionnaires administered prior to the experiment showed that the anxious group oscillated below the midpoint on both the DCQ (M = 33.7; SD = 17.4) and the DRAS (M = 18.2; SD = 14.5). The scores for the DBS oscillated above the midpoint (M = 3.6; SD = 0.7). The non-anxious group scored low on both the DCQ (M = 14.7; SD = 8.05), and DRAS (M = 4.96; SD = 5.66). The scores for the DBS oscillated below the midpoint (M = 3.2; SD = 0.4). The scores for state anxiety were observed pre-experiment and post experiment. For the pre-experiment, the anxious (M = 44.0; SD = 6.01) and non-anxious (M = 44.3; SD = 4.74) groups scored within the mid-range of the state anxiety subscale. Post experiment, the anxious (M = 42.3; SD = 5.81) and non-anxious (M = 43.9; SD = 4.08) scored lower on state subscale.

To test for differences between the anxiety groups for their scores for each questionnaire, a series of t-tests were conducted. See Table 14 for means and standard deviations for the anxiety questionnaires across the anxiety groups.

For the DCQ, the 2-tailed Weltch's t-test was associated with a statistically significant effect $t(38.6) = 5.2$, $p < .001$. Cohen's d was estimated at 1.40 which suggested a large practical significance (Cohen, 1992). Therefore, the anxious sample demonstrated more self-reported negative driving cognitions than the non-anxious driving sample.

For the DBS, the 2-tailed Weltch's t-test was associated with a statistically significant effect $t(45.3) = 2.5$, $p < .05$. Cohen's d was estimated at 0.68 which suggested a moderate practical significance (Cohen, 1992). Therefore, the anxious sample demonstrated more self-reported negative anxious driving behaviours than the non-anxious driving sample.

For the DRAS, a 2-tailed Welch's *t*-test was associated with a statistically significant effect $t(35.6) = 4.5$, $p < .001$. Cohen's *d* was estimated at 1.20 which suggested a large practical significance (Cohen, 1992). Therefore, the anxious sample reported to avoid driving more than the non-anxious driving sample.

To compare the anxiety levels pre and post experiment, a pre and post comparison of state anxiety was conducted via a repeated measures ANOVA. There were no differences in state anxiety pre and post experiment between the anxiety groups ($F(1, 51) = 1.8$, $p = .186$, $\eta_p^2 = .034$). This suggests that the experimental design did not influence anxiety levels between the groups. See Table 14 below for means and standard deviations for the self-reported questionnaires for anxiety and experience groups.

Error based driving performance between anxious and non-anxious routes

This analysis included the following variables that were compared between the anxious and non-anxious routes: stalling, collisions and hesitation. Stalling is measured in a binary format e.g. no stall = 0 and stall = 1. Collisions are also measured in a binary format e.g. no collisions = 0 and collision = 1. Both stalls and collisions are analysed at junctions using a binomial multilevel logistic regression which is a statistical test for predicting the likelihood of an observation with two possible outcomes. In this case the outcomes are whether a driver stalls (or not) and whether a driver has a collision (or not).

For hesitation, a multilevel linear regression was used with hesitation at junctions being measured in seconds. In order of analysis, first stalling behaviour and collisions will be discussed as they share the same analysis type. Then, findings on hesitations at junctions will be discussed.

Table 14: *Means and standard deviations of the anxiety questionnaires with scores of driving experience groups nested inside anxiety groups for study four.*

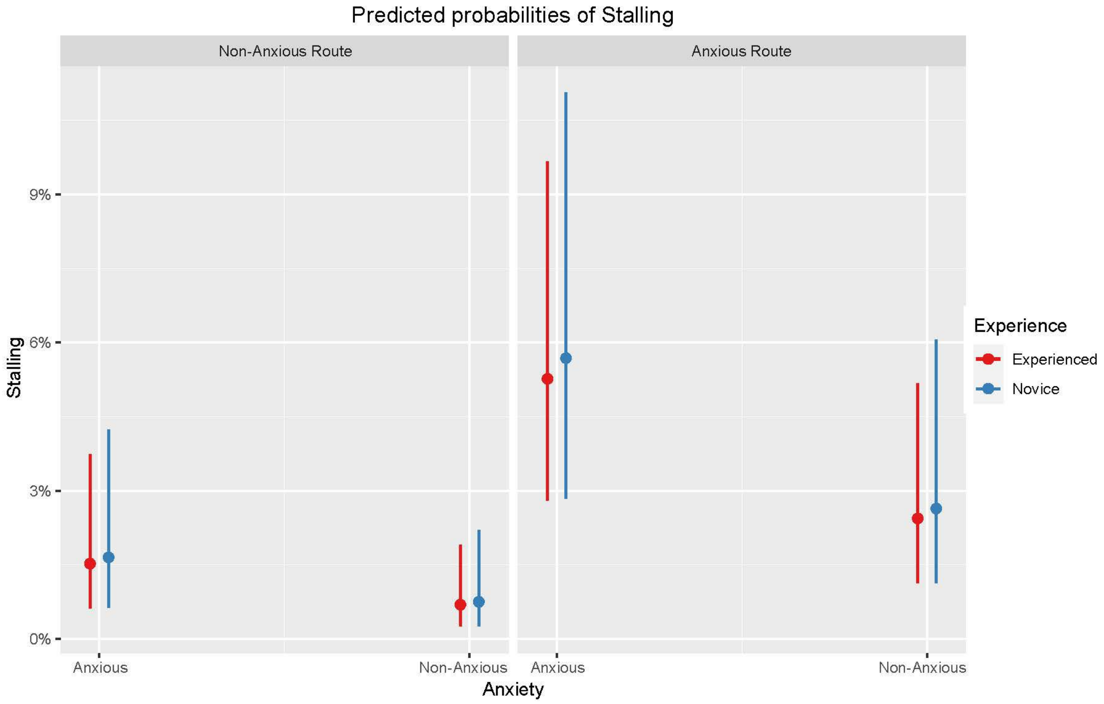
N = 54										
Descriptive variables										
Anxiety	**Anxious Drivers *n* = 28**				**Non-anxious Drivers *n* = 26**					
Experience	**Experienced *n* = 14**		**Novice *n* = 14**		**Experienced *n* = 13**		**Novice *n* = 13**			
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Me an	Standard Deviation	Score range	Cronbach's Alpha
DCQ Total	36.5	17.5	30.9	17.5	11.3	4.44	18.1	9.51	0 – 80	0.95
DBS Mean	3.79	0.84	3.39	0.56	3.17	0.45	3.18	0.46	1 – 7	0.79
DRAS Total	23.4	16.4	12.9	10.5	3.85	4.62	6.08	6.54	0 - 60	0.95
Pre-State Anxiety	43.1	7.15	44.9	4.74	45.0	4.88	43.7	4.70	20 - 80	0.55
Post-State Anxiety	41.5	5.76	43.1	5.97	44.2	3.80	43.6	4.48	20 - 80	0.47

Stalls

To test whether there were differences in the stall behaviour across the anxiety groups, experience group and route type, a 2x2x2 factorial analysis was performed. A binomial multilevel logistic regression was performed, with participants and junction number as random effects to account for the non-independence of observations from the junction or participant. Anxiety groups (anxious vs. non-anxious) and driving experience (experienced vs. novice) were fitted as between group factors. The within group factor was route type (anxious vs. non-anxious). The intercept only model estimated the *SD* of the participant random effect as 0.92 and the *SD* of the junction random effect as 0.76, indicating *acceptable* variability attributable to both junction number and participants. The deviance (likelihood ratio Chi Square G^2) for the intercept only model was 559.22, which decreased slightly to 554.53 for a model including main effects of anxiety and more substantially to 545.07 when the model accounted for the main effect of route type. The 3-way interaction model did not fit the data better than the main effects model G^2 (4) = 2.70, p = .60.

There was a main effect for anxiety (G^2 (1) = 4.69, p < .05). Pairwise comparisons with a Bonferroni correction revealed that the likelihood of stalling was significantly higher for anxious drivers (*M* = 2.96% 95% *CI* [1.61%, 5.38%]) compared to non-anxious drivers (*M* = 1.35% 95% *CI* [0.63%, 2.89%]) (*OR* = 2.22, *SE* = .85, z = -2.09, p < .05). There was a main effect for route type (G^2 (1) = 9.42, p < .001). Pairwise comparisons with a Bonferroni correction revealed that the likelihood of stalling was significantly higher for on the anxious route (*M* = 3.74% 95% *CI* [2.19%, 6.32%]) compared to non-anxious route (*M* = 1.07% 95% *CI* [0.46%, 2.48%]) (*OR* = .27, *SE* = .12, z = -3.07, p < .05). There was not a main effect for experience (G^2 (1) = 0.04, p = .83). There was no difference in stalling behaviour between experienced (1.93% 95% *CI* [1.01%, 3.64%]) and novice (2.09% 95% *CI* [1.01%, 4.27%]) drivers (*OR* = .92, *SE* = .34, z = -.22, p = .83). See Figure 32 for visualisation of the upper and lower confidence intervals for modelled predicted performance of stalls on the anxious and non-anxious route.

Figure 32: *Upper and lower Confidence Intervals for modelled predicted performance of stalls on the anxious and non-anxious route. Error bars represent Confidence Interval range.*



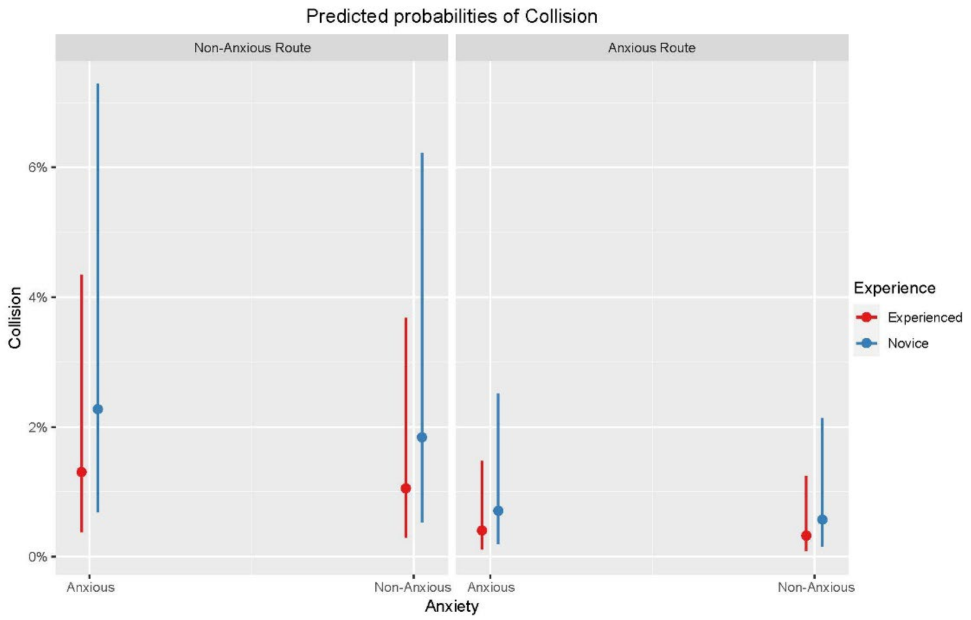
Collisions

To test whether there were differences in collisions across the different routes a 2x2x2 factorial design was analysed using a binomial multilevel logistic regression, with participants and junction number as random factors to account for the non-independence of observations from the junction or participant. The between group factors were anxiety groups (anxious vs. non-anxious) and driving experience (experienced vs. novice). The within groups factor was route type (anxious vs. non-anxious). The intercept only model estimated the SD of the participant random effect as 0 and the SD of the junction random effect as 1.27, indicating considerable variability attributable to junction number but not participants. The participant random effect of 0 was unusual. Upon checking the 1566 observations, there were only 21 cases of collision. This suggests that very few participants had a collision during the current study. The deviance (likelihood ratio Chi Square G^2) for the intercept only model was

215.05, which decreased slightly to 210.15 for a model including main effects of anxiety, experience, and route type.

It was revealed that neither the main effects model (G^2 (3) = 4.90, p = .18) nor the interaction model (χ^2 (4) = .76, p = .94) fitted the data better than a null model. There was no main effect of collision differences between anxious drivers (*M* = 0.96% 95% *CI* [0.36%, 2.56%]) and non-anxious drivers (*M* = 0.78% 95% *CI* [0.27%, 2.19%]) (*OR* = 1.24, *SE* = .56, *z* = -.48, *p* = .63). There was no main effect of collision differences between experienced (*M* = 0.65% 95% *CI* [0.23%, 1.81%]) and novice drivers (*M* = 1.14% 95% *CI* [0.42%, 3.07%]) (*OR* = 0.57, *SE* = .25, *z* = -1.27, *p* = .20). There was no main effect of collision differences between the anxious route (*M* = 0.48% 95% *CI* [0.15%, 1.2%]) and non-anxious route (*M* = 1.55% 95% *CI* [0.53%, 4.45%]) (*OR* = 3.26, *SE* = 2.15, *z* = -1.79, *p* = .07). See Figure 33 for visualisation upper and lower Confidence Intervals for modelled predicted performance of collisions on the anxious and non-anxious route.

Figure 33: *Upper and lower Confidence Intervals for modelled predicted performance of collisions on the anxious and non-anxious route. Error bars represent Confidence Interval range.*



Hesitation

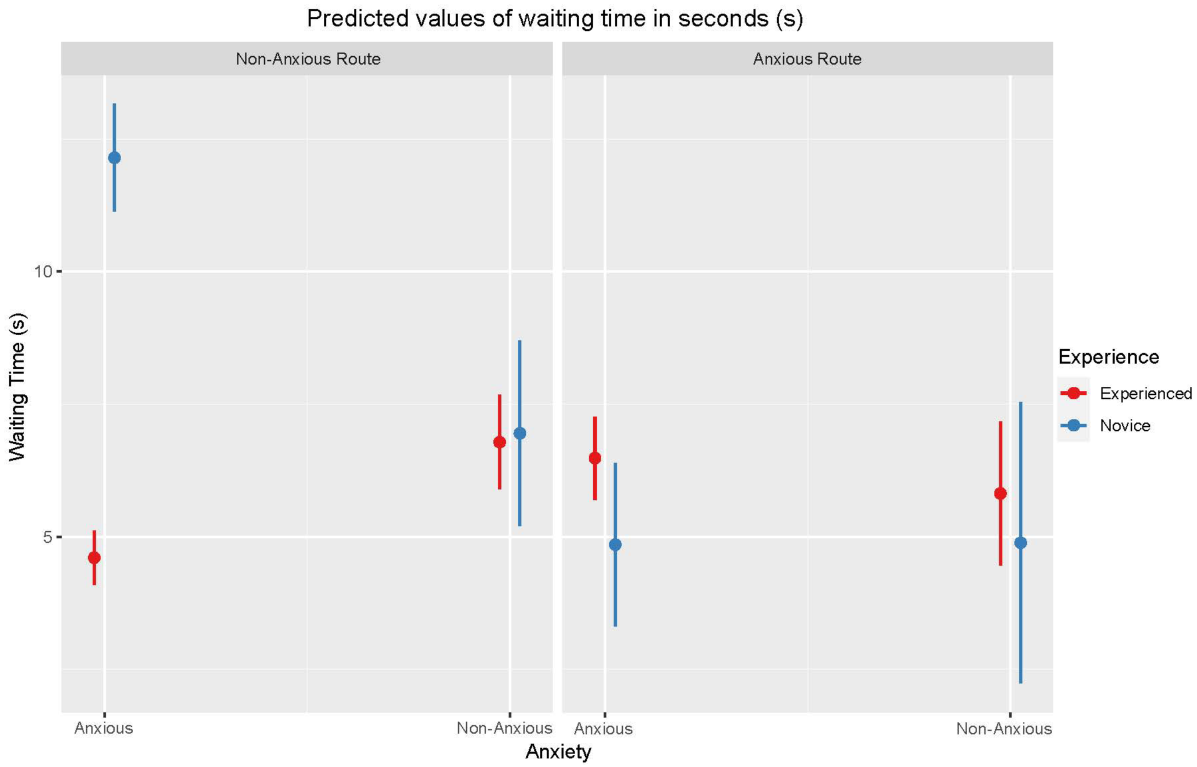
To test whether there were differences in the hesitation behaviour across the different routes a 2x2x2 factorial design was analysed using a multilevel logistic regression, with participants and junction number as random factors to account for the non-independence of observations from the junction or participant. The between group factors were anxiety groups (anxious vs. non-anxious) and driving experience (experienced vs. novice). The within groups factor was route type (anxious vs. non-anxious). The intercept only model estimated the *SD* of the participant random effect as 0.12 and the *SD* of the junction random effect as 4.46, indicating *considerable* variability attributable to junction number but not participants. The deviance (likelihood ratio Chi Square χ^2) for the intercept only model was 4371.04, which decreased slightly to 4370.41 for a model including main effects of anxiety, experience, and route. See Figure 34 for visualisation of predicted estimates of hesitations at junctions between anxious and experience groups across anxious and non-anxious routes.

Whilst the main effects model was non-significant (χ^2 (3) = .63, p = .89), the three-way interaction model was significant with a deviance of 4345.16 between all factors (χ^2 (4) = 25.25, p < .001). There was no evidence of a main effect based on driving anxiety (χ^2 (1) = .48, p = .48). The estimates of the mean scores found no difference in hesitation was found between anxious drivers (*M* = 7.02s, 95% *CI* [4.54s, 9.50s]) and non-anxious drivers (*M* = 6.11s, 95% *CI* [3.63s, 8.59s]). There was also no main effect based on experience (χ^2 (1) = .02, p = .88). The estimates of the mean scores no difference was in hesitation between experienced drivers (*M* = 5.92s, 95% *CI* [3.50s, 8.34s]) and novice drivers (*M* = 7.21s, 95% *CI* [4.66s, 9.76s]). There was also no evidence of a main effect based on route type (χ^2 (1) = .12, p = .72). The estimates of the mean scores found no difference in hesitation was found between the anxious route (*M* = 5.51s, 95% *CI* [3.02s, 8.00s]) and non-anxious route (*M* = 7.62s, 95% *CI* [3.62s, 11.60s]) (See Figure 34).

The three-way interaction was significant between anxiety (focal predictor), experience (moderator) and route design (higher order moderator) (χ^2 (4) = 25.25, $p < .001$). For the non-anxious route, the estimates of the mean scores found anxious novices (M = 12.14s, 95% CI [7.46s, 16.83s]) waited longer at junctions than anxious experienced drivers (M = 4.61s, 95% CI [.44s, 8.78s]) (E = 7.53, SE = 1.64, t = 4.59, $p < .001$). However, there was no difference in hesitation between non-anxious novice (M = 6.95s, 95% CI [2.39s, 11.51s]) and non-anxious experienced drivers (M = 6.78s, 95% CI [2.53s, 11.04s]) on the non-anxious route (E = .17, SE = 1.64, t = .10, p = .92). When comparing anxious experienced and non-anxious experienced drivers on the non-anxious route, there were no differences (E = 2.17, SE = 1.31, t = 1.67, p = .09). However, there was a difference between anxious novice and non-anxious novice drivers on the non-anxious route (E = 5.19, SE = 1.89, t = 2.75, $p < .001$). The anxious novices waited longer than the non-anxious novices (See Figure 34).

For the anxious route, there were no differences in hesitation between anxious novices (M = 4.85s, 95% CI [2.07s, 7.64s]) and anxious experienced groups (M = 6.48s, 95% CI [3.86s, 9.11s]) (E = 1.63, SE = .93, t = 1.76, p = .08). There were also no differences between non-anxious novices (M = 4.89s, 95% CI [2.12s, 7.66s]) and non-anxious experienced groups (M = 5.82s, 95% CI [3.19s, 8.41s]) (E = .93, SE = .90, t = 1.03, p = .31). When comparing anxious experienced and non-anxious experienced drivers on the anxious route, there were no differences (E = .66, SE = 0.77, t = .87, p = .38). When comparing anxious novice and non-anxious novice drivers on the anxious route, there were no differences (E = .04, SE = 1.04, t = .03, p = .97). Between the route types there was a difference between anxious novices drivers (E = 7.29, SE = 2.67, t = 2.73, $p < .001$). The anxious novice drivers waited longer on the non-anxious route (M = 12.14s, 95% CI [7.46s, 16.83s]) compared to the anxious route (M = 4.85s, 95% CI [2.07s, 7.64s]). Therefore, there were interaction effects between the anxious novice drivers and non-anxious novice drivers on the non-anxious route, and anxious novices between route types (See Figure 34).

Figure 34: *Predicted estimates of hesitation at junctions between anxious and experience groups based on the anxious and non-anxious route. Error bars represent standard error.*



Speeding and braking driving performance across different driving scenarios within the anxious route

The within route analysis involved speeding and braking as dependent variables across four different driving situations. The four situations were: gap judgement which involved a large vehicle coming in the opposite direction while the driver is on a narrow road, complex junctions based on traffic-light controlled junctions, tailgating where the driver is being followed closely by a red car and finally heavy traffic, where there is a build-up of AI vehicles on a series of intersections potentially influencing the driver's decision making. All situations used their respective path numbers (See Figure 25 and Figure 31). Within the anxious route, tailgating occurred once, gap judgment and heavy traffic occurred twice, and complex junctions occurred three times. For all analysis, main effects will be discussed before moving onto any interaction effects.

Speeding was analysed using a binomial multilevel logistic regression. Speeding was based on whether a participant broke the 30KPH speed limit. Speeding was measured using a binary format. If the participant's speed was higher than 30KPH then they would score a "1". If the participant's speed was less that 30KPH, they would score a "0". The binary scores were measured every 100ms. Hard Braking was analysed using a binomial multilevel logistic regression. Hard braking is measured when 0.5g of deceleration force is used. Hard braking was measured using a binary format (e.g. hard braking = 1, no hard braking = 0). The speeding model was discussed first followed by the hard braking model.

Speeding

To test whether there were differences in the speeding behaviour across the different driving situations a 2x2x4 factorial design was analysed using a multilevel linear regression, with participants and path number as random factors to account for the non-independence of observations from the junction or participant. The between group factors were anxiety groups (anxious vs. non-anxious) and driving experience (experienced vs. novice). The within groups factor was driving situation within the anxious route (complex junctions vs. gap judgement vs. heavy traffic vs. tailgating). The intercept only model estimated the SD of the participant random effect as 1.69 and the SD of the path number random effect as 3.22, indicating acceptable variability attributable to participants and path number. The deviance (likelihood ratio Chi Square G^2) for the intercept only model was 75048.33. The deviance decreased significantly to 75034.22 when the main factor of anxiety, experience and driving situation was added to the main model (G^2 (3) = 9.92, $p < .05$). When comparing the main model to a three-way interaction model (anxiety x experience x driving situation), the interaction model, with a deviance of 73905.88 further improved model fit (G^2 (10) =

1128.35, $p < .001$). This suggests that the three-way interaction model fit the data better than the main effects model. Main effects will be discussed in the next section followed by interaction effects. See Figure 35 for visualisation upper and lower Confidence Intervals for modelled predicted performance of speeding between anxious driving situations on the anxious route.

Main effects of speeding model

There was not a main effect for anxiety (G^2 (1) = 2.42, p = .12). There was no difference in speeding behaviour between anxious (*M* = 9.39% 95% *CI* [4.30%, 19.30%]) and non-anxious (*M* = 5.55% 95% *CI* [2.46%, 12.00%]) drivers (*OR* = 1.77, *SE* = .62, *z* = 1.63, p = .10). There was also no main effect for experience (G^2 (1) = 1.76, p = .18). There was no difference in speeding behaviour between experienced (*M* = 8.49% 95% *CI* [3.99%, 17.20%]) and novice (*M* = 6.16% 95% *CI* [2.66%, 13.60%]) drivers (*OR* = 1.41, *SE* = .50, *z* = -.99, p = .32). A main effect was observed for driving situation (G^2 (3) = 9.92, $p < .001$). Predicted probabilities for speeding revealed participants were more likely to speed in the gap judgement situation (*M* = 49.18% 95% *CI* [21.28%, 77.60%]), followed by tailgating (*M* = 5.20% 95% *CI* [0.93%, 2.44%]), and heavy traffic (*M* = 2.65% 95% *CI* [0.75%, 8.89%]), with scores lowest for complex junctions (*M* = 2.50% 95% *CI* [0.71%, 8.43%]) situation (See Figure 35).

Interaction effects of speeding model between anxious and experienced groups based on each driving situation

The three-way interaction was significant between anxiety (focal predictor), experience (moderator) and driving situations (higher order moderator) (G^2 (10) = 1128.35, $p < .001$). The sections below demonstrated each two-way interaction between anxiety and experience groups for each driving situation.

Gap judgment

For gap judgement, no interaction was observed between anxious experienced drivers (M = 52.72% 95% CI [22.34%, 81.21%]) and non-anxious experienced drivers (M = 59.45% 95% CI [27.14%, 85.22%]) (OR = .76, SE = .32, z = -.64, p = .52). There was an interaction between anxious novices and non-anxious novices (OR = 5.06, SE = 2.81, z = 2.91, p < .01). Anxious novice drivers (M = 62.23% 95% CI [27.90%, 87.52%]) were more likely to speed than non-anxious novice drivers (M = 24.58% 95% CI [7.08%, 58.19%]). There was no interaction between the anxious experienced drivers and anxious novice drivers (OR = .67, SE = .33, z = -.80, p = .42). However, there was an interaction between non-anxious experienced drivers and non-anxious novice drivers (OR = 4.50, SE = 2.36, z = 3.00, p < .01). Non-anxious experienced drivers were more likely to speed more than non-anxious novice drivers (See Figure 35).

Tailgating

For tailgating, no interaction was observed between anxious experienced drivers (M = 7.62% 95% CI [1.31%, 33.94%]) and non-anxious experienced drivers (M = 5.33% 95% CI [0.89%, 26.19%]) (OR = 1.47, SE = 0.63, z = 0.89, p = .37). No interaction was observed between anxious novice drivers (M = 3.87% 95% CI [0.60%, 21.24%]) and non-anxious novice drivers (M = 4.62% 95 % CI [0.72%, 24.52%]) (OR = .83, SE = .47, z = -.33, p = .74). No interaction was observed between anxious experienced drivers and anxious novice drivers (OR = 2.05, SE = 1.00, z = 1.50, p = .14). Finally, no interaction was observed between non-anxious experienced drivers and non-anxious novice drivers (OR = 1.16, SE = 0.59, z = 0.30, p = .76). Overall, there were no differences between anxiety and experience groups for the tailgating (See Figure 35).

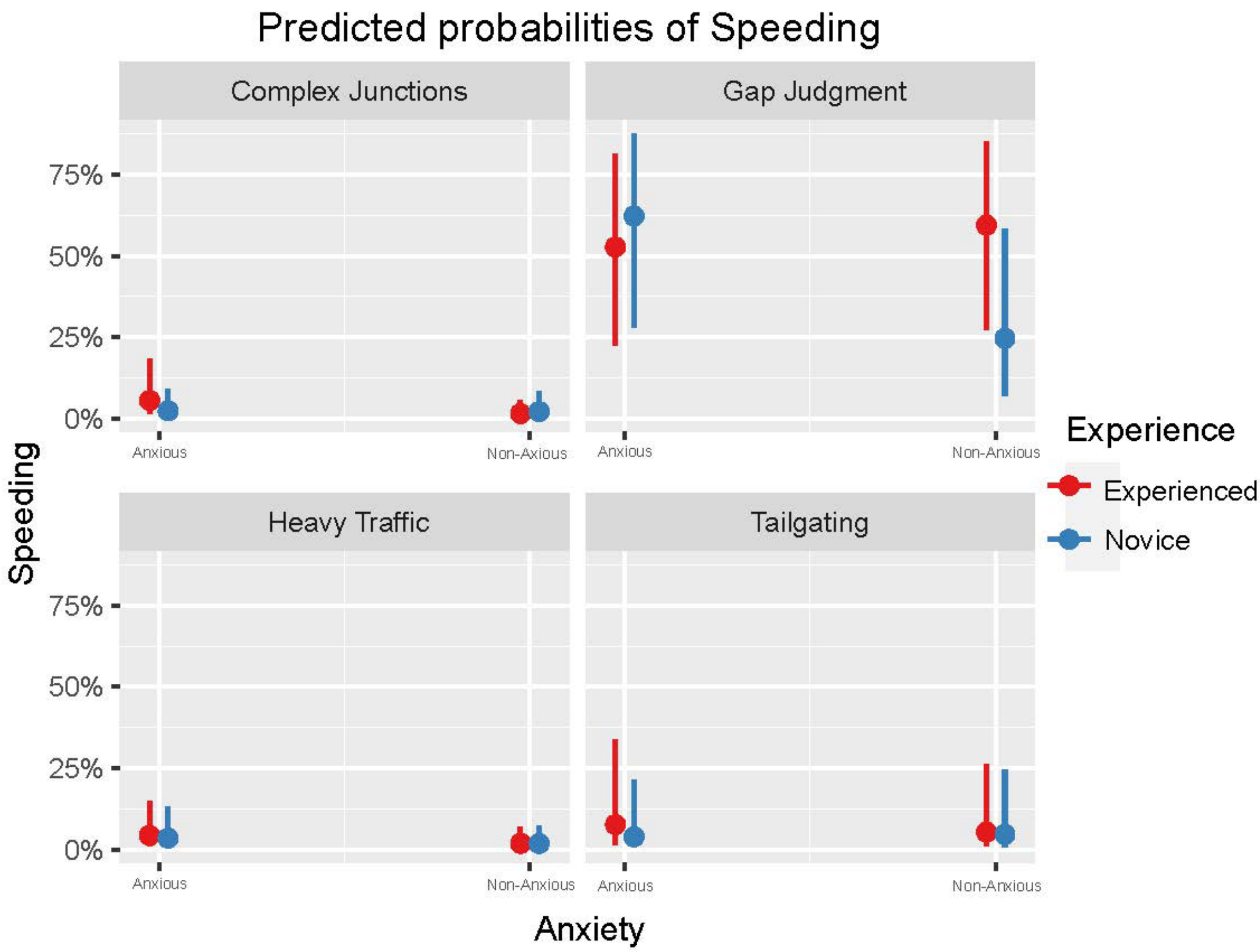
Heavy traffic

For heavy traffic, there was an interaction between anxious experienced drivers and non-anxious experienced drivers (*OR* = 2.41, *SE* = 1.03, z = 2.06, $p < .05$). Anxious experienced drivers (*M* = 4.29% 95% *CI* [1.11%, 14.86%]) were more likely to speed than the non-anxious experienced drivers (*M* = 3.43% 95% *CI* [0.5%, 6.8%]). No interaction was found between the anxious novice drivers (*M* = 3.43% 95% *CI* [0.83%, 13.19%]) and the non-anxious novice drivers (*M* = 1.81% 95% *CI* [0.43%, 7.34%]) (*OR* = 1.93, *SE* = 1.08, z = 1.17, p = .24). No interaction was observed between anxious experienced drivers and anxious novice drivers (*OR* = 1.26, *SE* = 0.62, z = 0.47, p = .63). Finally, no interaction was observed between anxious novice drivers and non-anxious novice drivers (*OR* = 1.01, *SE* = 0.51, z = 0.01, p = .99) (See Figure 35).

Complex junctions

For complex junctions, there was an interaction between anxious experienced drivers and non-anxious experienced drivers (*OR* = 3.90, *SE* = 1.67, z = 3.17, $p < .05$). Anxious experienced drivers (*M* = 5.50% 95% *CI* [1.49%, 18.43%]) were more likely to speed than the non-anxious experienced drivers (*M* = 1.47% 95% *CI* [0.38%, 5.57%]). No interaction was found between the anxious novice drivers (*M* = 2.30% 95% *CI* [0.55%, 9.14%]) and the non-anxious novice drivers (*M* = 2.08% 95% *CI* [0.49%, 8.33%]) (*OR* = 1.11, *SE* = 0.62, z = 0.19, p = .85). No interaction was observed between anxious experienced drivers and anxious novice drivers (*OR* = 2.47, S*E* = 1.21, z = 1.84, p = .06). No interaction was observed between anxious novice drivers and non-anxious novice drivers (*OR* = .70, *SE* = .36, z = -.70, p = .49) (See Figure 35).

Figure 35: *Upper and lower Confidence Intervals for modelled predicted performance of speeding above 30KPH between anxious driving situations on the anxious route. Error bars represent Confidence Interval range.*

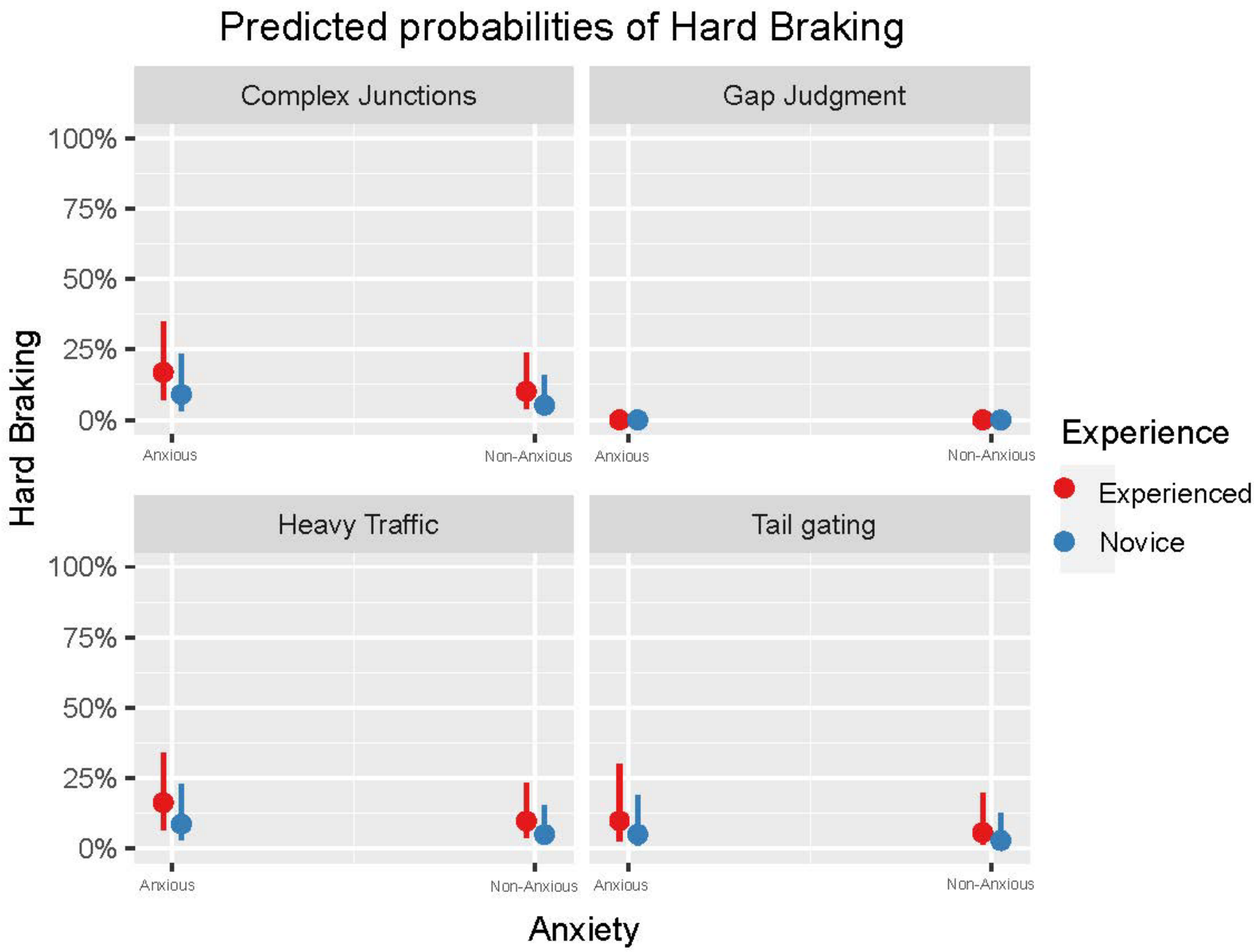


Hard braking

To test whether there were differences in braking behaviour across different anxious driving situations, a binomial multilevel logistic regression, with participants and path number as random factors to account for the non-independence of observations from the path or participant. The between group factors were anxious groups (anxious vs. non-anxious) and driving experience (experienced vs. novice). The within groups factor was driving situations (complex junctions vs. gap judgement vs. heavy traffic vs. tailgating) within the anxious route. The intercept only model estimated the *SD* of the participant random effect as 1.09 and the *SD* of the path random effect as 1.30, indicating acceptable variability attributable to junction number and participants. The deviance (likelihood ratio Chi Square G^2) for the intercept only model was 222.12, which decreased to 204.50 for a model including main effects of anxiety, experience and driving situation (G^2 (3) = 14.39, p < .01). When checking for interactions, the interaction model did not fit the data better than the main effects model (G^2 (10) = 6.61, p = .76). See Figure 36 for visualisation upper and lower Confidence Intervals for modelled predicted performance of hard braking between anxious driving situations on the anxious route.

There was not a main effect for anxiety (G^2 (1) = 1.28, p = .25). There was no difference in hard braking behaviour between anxious (M = 11.70%, SD = 32.30%) and non-anxious drivers (M = 7.69%, SD = 26.70%). There was also no main effect for experience (G^2 (1) = .06, p = .81). There was no difference in hard braking behaviour between experienced (M = 11.70%, SD = 32.30%) and novice drivers (M = 6.80%, SD = 25.30%). A main effect was observed for driving situation (G^2 (3) = 34.85, p < .001). On average, hard braking behaviour had the same likelihood between complex junctions (M = 14.80%, SD = 35.70%) and heavy traffic (M = 14.80%, SD = 35.70%), then lower for the tailgating situation (M = 9.26%, SD = 29.30%) and finally there was no hard braking found in the gap judgement section (M = 0.00%, SD = 0.00%). Therefore, participants were equally likely to demonstrate hard braking behaviour for both complex junctions and heavy traffic situations, less likely to heavily brake in tailgating section and not brake at all for the gap judgement section.

Figure 36: *Upper and lower Confidence Intervals for modelled predicted performance of hard braking between driving situations within the anxious route. Error bars represent Confidence Interval range.*



Discussion

The aim of the present study was to assess whether driving anxiety has an impact on driving performance across different levels of driving experience and anxiety groups. To do this, two pre-built driving routes were chosen (anxious vs. non-anxious route), one of which included four anxious driving situations. A series of driving behaviours were measured (stalling, collisions, hesitations at junctions, speeding and hard braking) and compared across the different routes and driving groups. It was hypothesised that anxious drivers would stall more than their non-anxious counterparts on the anxious route. It was also hypothesised that anxious drivers would wait longer at junctions compared to non-anxious drivers, again on the anxious route. It was predicted that driving anxiety would have no impact on collisions.

When looking at speeding and braking behaviour based on the anxious driving situations within the anxious route, it was hypothesised that anxious drivers were less likely to speed compared to non-anxious drivers. Finally, it was hypothesised that anxious drivers were less likely to perform hard braking manoeuvres.

Anxiety and route can lead to increased stalling behaviours

When looking at specific slip errors, it was found that anxious drivers were significantly more likely to stall than their non-anxious counterparts on both routes. There was more stalling behaviour on the anxious route compared to the non-anxious route. These results suggested that driving anxiety does have an impact on stalling behaviour and that the anxious situations included in the anxious route provoked more stalling behaviour. These findings support the initial hypothesis that anxious drivers make more errors during post-perceptual behavioural processes compared to pre-perceptual ones. In addition, the results in study two of this thesis also revealed that there was a positive relationship between driving anxiety and slip errors. Stalling is a type of slip error as this type of error is an action that deviates from what was intended (Norman, 1983; Reason et al., 1990). There are several reasons why anxiety may impact stalling behaviour. Many of these unintentional errors are due to panic behaviour which can influence motor control. Muscle tension has been reported by anxious individuals as a symptom of anxiety, being mostly described as “feeling of tightness, as if muscles are taut”, “stiffness of the muscles”, “being cramped”, and “unable to relax my body” (Sainsbury & Gibson, 1954; Zeidner, 2008). If anxiety can lead to such muscle tension, there is a potential that this could impair motor control (Martins et al., 2024). Previous research has demonstrated that anxiety can lead to inaccurate movement, leading to a repetition of attempts to ensure a task has been carried out correctly (e.g., Behan & Wilson, 2008; Causer et al., 2011; Nieuwenhuys et al., 2008; Nieuwenhuys & Oudejans, 2011, 2012; Vickers & Williams, 2007; Wilson et al., 2009). It could be argued that an inaccurate motor movement of depressing the clutch could fall into the same type of tasks, and this is what can lead to a stall. In fact, as clutch control relies on more sensitive movement, this could require finer motor controls. This would explain why stalling occurred on both the non-anxious and anxious routes, as the basis of the stalling behaviour comes from the individuals themselves. While anxious drivers may correctly perceive and be aware of the driving situation, an overestimation of its dangerousness, coupled with panic, can adversely impact their driving behaviour, leading to these types of errors.

Considering that stalling behaviour among anxious drivers was also exacerbated during the anxious route, this suggests that anxious situations can indeed trigger driving anxiety and significantly impact driver behaviour. For example, the anxious route included scenarios with heavy traffic, which often resulted in stop-and-go conditions. Such situations increase the likelihood of stalling, as drivers are required to frequently engage the clutch to move from a stationary position. Equally, tailgating situations can cause an additional pressure to anxious drivers, particularly when turning right at a traffic-controlled junction. The results demonstrated that the selected scenarios did trigger greater levels of driving anxiety compared to scenarios not previously identified by anxious drivers which was clearly noticeable in their driving behaviour.

The current study did not find significant differences in stalling behaviour based on experience levels. While the findings align with those from study two where driving experience did not moderate the relationship between driving anxiety and slip errors, it was surprising that novices did not stall more than the experienced drivers. Previous studies, such as the work conducted by Fairclough et al. (2006), have primarily focused on the association between stalling behaviour and novice drivers during formal driving assessments, where novices stall significantly more than the experienced drivers. Therefore, it was expected to find these differences at least in the non-anxious group. The findings regarding driving experience and performance are mixed (Divekar et al., 2012; Ventsislavova et al., 2019), indicating a need for further research to understand why novice drivers sometimes perform equally good as experienced drivers. Nonetheless, the findings suggest that regardless of their level of driving experience, anxious drivers are susceptible to stalling incidents, indicating that driving anxiety may transcend proficiency levels and impact drivers at different stages of skill development (Scott-Parker, 2015).

Opportunity to ruminate may lead to hesitation among inexperienced drivers

While stalling behaviour between anxious and non-anxious drivers was expected, an unexpected finding was that there was not a main effect of anxiety on hesitations, as hypothesised. The reason for this finding may be that hesitation is linked to information processing skills rather than anxiety (Bhatt et al., 2024; Li et al., 2024). Previous research has shown no significant difference in hazard perception abilities between anxious and non-anxious drivers (See Chapter Five). As anxious drivers demonstrated similar hazard perception skills to those of non-anxious drivers, it suggests that both groups are processing key information in a similar way. Lemonnier et al. (2014) found a connection between decision-making and eye movements during driving tasks. They argued that once a decision is made, eye movements are needed to confirm if the decision was correct. Since Chapter Five suggested that the eye movement rates of anxious and non-anxious drivers are similar, this may indicate that their decision-making processes are also similar, as both rely on eye movements to verify outcomes. This supports the idea that hesitation at junctions may not be caused by anxiety, but by how well drivers process the information necessary for making safe decisions. While there may be a link between decision making, hesitation and eye movements, to date, no other studies have exclusively investigated driving anxiety and hesitation behaviours on a road setting. Previous research has measured related emotions to driving anxiety, such as anger, but not driving anxiety itself (Lim et al., 2022). It is only recently that hesitation has been observed through video-based observations on high-speed roads (Li et al., 2024) and unsignalised junctions (Bhatt et al., 2024). Moreover, the studies which determined the types of drivers that demonstrate more hesitation behaviours were theoretical papers used to create models of car following (Tong et al., 2016) and traffic flow (Peng & Qing, 2016). These models have not been tested on a road setting. As such, it may be argued that the association between anxiety and hesitation behaviours requires further empirical investigation and refinement within the literature.

Although a main effect of anxiety was not found, there were differences in hesitations based on an interaction between anxiety and experience. Anxious novice drivers waited longer at junctions than non-anxious novice drivers, specifically on the non-anxious route. While this was not surprising due to prior literature suggesting that novice drivers would be more uncertain in their decisions on a junction (Upahita et al., 2018), it was surprising that hesitation only occurred on the non-anxious route. One explanation could be that route complexity may influence driving behaviour more than previously expected (Ringhand & Vollrath, 2019). The non-anxious route was intentionally chosen to minimise complexity, featuring elements such as run-off areas, reduced traffic density, and fewer junctions. This simplified environment aimed to mitigate anxiety-inducing stimuli for participants. However, one issue with having less stimuli in the immediate environment could be that drivers may start to engage in task-unrelated thoughts or mind wandering. Previous research has shown that mind wandering can affect driving performance, such as maintaining lane position (Özbozdağlı, 2021). Anxiety has also been linked to mind wandering (Fell et al., 2023), which may be more common in novice drivers, who are more likely to feel overwhelmed and distracted (McKnight & McKnight, 2003). As it was the non-anxious condition which had significantly longer hesitations, the types of mind wandering could be based on "what if" scenarios, which could consume additional time as they navigate through their internal experiences (Seli et al., 2019). This is also supported by study one, where some of those "what if" situations have been described by some of the participants (See Eleanor, p. 91). Conversely, the anxious route, situated within a city environment, was intentionally designed to be more challenging, with constant changes in driving conditions. In this complex setting, anxious drivers were compelled to concentrate on the immediate external environment, leaving less room for internal rumination (Bradley & Higenbottam, 2003; Taylor et al., 2016). This is particularly pertinent for novice drivers, as their limited driving experience necessitates heightened attention to the immediate surroundings to compensate for the lack of automated driving skills (De Craen et al., 2007). Therefore, the observed difference in hesitation behaviour between anxious and non-anxious novice drivers on the non-anxious route can be attributed to the extent of stimuli within the immediate environment imposed by route complexity. The simplified environment may have allowed anxious novice drivers to ruminate, consequently delaying their responses at junctions, whereas the highly stimulating anxious environment may have left little room for unrelated task distractions.

Anxiety alone does not lead to unsafe driving behaviours

Moving onto more serious errors, it was expected that anxious drivers would be less likely to speed in anxious situations when compared to non-anxious drivers. This hypothesis was not supported by the findings. The study revealed an interaction between anxiety and experience. For gap judgement situations, it was found that there were no significant differences in speeding between anxious experienced drivers and their counterparts. However, there was a significant difference in speeding between anxious novices and non-anxious novices. Anxious novices were more likely to speed compared to non-anxious novices. While there was no interaction between anxious experienced drivers and anxious novice drivers, there was an interaction between non-anxious experienced drivers and non-anxious novice drivers. Non-anxious experienced drivers were more likely to speed more than non-anxious novice drivers.

Although there were no significant differences between experience groups, experienced drivers in both the anxious and non-anxious groups would speed in the gap judgement situation over 50% of the time, whereas anxious novices would speed over 60% of the time. Overall, these results are surprising due to the historical understanding that anxious drivers tend to be linked to more cautious driving behaviour (Lucidi et al., 2019). However, the findings of this study may suggest this is not the case. One explanation as to why the anxious groups were speeding could be due to the loss of spatial awareness. The loss of spatial awareness has been found to increase risk taking behaviours such as speeding in anxious drivers, due to anxious drivers desiring to escape challenging situations as soon as possible (Traficante et al., 2024). The reason why there may be no differences between the anxious experienced and anxious novice groups could be that driving anxiety could be based on a cyclical response, where poor spatial skills lead to increased anxiety, which leads to increased avoidance of driving, and ultimately leads to minimised opportunities for improvement in spatial skills (Berman et al., 2010, Geer et al., 2024). Therefore, both experienced and novice drivers would have similar spatial skills due to the influence of their driving anxiety. In contrast, non-anxious experienced drivers may be more likely to speed in this situation due to their confidence in accurately judging the gap between their vehicle and the bus (Nilsson, 2000). These drivers may have assessed that the bus was not obstructing the road ahead, allowing them to maintain their speed through the scenario. This may also explain the difference between non-anxious experienced drivers and non-anxious novice drivers. Non-anxious novice drivers, lacking sufficient real-world experience, may have been less certain about whether the bus posed a potential danger. As a result, they were less likely to speed, opting instead to give themselves more time to assess the situation (Mitsopoulos-Rubens et al., 2009).

For the heavy traffic and complex junctions situations, the results were very similar. In both situations, the anxious experienced drivers were more likely to speed compared to the non-anxious experienced drivers. No other differences were found between anxiety and experience groups. The findings were unexpected, as it was hypothesised that non-anxious drivers would have a higher likelihood of speeding. Anxious drivers typically exhibit a more cautious driving style (Clapp et al., 2011) or at least similar levels of speeding as reported by other studies which have looked at anxiety on real on-road environments (Stephens et al., 2015). Traditionally, anxiety has been linked to slower driving speeds, which allows for an increase in attention and arousal that facilitates faster responses in hazardous situations (Schmidt-Daffy, 2013). However, recent research has challenged the notion of anxiety leading to a cautious driving style. Eboli et al. (2017), using structural equation modelling, argued that when drivers experience fatigue, sleepiness, illness, or boredom, they tend to adopt a more cautious driving style. Conversely, when drivers feel gloomy, worried, nervous, or angry, they are inclined toward a more aggressive driving style. This framework suggests that anxiety may not uniformly lead to a cautious driving style, as previously assumed. Instead, the manifestation of anxiety in driving behaviour may depend on other emotional states and situational factors. Therefore, experienced drivers who are anxious may exhibit a higher likelihood of speeding if their anxiety is accompanied by feelings of nervousness or agitation, which are associated with an aggressive driving style.

While anxious experienced drivers had a higher likelihood of speeding to their non-anxious counterparts, there were no difference between anxious novices and non-anxious novices for both the heavy traffic and complex junction situations. One explanation for this could be that novices have less experience, therefore are inherently less confident in their skills. Unlike the gap judgement situation, the heavy traffic and complex junction situations are slower sections in the anxious route as these situations are dictated by traffic lights and heavy traffic, both of which can force you to drive slower. Although all anxious drivers may want to get to the end of the anxious route as soon as possible due to the increased stress based on interactions with other vehicles (Hill & Boyle, 2007; Scott-Parker et al., 2018), only the anxious experienced drivers may have the capacity to use all available space to get to the end of the route faster, anxious novice drivers may be forced to let the road structure dictate their speed even if they want to get to the end of the drive sooner due to their lack of confidence in their skills.

While there was an interaction between anxious and non-anxious experienced drivers in both the heavy traffic and complex junction scenarios, no significant differences were observed between anxiety and experience groups in the tailgating scenario. A possible explanation for this could be that the red car only approached the driver closely once they reached the traffic signal. Prior to this, the red car followed the participant's vehicle at a relatively safe distance. As a result, the tailgating situation may not have induced significant stress until the later stage of the scenario. This could explain why the likelihood of speeding percentage was low for all anxiety and experience groups as all participants may not have felt the need to speed due to the lack of tension moving toward the traffic light and may only have attempted to speed at the end of the situation, when moving off from the traffic light to create space between the vehicles.

Although the likelihood of speeding was different between situations, the rate of speeding was not excessive. While it was hypothesised that anxious drivers would be less likely to brake heavily compared to non-anxious drivers, due to the lack of speed, it was not surprising that the current study also found no disparities in braking behaviour between the anxiety or experienced groups across all driving situations. This finding is consistent with the evidence indicating that anxiety is not linked to unpredictable braking behaviour. Stephens and Groeger (2009) found that individuals who reported more violations on the DBQ tended to brake less heavily throughout their drive in a driving simulator. Anxious drivers, primarily anxious experienced drivers, in the current study did commit speeding violations which aligns with Stephen and Groeger's (2009) findings. In the current study, although violations were made and a speeding ticket could be enforced in the UK, the speed was relatively low (between 32KPH to 34KPH). At this speed, hard braking would not have been required to stop the car effectively. This is supported by Stephens et al. (2015), using a real world on-road assessment, who found that braking behaviours did not differ based on anxiety. The explanation on why anxiety did not have an impact was based on the complexity of the environment. Stephens et al. (2015) suggested that when the driving environment is more demanding, anxious drivers displayed more unsure driving behaviour. Drivers more prone to anxiety were found to have less focus on specific elements of the situation (Stephens et al., 2015). Therefore, in the context of the current study, it could be suggested that the specific anxious driving situations may have less impact on driving anxiety exclusively, which would explain why there was no main effect of anxiety on both speeding and braking behaviours. This could also explain why an interaction with experience was necessary to observe differences in speeding. Thus, the findings underscore the importance of considering the context in which violations occur, highlighting the importance of interactions between anxiety, experience and driving situation on driving performance.

As hypothesised, no differences were observed in collision rates among the groups or across the different types of routes. This finding may appear unexpected considering the existing literature that links driving anxiety to a history of collisions (Taylor et al., 2000; Ehlers et al., 1998; Delahanty et al., 1997). For instance, Dula et al. (2010) reported significant differences in dangerous driving behaviours, such as at-fault crashes, aggressive driving, and violations of traffic signals, across drivers with varying levels of anxiety (low, medium, and high). However, it is important to note that the effect sizes for Dula's et al (2010) were relatively small ($\eta^2 = .07$). Instead, the current findings have been supported by more recent literature which has found that it is only the highly anxious drivers, potentially coupled with other factors, such as aggression which seem to lead to more risky driving behaviour (Haustein et al., 2022). Therefore, it is not surprising that the current study did not find significant differences in collision rates as other factors that were not controlled may have influenced the outcomes. In fact, research has also found that drivers with high anxiety can also be one of the safest drivers on the road due to being more careful and avoiding threatening situations, although age may also be an important factor to consider (Nordfjærn & Rundmo, 2013).

One reason why they may have been no differences in collisions could be based on two factors, route type and the speed behaviour of participants during the anxious route. In the non-anxious route, it was expected that there would be a limited number of collisions. The non-anxious route was not densely populated and it included run off areas. As a result, drivers may have had a low number of collisions on this route as there were no objects to collide with. Furthermore, while anxious drivers may commit more errors while driving this does not necessarily mean that they get involved in more collisions. Near-collisions which were not recorded in the current study could have occurred more often than actual collisions as a result of the errors anxious drivers commit while driving. As some of these unintentional errors could significantly impact the confidence and self-efficacy of drivers, this can lead to apprehension during the driving experience (Taubman-Ben-Ari, 2008). For example, being anxious about stalling a vehicle can lead to embarrassment in front of peers or instructors (Gross & Stone, 1964). Therefore, once a driver has stalled, there is a potential that they would be adjusting their driving behaviour to extra cautious for the duration of the route, leading to reduced chance of having a collision. Within the current study while stalling occurred on both routes, collisions were only observed 26 times out of 1566 observations which demonstrates that the number of collisions was extremely low (1.7%). This provides further evidence that unintentional errors may lead to more cautious driving behaviour, especially when being observed. This, of course, does not imply that all anxious drivers never get involved in collisions. As discussed, the likelihood of a collision depends heavily on the specific situations and scenarios. However, in this study, the base speed, even on the anxious route, was low (30 KPH/18 MPH), giving drivers ample time to respond and avoid collisions in most cases. As a result, factors such as the severity of anxiety (Haustein et al., 2022), and type of error need to be considered as they may contribute to variations in collision rates among drivers with varying levels of anxiety.

In summary, the collective results suggested that anxiety has a limited impact on driving performance and seems to require other factors, such as experience to have a significant impact. Therefore, the main contributing factor of the current study is that overall, anxiety may have a limited impact on post-perceptual decision making while driving.

The outcomes of this study suggest that interventions that target anxiety also need to consider experience type. While it would be expected that targeting driving anxiety would reduce the number of stalls, behaviours such as hesitation may be based more on inexperience than previously expected. Therefore, to reduce hesitation in the real-world environment, novice drivers need to develop confidence in their skills to make decisions effectively (McKnight & McKnight, 2003). For speeding errors anxious-experienced drivers were more likely to speed in the majority of anxious driving situations. While the likelihood of speeding is typically low, speeding still exists which can lead to unsafe driving environments. Therefore, tailored support for the most high-risk driving situations needs to be developed. This tailored support should be prioritised for anxious-experienced drivers.

Anxiety may lead the driver to want to get out of the situation quickly (e.g. Muir-Cochran et al., 2017). Anxiety coupled with experience may lead the driver to have overconfidence in their skills (Wohleber & Matthews, 2016). In particular, gap judgement situations, which had the highest likelihood of speeding need to be prioritised which suggests that anxiety is inflating their gap judgement skills. After gap judgement, heavy traffic conditions need to be addressed due to increased risk to a larger population. While this tailored support would be the most beneficial to anxious-experienced drivers, training should be available for all drivers to ensure increased road safety.

Limitations

The main limitation of the current study pertains to the number of situations that were included in the study. Ideally it would have been optimal to include all the anxious situations that have been identified within the literature and this thesis. More situations such as adverse weather conditions (e.g. rain) could have been added (Chakrabarty & Gupta, 2013; Khan et al., 2020; Roidl et al., 2014; Taylor & Koch, 1995). However, the processing power of the simulator system caused low framerates and stuttering when raindrops were added. This issue, alongside the physics of the program which caused the car to slide uncontrollably when the rain was preset made the driving environment less realistic.

Another limitation was time and complexity. The current study took 45 minutes to complete. It would have been difficult to include all other potential driving situations while keeping the experimental duration as convenient as possible for the participant. Furthermore, it would not have been realistic to add different situations one after another without it affecting the flow of the driving route itself. By adding an increased number of situations, this may have hindered the eco-logical validity of the simulator. Instead, further research can verify situations which were exempted from the current study.

Conclusion

In conclusion, this study shed light on the relationship between anxiety and driving performance, particularly regarding slip errors such as stalling. While anxiety has been shown to impact driving behaviour, this study unveils a more nuanced understanding of this relationship. Specifically, it revealed that an interaction between anxiety and driving experience is required for certain driving errors and violations to be produced. For instance, hesitation appeared to be more prevalent among anxious novice drivers, while anxious-experienced drivers seemed to have a higher likelihood of speeding overall. These novel findings underscore the need for future research to delve deeper into understanding the complex interplay between personal driving anxiety, driving experience, and situational factors based on driving anxiety.

In essence, this study contributed valuable insights into the multifaceted nature of anxiety's impact on driving behaviour. It has shown that some errors are based on the trait driving anxiety within the participant, whereas other errors and violations need combination of differing anxiety and experience levels. Finally, the current study has confirmed that certain anxious driving situations can lead to a difference in basic driving performance behaviours such as speeding. However, the current study has also highlighted that error and violations performed by anxious drivers are relatively low risk, and only seem to impact the anxious individual themselves rather that the overall driving environment. These findings allow future research to have a basis on developing interventions aimed at improving road safety as well as develop ways of limiting the impact of traffic flow based on such slip errors.

Chapter 7: General discussion

Chapter overview:

This thesis so far has outlined what driving anxiety is and its underpinnings using attentional control theory to explain how driving anxiety impacts driving performance. This chapter subsequently synthesises and discusses the findings of each one of the studies included in this thesis, highlighting how the research aims have been met, the implications of the research described in this thesis, in relation to the wider literature, policy, and practice, and what the next steps are for future research going forward.

Aims of this thesis

As noted in Chapter One, this thesis intended to explore the origins of driving anxiety and its impact on driving skills and behaviour. Thus, this thesis aims were as follows:

1. To overcome the limited research on the origins and impact of driving anxiety by offering an in-depth exploration of anxious drivers' lived experiences.
2. To determine what driving scenarios, give rise to driving anxiety and the specific triggers that maintain it.
3. To develop a predictive model to assess whether the identified dimensions of driving anxiety can predict intentional and unintentional driving errors.
4. To assess whether driving anxiety has an impact on perceptual and attentional processes related to the ability to perceive hazards while driving.
5. To assess whether driving anxiety has an impact on actual driving performance on a driving simulator and whether more stressful driving routes can induce more driving errors in comparison to less stressful ones.

Overview of results

Study one: What are the origins of driving anxiety and how is it maintained?

Study one sought clarity on the origins of driving anxiety following inconsistencies within the literature on whether driving anxiety could develop without prior driving experience (Taylor, 2018), or if it was caused by motor vehicle collisions (Taylor & Koch, 1995). Semi-structured interviews with 14 anxious drivers were conducted to explore the origins and impact of their driving anxiety (aim one) and which driving scenarios trigger driving anxiety (aim two). Insights generated from a thematic analysis suggested that the origins of driving anxiety seemed to be linked with generalised anxiety. Through general anxiousness, drivers were more susceptible to negative driving experiences which may have led to the development of driving anxiety. Participants tended to anticipate worst-case scenarios, such as a pedestrian suddenly stepping into the road, while disregarding the actual likelihood of such events occurring. As a result of these distortions, anxious drivers in the first study appeared to overestimate the level of danger they faced, leading to exaggerated perceptions of potential driving risks (e.g. Notebaert et al., 2016). This may explain why some ordinary driving situations could often be perceived as anxiety-provoking. For instance, if an anxious driver believes they are likely to be hit by another vehicle, situations involving heavy traffic can become anxiety-inducing due to the increased number of cars in their immediate surroundings (e.g. Paiva et al., 2019; Stephens et al., 2020).

This was the first instance in the thesis where a connection between driving anxiety and perception was established. Anxious drivers further reported that when they experienced anxiety on the road, they became more attentive to stimuli in their immediate environment (Love et al., 2022; Notebaert et al., 2020). This heightened attention can include both potential and actual threats. However, as a result of this hypervigilance, anxious drivers may struggle to differentiate between relevant and irrelevant information, potentially overlooking important cues, such as precursors to real hazards (e.g. Lowe et al., 2019; Walklin, 1993). Therefore, it is important to identify the specific situations that can maintain driving anxiety and impact attentional focus while driving.

Whilst exploring aim two, participants reported that the main stressor maintain driving anxiety was interactions with other drivers on the road. The reason why other drivers were identified as a stressor was due to their unpredictable driving behaviour. By being unpredictable, anxious drivers found it difficult to anticipate and predict the behaviour within their immediate environment. The inability to anticipate and control the actions of other drivers creates a heightened sense of vulnerability and uncertainty, which increased anxiety levels (Cocks et al., 2016). As other drivers seemed to maintain driving anxiety, situations relating to other drivers also maintained driving anxiety. This could be why situations such as close proximity to cars, heavy traffic, roundabouts and complex roads all were identified as anxious driving situations. Another maintainer of anxiety reported was the role of social judgement. Anxious drivers believe that they are less skilled drivers and therefore are less confident than their non-anxious counterparts (Traficante et al., 2024). The perception of being less skilled supported the anxious driving situations highlighted above, as these situations could have led to judgement from other drivers regarding the anxious driver's driving skills and behaviours (Stephens et al., 2024). However, participants reported being aware of situations that maintained their anxiety and shared techniques they engaged in that helped reduce their anxiety.

These techniques involved different types of avoidance techniques depending on the experience of the individual. Novice drivers would actively avoid situations which maintained their anxiety (See Narina, p. 94). Alternatively, experienced drivers would distract themselves with another task, e.g. listening to music to reduce the cognitive distortions related to the driving task (See Catherine p. 95). These results suggested mitigation techniques were dependent on the level of experience the drivers had.

It should be noted that while study one offers valuable insights into the lived experiences of individuals with both clinical and non-clinical driving anxiety, only 14 individuals were interviewed. As a result, the findings presented here should be interpreted as exploratory rather than exhaustive. The rich, in-depth accounts help to illuminate key themes and personal narratives that highlight how driving anxiety can affect everyday life and on-road performance. However, given the small and potentially non-representative sample, it is important to recognise that these experiences may not capture the full breadth or diversity of how driving anxiety manifests across different populations. Nevertheless, it should not be understated that while the sample size may be small, the insights provided by these 14 individuals surpassed the level of insight provided by a simple one-item questionnaire which has been used to infer driving anxiety previously (Hempel et al., 2017). Future research with larger and more varied samples is necessary to build on this foundation and deepen our understanding of the phenomenon.

Study two: Can dimensional predictive model assess whether driving anxiety can predict driving errors?

Study two sought to extend the findings of study one by developing a predictive model of driving anxiety (aim three), that could be measured among the wider population. The predictive model included the differing dimensions of driving anxiety identified by participants in study one and previous literature: generalised anxiety, cognitive distortions, anxious driving behaviours, and driving avoidance (Clapp et al., 2011; Ehlers et al., 2007; Stewart & St. Peter, 2004). Existing validated scales were utilised to measure these dimensions against intentional and unintentional driving error. Driving error was measured using the DBQ (Reason et al., 1009). Four types of driving error were captured by the DBQ: slips, mistake, unintended violations and deliberate violations.

Results from 249 participants indicated that driving anxiety was a significant predictor of driving errors, however, this effect was primarily driven by the specific dimensions of anxious driving behaviours. Within the anxious driving behaviour dimensions, both anxiety performance deficits and anxiety-based aggressive behaviour were significantly linked to driving error. The significance of anxiety-related driving performance suggests that drivers recognised how their anxiety can affect various aspects of their driving. When drivers hold this view, they tend to perceive themselves as making more driving errors overall. This supports the idea that anxiety can substantially influence drivers' self-perception, leading them to believe that their driving abilities are deficient, which may in turn contribute to an increased likelihood of errors on the road (Taylor et al., 2008).

Surprisingly, the anxious cognitions dimension was not associated with driving error in study two. The complex characteristic of anxiety, such as heightened physiological arousal, negative emotional state, catastrophising and panic-related cognitions (Bar-Haim et al., 2007) could explain this. For example, while it has been observed that catastrophising thoughts can affect attention and lead to prioritising perceived threats, this may not aways result in actual driving errors (Stefanopoulou et al., 2014). In fact, such cognitions could encourage hypervigilance, thus increasing the attention to the driving environment (Richards et al., 2014). Therefore, driving anxiety may have positive and negative associations with driving performance. As driving error is typically associated with negative outcomes of driving (Wickens et al., 2008), it does not capture potential positive aspects of driving. Therefore, future research needs to consider that driving anxiety may have a positive impact on driving.

Driving avoidance was also not associated with driving error in study two. An explanation for this finding could be due to anxious drivers avoiding anxious situations. By avoiding the anxious situations, the risk of error is limited as anxious drivers are no longer encountering situations that trigger their driving anxiety (Molnar et al., 2013; Stephens et al., 2010). If anxious drivers did repeatedly face anxiety-provoking situations, their anxiety might escalate, leading to a greater risk of errors due to the mental strain and divided attention caused by their anxiety. However, avoidance has also been found to reinforce driving anxiety due to the underlying situations that trigger the anxiety not being addressed (Newman & Llera, 2011). Additionally, whilst avoidance might limit driving errors in the short term, it might also prevent drivers from gaining the necessary experience and confidence to handle these situations effectively in the future when avoidance is not a possibility (Gugerty, 1997; Stephens et al., 2010). Therefore, driving avoidance could be considered as a mediator between driving anxiety and driver error since it was not directly related to errors.

Alongside the aim of predicting driving anxiety and driving error, study two also expanded on study one by identifying clusters of driving situations that can potentially trigger driving anxiety. As with study one, “Complex roads” emerged as the primary source of anxiety among participants, followed by “other road users”. Other road types, such as roundabouts, high speed roads and unfamiliar roads were also identified. Roundabouts are complex road junctions that require drivers to navigate multiple lanes and interact with other drivers continuously. Similarly, high-speed roads, such as dual carriageways and motorways, have fast-moving traffic surrounding the driver as well as other drivers merging from slip roads. Both road types have been linked to anxiety in previous research (Ratering et al., 2024). The risk of these situations eliciting anxiety-related performance deficits, highlights the necessity of exploring how these scenarios link to and influence anxiety-related processes.

Study three: Does driving anxiety impact on perceptual and attentional processes related to the ability to perceive hazards while driving?

As study two covered the concept of driving anxiety and driving error, study three aimed to assess whether driving anxiety had an impact on perceptual and attentional processes related to the ability to perceive hazards while driving (aim four). The necessity for this investigation arose from findings in study one, which established a link between anxiety and perception. However, it remained unclear whether driving anxiety enhances perception through hypervigilance, or whether it impairs perception by diverting attention to irrelevant information as a result of anxious driving cognitions. Another area of interest was to confirm whether the anxious driving situations that were identified in study one and two could trigger anxiety and impact certain perceptual processes. To address these gaps, driving anxiety and anxious driving situations were measured to determine the impact they have on the ability to perceive hazards. The study featured hazard perception video clips which were included in three different experimental conditions. The first condition contained hazardous stations that would typically trigger driving anxiety. The second condition included very similar scenarios as the first one but without any hazardous situations. The third one included control video clips that did not include stressful scenarios or hazards. Experience was controlled as experienced drivers have historically performed better on hazard perception tests than novice drivers (Crundall, 2016; Wetton et al., 2011). To measure whether anxiety was elicited based on the environment, self-report anxiety and objective anxiety measures in the form of SCRs were used.

In total, 65 participants took part in all three conditions. The findings revealed that there was no difference between anxious and non-anxious drivers in hazard perception or hazard response times. This suggested that for a fundamental skill such as hazard perception, anxious drivers performed equally well as non-anxious drivers. The unexpected nature of this finding initially raised questions about the statistical power of the study. However, the sample size was determined through a priori power analysis and was sufficient to detect a medium effect size, suggesting that statistical power was unlikely to be the primary issue. An alternative explanation may lie in the unique context in which the study was conducted, which was during the COVID-19 pandemic. It is plausible that heightened general anxiety related to the health crisis affected both anxious and non-anxious participants, potentially narrowing the expected differences between groups. This elevated baseline anxiety may have masked group effects typically observed in non-pandemic conditions. While the study offers a potentially novel contribution to the driving anxiety literature, the findings must be interpreted with caution, considering the broader situational context in which the data were collected. Anxious and non-anxious drivers may have similar hazard perception abilities because anxiety, despite its impact on behaviour, does not necessarily impair the cognitive skills involved in detecting hazards. Hazard perception primarily involves attentional processes, such as scanning the environment, identifying potential threats, and reacting to them in a timely manner (Cao et al., 2022). Both anxious and non-anxious drivers may be equally capable of recognising hazards because these tasks may rely more on basic perceptual and cognitive skills. These basic perceptual and cognitive skills would have been developed while they were learning to drive leading to a higher retention of hazard perception skills (Prabhakharan et al., 2024). Therefore, these core driving skills may remain intact even in individuals with anxiety. This would also explain why there were also no differences in fixation time to the hazardous target between experienced and novice drivers. Therefore, when combining the results of study two and three, it seems that anxiety has a greater impact on anxious drivers' subjective self-perception of driving error rather than their objective skills. As hazard perception tests are taught to all drivers when learning to drive in the UK, perhaps a more sensitive test to measure hazards would be able to differentiate between anxious and non-anxious drivers. For example, hazard prediction has been found to be more sensitive in differentiating between experienced and novice driving groups, while hazard perception did not (Ventsislavova et al., 2019). As no differences were found between experienced and novices in the current study, then it is conceivable that hazard prediction could find differences in these driving groups, as well as anxiety due to hazard prediction being a more robust discriminator of these hazard-based skills (Lim et al., 2014; Castro et al., 2014; Crundall, 2016). Other skills and behaviours between anxious and non-anxious drivers should be measured in future research, as investigated further in study four.

Regarding the conditions themselves, it was confirmed that the hazardous and non-hazardous conditions were more anxiety inducing for anxious drivers, but this was only found for the self-report anxiety measure. This further supports the argument that self-perception is a key factor of anxiety (e.g. Zou & Abbott, 2012). Although SCRs associations with anxiety have been mixed (Marin et al., 2017; Watts et al., 1975), SCRs were originally expected to measure objective driving anxiety (Najström & Jansson, 2007). However, SCRs did not align with the with the self-report measure of anxiety between conditions. There was a main effect of condition, with the hazardous condition showing significantly more SCRs compared to the non-hazardous and control route among all driver types. An explanation for this could be that SCRs may not be linked to anxiety, instead they could be linked to general threat response (Rosebrock et al., 2016; Tomaka et al., 1993; Palomba et al., 2000). Within study three, the hazards in the hazardous condition were designed to be the significant threatening stimuli. As the hazard was threat, then SCRs based on the hazard is plausible to the psychological response of facing a hazard (Barnard & Chapman, 2016).

There was also more visual search in both the anxiety-based conditions compared to the control condition suggesting that the anxious situations have more visual clutter to attend to. However, the difference of the visual search between the anxious situations and the control situation was found for all drivers, not exclusively for the anxious group. This indicated that all participants recognised the anxiety-based conditions as more demanding and requiring increased attention. This behaviour seems to be driven by a general inclination to scan for hazards based on the environment itself, rather than being solely influenced by their current anxiety levels (e.g., Muela et al., 2021). These findings, coupled with the observed differences in behavioural responses, suggested that the video clips possess the qualities to distinguish drivers based on their ability to identify stressful/demanding road scenarios and pre-defined hazards. Since no formulated predictions were made regarding the spread of search, one possible explanation for the lack of differences between the anxiety groups could be that anxious drivers are just as vigilant as non-anxious drivers, and the source of threat does not alter their eye movement behaviours compared to non-anxious drivers.

Study four: Does driving anxiety have an impact on driving performance during specific anxious driving scenarios?

Following study threes insights into how anxiety impacts perceptual processes relating to hazard identification, study four aimed to evaluate whether driving anxiety impacted actual driving performance based (aim five). Prior literature outlines how anxiety can lead to inappropriate responses (Birenbaum et al., 1986; Hinds & Sanchez, 2022) therefore, anxious drivers seem to be able to allocate their attention to the relevant stimuli but may struggle to elicit an appropriate response to anxious scenarios (Bowen et al., 2020). This is where possible driving errors could occur. To investigate this, two pre-designed routes were selected and incorporated into a driving simulator, where participants were instructed to drive . The non-anxious route was a generic drive through a rural setting with limited traffic and junctions. The anxious route contained four anxious situations (complex junctions, gap judgement, heavy traffic and tailgating) described as such in previous literature (Scott-Parker et al., 2018; Taylor et al., 2018) and participants in study one and two. Driving performance was captured between the anxious and non-anxious route (stalls, hesitations, and collisions) and within the anxious route (speeding and hard braking).

With a sample of 54 participants, the anxious drivers were significantly more likely to stall than their non-anxious counterparts on both routes. This suggested that anxious individual's trait driving anxiety can increase the likelihood of stalling behaviour. Anxiety may be impacting the physical control of the car to incite stalling behaviour possibly due to anxiety's influence on motor control (e.g. Mullen & Hardy, 2000; Noteboom et al., 2001).

When observing the lower limbs primarily, Carpenter et al. (2004) highlighted that an increase in anxiety could lead to a deficit in balance. As clutch control requires fine motor control to both find and release from the biting point precisely, this type of action could also be impacted by anxiety (Vivas et al., 2021). Route type also increased the likelihood of stalls, with anxious drivers more likely to stall than non-anxious drivers on the anxious route. The anxious route utilised anxious driving situations outlined in study's one, two and three. Since anxious drivers did stall more during the anxious route, study four highlights that the identified anxious driving situations throughout this thesis may be anxiety triggering (Scott-Parker et al., 2018; Taylor et al., 2018). Once anxiety was induced, the anxious driver may have begun to panic due to the inability to perform their anxiety mitigation techniques (e.g. Borden et al., 1988). From the findings of study one, outside of simulator conditions, anxious novice drivers may have tried to avoid the anxious situation, and anxious experienced drivers may have tried to distract themselves. Both maladaptive solutions were not available during the simulated drive. However, as the results for stalls only compare between the two routes and not the anxious situations themselves, for this variable, future research could investigate the impact of specific anxious driving situations in relation to stalling behaviour.

No main effect of anxiety was found on hesitation; however, an interaction between anxiety and novice drivers indicated that the combination of these factors could lead to hesitation. While this interaction was observed, differences were primarily found among novice drivers. Specifically, anxious novice drivers waited significantly longer than non-anxious novice drivers on the non-anxious route, and generally waited longer when compared to the anxious route.

Novice drivers are still developing essential skills such as multitasking between vehicle control and environmental scanning (Chen et al., 2021; Robbins & Chapman, 2019), and previous research has shown that these tasks can be negatively impacted by driving anxiety. Gotardi et al. (2019) found that when anxiety is induced, novice drivers tend to relinquish some vehicle control as they focus more on perceived threats, such as nearby cars. The combination of limited skill development and anxiety-induced panic may cause anxious novice drivers to hesitate longer during driving tasks.

Although hesitation may not directly harm the individual driver, it can negatively affect the surrounding driving environment. For instance, prolonged waiting can trigger non-compliant or risky behaviours from other motorists. Shinar (1998) found that in situations where drivers are familiar with long traffic light cycles, they are more likely to exhibit aggressive driving to take advantage of a brief opportunity to proceed through a junction. If an anxious novice driver is holding up traffic, it could provoke aggressive behaviour from other drivers, potentially exacerbating the anxiety of the novice driver and further increasing hesitations (Hidalgo-Muñoz et al., 2021).

However, it should be noted that extreme risky behaviour from other drivers is relatively rare. Larue et al. (2019) found that it typically requires excessive hesitation of around three minutes to provoke life-threatening behaviour, such as attempting to cross a railway level crossing. In the case of anxious novice drivers, the hesitations observed were measured in seconds rather than minutes, making it unlikely that they would prompt such extreme actions. Nevertheless, the findings of this study underscore that the combination of anxiety and inexperience can lead to hesitations, which may have a negative impact on the immediate driving environment.

When discussing more serious errors based on different anxious driving situations, there was no main effect of anxiety on speeding behaviour, but an interaction between anxiety and experience was observed. In the gap judgment situation, experienced drivers - both anxious and non-anxious - sped over 50% of the time, while anxious novices exceeded this, speeding over 60% of the time. This contrasts with the common view that anxious drivers tend to be more cautious (Lucidi et al., 2019). One possible explanation is that anxious drivers may experience a loss of spatial awareness, prompting them to speed in an effort to escape challenging situations (Traficante et al., 2024). In contrast, non-anxious experienced drivers may speed due to confidence in their ability to accurately judge gaps and assess the road ahead (Nilsson, 2000).

In both heavy traffic and complex junction situations, anxious experienced drivers were more likely to speed than their non-anxious counterparts, which was unexpected. It was initially hypothesised that non-anxious drivers would be more prone to speeding, as anxious drivers are traditionally associated with a more cautious driving style (Clapp et al., 2011). Anxiety has been linked to slower speeds, allowing drivers to increase attention and react faster to hazards (Schmidt-Daffy, 2013). However, recent research challenges this view. Eboli et al. (2017) found that emotions such as nervousness or agitation, often linked with anxiety, can lead to more aggressive driving behaviours rather than caution. This suggests that the anxious drivers' speeding may result from anxiety-driven agitation rather than caution, especially among experienced drivers.

Finally, there were no significant differences found between anxiety and experience groups in the tailgating scenario. A possible explanation is that the red car only followed closely near the traffic signal, maintaining a relatively safe distance beforehand. As a result, anxiety may not have been induced until the later stage of the scenario, explaining the low likelihood of speeding across all groups. Participants may not have felt the need to speed until the end, when creating space after the traffic light. This explanation is supported by the fact that within the past three decades, more people are driving, leading to more traffic and increased congestion (Stephens et al., 2023). For example, vehicle ownership has increased worldwide, there has been a 10% increase in the average number of cars per household from 2003 to 2019 in the UK and a similar stable increase in car ownership in Australia (Dargay et al., 2007). Therefore, it could be that contemporary drivers are used to tailgating behaviours and therefore are not pressured into speeding when interacting with a tailgater.

Study four also found no significant differences in braking behaviour between anxiety or experience groups across all driving situations, aligning with research indicating that anxiety does not necessarily lead to unpredictable braking. Stephens and Groeger (2009) observed that drivers who reported more violations on the DBQ tended to brake less heavily. In the current study, although anxious drivers committed speeding violations, the speeds were relatively low (32–34 KPH), minimising the need for hard braking. This is consistent with findings by Stephens et al. (2015), who, in a real-world on-road assessment, found that anxiety did not significantly impact braking behaviour. They suggested that in more complex driving environments, anxious drivers may display uncertain driving behaviours, focusing less on specific elements of the situation. In less demanding contexts, such as those in study four, anxiety may have less of an effect on driving performance, explaining the lack of differences in both speeding and braking behaviours.

Finally, study four found that there were no differences in collisions between anxious and non-anxious groups on either route. There are two factors on why there were no differences in collisions. The first is route type and the second is lack of excessive speeding behaviour. For route type, the design of the non-anxious route ensured that there were run off areas limited traffic and no anxiety-inducing situations. Therefore, collisions may have been limited because there were less stimuli to collide with. Furthermore, the two types of errors found on the non-anxious route, which were stalling and hesitation both require the driver to be stationary. For the anxious route, although there were more stimuli alongside anxious situations, speed limit of the route was low. Therefore, it could be argued that all drivers had enough time to avoid hazards, which reduced the chances of a collision.

While these findings add to the current driving anxiety literature the ecological validity of using a driving simulator should be considered. While the simulated environment may mimic the visual and procedural elements of driving, it may not fully replicate the physical sensations, real-world consequences, and complex environmental cues involved in on-road driving (Mueller, 2015). This gap may influence how participants respond, especially in terms of anxiety and behaviour. For example, individuals may experience lower levels of perceived risk in a simulator, potentially underestimating the true impact of anxiety on their decision-making or reaction times.

Therefore, while the simulator offered a practical and ethical means to explore the effects of driving anxiety on performance (e.g. Fischer et al., 2020), these findings should be interpreted with an awareness of the limitations inherent in simulated driving environments. Future research may benefit from triangulating simulator-based findings with on-road assessments or naturalistic driving studies to build a more comprehensive understanding of anxious driving behaviour in real-world settings.

Areas where the thesis was successful

Collectively, the research documented within this thesis provided a more holistic understanding of and approach to driving anxiety which strengthens existing literature. Previously, driving anxiety literature had assessed driving anxiety in relation to generic state-trait measures without adopting a holistic approach to it (Pourabdian & Azmoon, 2013; Shahar, 2009; Wong et al., 2015). By limiting driving anxiety to state-trait, then outcomes can only be based on personality and/or the environment, without considering how driving anxiety can impact different conditions or behaviours. While some studies have attempted to measure select dimensions of driving anxiety, most of these studies have focused on clinical samples, particularly those with driving phobia (Ehlers et al., 1994). As a result, it remains unclear whether the existing dimensions of driving anxiety are sensitive enough to capture non-clinical forms of anxiety.

The exploration of lived experiences of drivers with anxiety supported the holistic approach by generating insight into new dimensions of driving anxiety, such as driving anxiety's link with general anxiety. By understanding the complex thoughts and behaviours of anxious drivers in general, this approach allowed each dimension of anxiety to be explored from the perspective of those living with driving anxiety.

Given the absence of a single, all-encompassing instrument to assess the multifaceted nature of driving anxiety, study two and all subsequent studies employed a combination of established questionnaires to capture various dimensions of driving anxiety. Specifically, the Driving Cognitions Questionnaire (DCQ) was used to assess maladaptive thought patterns, the Driving Behaviour Survey (DBS) captured safety and performance-related behaviours, the Driving and Riding Avoidance Scale (DRAS) assessed the extent and context of avoidance, and the State-Trait Anxiety Inventory (STAI) provided a general measure of anxiety disposition and current state.

While this approach allowed for a more holistic understanding of driving anxiety by addressing cognitive, behavioural, and affective components, it also introduces complexity when interpreting results across different measures with varying psychometric properties and theoretical underpinnings. Moreover, the use of multiple instruments increases the burden on participants and may introduce redundancies or gaps in the data. Nonetheless, this strategy was necessary to build a comprehensive picture in the absence of a unified tool. The findings therefore reflect a multi-dimensional view of driving anxiety but also highlight the need for the development or refinement of a validated, integrated measure that can capture the full spectrum of this experience within a single framework.

Nevertheless, this process enabled the development of a predictive model specific to non-clinical driving anxiety. It is important to note that the thesis does not claim these identified dimensions as the only means of measuring driving anxiety. However, the proposed predictive model contributes to the literature by supporting the use of existing dimensions while offering a framework to assess whether certain driving behaviours can be attributed to specific aspects of anxiety.

This thesis further contributed to the existing literature by confirming specific anxious driving situations and their ability to elicit driving anxiety (Scott-Parker et al., 2018; Taylor et al., 2018). Initially identified in study one and expanded in study two, these situations were tested to determine whether they could provoke anxiety in drivers. The results indicated that anxious drivers perceived these situations as anxiety-inducing, demonstrating that driving anxiety can be triggered by various scenarios beyond motor vehicle collisions (MVCs). Study three expanded these findings further by confirming that these anxious driving situations elicited anxiety, and in study four, the anxious driving situations were found to impair driving performance. Thus, this research challenges the traditional focus on MVCs as the primary source of driving anxiety (Rapoport et al., 2023; Taylor, 2008; Taylor, 2011). Collectively, these findings suggest that anxious drivers are able to identify specific situations that provoke their anxiety. However, similar to driving anxiety itself, the impact of these situations on driving performance appeared to be limited, affecting only certain aspects of driving behaviour under specific conditions. This nuanced understanding extends the literature by offering a broader perspective on how driving anxiety manifests in non-MVC situations and its selective influence on driving performance.

Lastly, a significant contribution of this thesis is its ability to examine attentional, perceptual, and behavioural processes in relation to driving performance. Previous research has predominantly relied on self-report and survey-based methods to assess the impact of driving anxiety on driving behaviour (Dula et al., 2010; Hempal et al., 2017; Shahar, 2009). In contrast, this thesis employed a mixed-method approach, combining qualitative and quantitative methodologies, which enabled a more comprehensive exploration of unanswered questions. This approach provided valuable insights into how anxious drivers' perceptions of their driving ability may differ from their actual driving performance.

The use of eye-tracking and driving simulator methodologies was critical to this investigation, offering experimental data that would not have been possible through self-report alone. While this thesis does not disregard the emotional distress the anxious drivers may feel, ultimately the difference between perception and experimental data can give the anxious driving community hope that driving anxiety is not as potentially debilitating as previously expected (Mullen et al., 2012; Taylor et al., 2002).

Reflections of the methods within the thesis

Sample

Driving anxiety, is best understood as dimensional rather than categorical (Zinzow & Jeffers, 2018). This thesis intentionally included participants across a spectrum of anxiety experiences rather than focusing solely on those with extreme symptoms. This approach allowed for a more nuanced exploration of driving anxiety and helped to capture the diverse ways in which anxiety manifests in everyday driving contexts.

By including individuals with elevated, yet subclinical, levels of self-perceived driving anxiety, particularly evident in study 3, the thesis was able to reflect the experiences of a broader, more ecologically valid population (Taylor, 2018). This is critical, as many anxious drivers within the general population may not meet formal diagnostic thresholds but still experience anxiety that meaningfully affects their driving confidence and behaviour (Taylor, 2018). Indeed, this was supported by findings in study 4, where self-perceived anxiety appeared to have a measurable impact on driving performance indicators such as hesitation and stalling behaviour. In study two, it was observed that participants identified as anxious drivers scored relatively low on both the GAD scale and DRAS. This finding further highlights the importance of distinguishing between generalised anxiety and context-specific anxiety. The low GAD scores suggest that these individuals were not broadly anxious in their daily lives; rather, their anxiety was specifically elicited by the act of driving (e.g. Dula et al., 2010). This situational nature of their anxiety is consistent with the thesis' focus on driving-related, rather than general or clinical, anxiety.

The relatively low scores on the DRAS can be interpreted in light of the sample characteristics. The participants in this thesis did not represent individuals with severe or phobic levels of driving anxiety. As such, these individuals were less likely to engage in complete avoidance of driving. This distinction is important as while they may experience significant anxiety in certain driving situations, they do not necessarily meet criteria for driving phobia. Instead, they represent a substantial group of drivers who continue to drive despite their anxiety

Overall, the inclusion of a varied sample enhanced the richness of the data and allowed for a more representative understanding of driving anxiety. It also underscores the importance of recognising self-identified anxiety as a legitimate and behaviourally relevant experience, even when it does not meet clinical severity.

Measures

As outlined in the preceding sections, this thesis set out to advance the current understanding of driving anxiety. A crucial first step in achieving this was to critically evaluate how driving anxiety is defined and measured within the literature. Traditionally, research in this area has relied heavily on psychometric methods (Taylor et al., 2021), with limited use of qualitative approaches to explore and define the construct in depth. In many experimental studies, driving anxiety has been operationalised using questionnaire data

(Banyard & Chapman, 2018a), or in some cases, single-item measures (Hempel et al., 2017), to categorise participants into anxious and non-anxious groups before assessing relevant behavioural outcomes.

While this thesis followed similar methodological conventions, it also made a conscious effort to adopt a bottom-up approach. This included a qualitative investigation of the lived experience of driving anxiety, and the use of multiple validated scales to capture its cognitive, behavioural, and affective dimensions. Although these measures do not provide a clinical diagnosis of driving anxiety, they offer a useful means of distinguishing between individuals with higher and lower levels of driving-related anxiety, thus helping to advance conceptual clarity in the field.

Importantly, the thesis also sought to go beyond self-report by incorporating physiological data, specifically, SCRs, in an attempt to measure driving anxiety more objectively (see Chapter Five). A key reflection from this work is that driving anxiety is a complex, construct that is difficult to define and measure consistently. Individual experiences of driving anxiety can vary significantly, influenced by context, personality, and prior experience. Nevertheless, this research has contributed to building a foundational understanding of the features of driving anxiety and its potential impact on driver behaviour.

Although the development of a new comprehensive measure of driving anxiety would have been a valuable contribution, it was beyond the scope of this thesis. However, care was taken to use the most reliable and valid measures available within the existing literature, and the findings provide a solid platform for future work seeking to refine or expand measurement approaches in this area.

Theoretical implications

A lack of existing psychological theories relating to driving anxiety prompted the application of ACT (Eysenck et al., 2007) to aid understanding of driving anxiety and its impacts. ACT was perceived to be ideal due to its contemporary utilisation within anxiety research across differing disciplines (Barnes et al., 2024; Xiao et al., 2024; Zhang et al., 2024) such as sport psychology (Kegelaers & Oudejans, 2024; Maurin et al., 2024) and transport research (Collins, 2024; Del Campo et al., 2024; Love et al., 2024). Early studies appeared to support the application of ACT to driving anxiety.

Study one demonstrated clear links between how anxiety can impact driving performance through attentional control. For example, participants suggested that their attention was influenced by their anxiety when attending to multiple threatening stimuli. Applying ACT to this finding suggests that anxious drivers were unable to inhibit their attention, as participants recognised their own limitations in information processing when attempting to deal with multiple stimuli simultaneously (Broadbent et al., 2023; Love et al., 2022). Some stimuli may have been irrelevant which participants attributed to internal catastrophising thoughts, as they reported engaging in "what if" scenarios based on uncertainty of their environment which diverted their attention. The negative impact of internal factors such as worried thoughts is well established (White et al., 2021) and their reported utilisation by anxious drivers supports the application of ACT.

Beside the internal factors, participants also highlighted external factors which impacted attention. For example, most of the participants identified that other road users create a level of uncertainty on the road, as explained with Rosie in study one. These external factors tended to distract the driver from their goal-directed behaviour, leading to reduced performance (Niranjan et al., 2022). This demonstrates that study one evidences ACT through a lack of inhibition and increased attention to both irrelevant internal and external stimuli, which reduced their driving performance.

Further support of ACT was partially found by study two. Anxious driving behaviours were significantly associated to driving error as expected when applying ACT to driving anxiety. Anxious drivers showed significant association with all forms of driving error which, according to ACT, demonstrates that their driving performance was hindered. Driving performance was hindered due to increased attention to irrelevant anxious stimuli in environment rather than goal-directed behaviour (Tsai et al., 2017). However, study two revealed some limitations when applying ACT to driving anxiety. There was no significant association between anxious driving cognitions and driving error. Anxious driving cognitions pertain to the driver's internal thought processes and worries while driving (Ehlers et al., 2007). With anxious driving cognitions not significantly associating with driving error, this could suggest that the internal irrelevant stimuli could have less impact on the ACT mechanism than originally expected. The overall findings suggested that irrelevant external stimuli seemed to have more impact on driving error in comparison to internal stimuli such as catastrophising thoughts. Thus, despite the importance that participants placed on such thoughts impeding their driving capabilities in study one, these thoughts do not practically impact driving error. There is potential that anxious driving cognitions could be influencing the anxious driving behaviours as actions can only be performed once the intention has been developed (Ajzen, 1991; Kuhl & Beckman, 2012). Therefore, future research could explore the mediation between anxious cognitions and driving error through anxious driving behaviours. Such research may fully explore ACTs utility as a mechanism for explaining driving anxiety.

The limitations of ACT highlighted in study two were confirmed in study three. Anxious drivers had similar fixation and accuracy rates to hazards in anxious environments as their non-anxious counterparts. These findings oppose ACT literature which have suggested that anxiety may facilitate threat identification, even if the threat is not related to the goal (Cisler & Koster, 2010; Eysenck et al., 2007; Mathews & Mackintosh, 1998; Mogg & Bradley, 2018; Okon-Singer, 2018). It was also anticipated that anxious drivers would exhibit slower reactions to hazards compared to the non-anxious group, aligning with ACTs explanation that the processing of irrelevant internal stimuli would impede reactions towards relevant stimuli (Edwards et al., 2015; Eysenck & Derakshan, 2011; Hartanto & Yang, 2022; Majeed et al., 2023). These results were not found as there was no difference in reaction time between anxious and non-anxious drivers. Although there were no differences between anxiety groups for hazard perception and response, study three did find that experience took a more prominent role in driving compared to anxiety. ACT in its current form does not account for experience levels on task related performance (Eysenck & Derakshan, 2011), however study three suggests that experience does impact performance levels. If ACT is to be applied within the transport sector, it needs to consider the effects of experience more explicitly. However, ACT limitations may be more nuanced than originally thought. This is because study three also reported that anxious experienced drivers had the highest mean score for hazard perception, despite marginally significant interaction between experience and anxiety levels ($p = .052$). Anxious experienced drivers also reporting perceiving more hazards than were present, although this was only significant for experience levels. Therefore, if adjustments to ACT are made within the transport sector, then there should also be some considerations to the potential interaction between anxiety and experience. This consideration may find that when experience is coupled with anxiety it would be these combined factors which increase facilitation to hazards.

Overall, the findings of the first three studies within the thesis highlight that ACT can be used to explain driving anxiety but to a limited degree. ACT is best used for anxious drivers' perceptions about themselves. According to anxious driver perceptions, anxiety can lead to an inhibitory deficit which can lead to attention towards irrelevant stimuli from both internal and external sources. However, when measuring anxiety's impact then it seems that while anxiety does have an impact on inhibitions, there seems to only be a focus on external irrelevant stimuli and only when the anxious environment is ambiguous. If the environment has concrete threats, then both anxious and non-anxious drivers will demonstrate the same level of attention, hindering the influence of ACT in these situations.

Practical implications

The findings from this thesis can have a range of practical implications within the wider private transport sector. Firstly, driving anxiety can impact driving performance by increasing the likelihood of driving errors being committed. Thus, considering solutions to overcoming driving anxiety would be beneficial in increasing actual and perceived road safety of anxious drivers. Development of targeted interventions may prove useful in reducing driving anxiety's overall impact, particularly where these interventions involve step-by-step processes. This thesis has highlighted a discrepancy between anxious drivers actual driving performance and their perceived driving performance. Thus, the first step in developing a driving intervention would be to target the core anxious belief that anxiety increases poor driving performance. Targeting such a core belief may benefit anxious drivers by reducing their anxiety and improving their driving behaviour and confidence.

Once the core belief has been addressed, the second step would be to expose the driver to anxious driving stimuli to see if step one was implemented successfully. Therefore, step two recommends anxious drivers to undertake Exposure Therapy. Exposure therapy, a form of Cognitive Behaviour Therapy (CBT), is considered the "gold standard" for treatment of specific phobias, PTSD, and other anxiety disorders (Hood & Antony, 2012; Foa & Meadows, 1997) and may be beneficial to populations with non-clinically recognised anxiety such as driving anxiety. Many individuals with clinically diagnosed anxiety who receive this treatment show significant improvement in symptoms, and effect sizes on primary outcome measures are generally large (Powers et al., 2010; Wolitzky-Taylor et al., 2008). These outcomes may be transferable to non-clinical populations if adapted to the individual's needs.

Exposure therapy involves repeatedly exposing an individual to perceived threatening stimuli (i.e., anxious driving situations) either through imaginary (e.g., imagined encounters with feared stimuli) or “in vivo” means (i.e., confronting the actual stimulus). However, having anxious drivers confront anxious situations during in vivo exposure therapy may be dangerous for anxious drivers. To overcome this concern, the utilisation of virtual reality (VR) may be preferable. VR can offer several advantages including mitigating the common experience of patient aversion associated with in vivo exposure (Bouchard et al., 2017); reducing the risk of conducting exposure therapy on road (Bush, 2008); and improving the ability to control and tailor the environment to the needs of the patient (Knott et al., 2021). Furthermore, VR has gained interest due to the decreased cost of hardware, growing acceptability, and improved ease of access (Carl et al., 2019; Menelas et al., 2018).

However, one issue with the intervention at this point is that the anxious driver would still be observing the stimuli without interacting with it. One solution would be to use a Virtual Reality Exposure Therapy environment with high-fidelity that can also be controlled via a driving simulator. For example, in recent years, certain products such as City Car Driving (Forward Development, 2014) (Mackenzie, 2016; Zontone et al., 2022) have implemented VR in a video-game format which can be controlled by a driving simulator. Such products have implemented features such as cities with adjustable traffic density and varied road crossings. These types of VR environments increase presence, particularly with anxiety (Bouchard et al., 2008). These environments could also help facilitate learning, through presence and agency, which could allow novice anxious drivers to reduce the influence of driving anxiety while developing their driving skills (Petersen et al., 2022; Xie et al., 2021). For example, Lang et al. (2018) created a system to automatically synthesize a training program that improves bad driving habits of drivers. Based on the collected eye movement data, the system synthesizes a personalised training route for the trainee to encounter events and practice their skills. The results indicated that the personalised VR driving system improved drivers' bad driving habits. The training effect is more significant and long-lasting compared to that of traditional training methods (e.g., booklets, videos). Although Lang et al's. (2018) study was not based on an anxious driving sample; the findings are useful and could be extrapolated to a driving anxious sample. Certain VR simulator products also have in-built traffic rules control systems which provides statistics of a variety of driving errors which can be exported. However, results from in-built systems need to be taken with caution as it is unclear if such systems have been developed based on scientific literature. Although VR-based psychological interventions could be feasible and acceptable in a driving anxious population (e.g. Beck et al., 2007; Kaussner et al., 2020), current research needs to improve methodological quality with improved study design, increased trials, and long-term assessment with larger samples (Elphinston et al., 2023). If this intervention is to be implemented, then simulation sickness should also be considered as it has been shown to reduce the presence of interventions involving simulators (Almallah et al., 2021). Likewise, a third step involved a follow-up session may need to be considered to ensure that any improvements to driving performance via reduced driving anxiety are long lasting.

A second practical implication of the thesis is to use mindful driving techniques while driving. Mindfulness practice has been demonstrated to significantly reduce depression, anxiety and stress, particularly in a short space of time using randomised controlled experiments (Strohmaier et al., 2020). This may be due to mindfulness' positive link with self-efficacy. Self-efficacy refers to the belief in one's own capacity (Bandura, 1997) and has a negative association with anxiety, stress and depression (Sharma & Kumra, 2022). If mindfulness can improve self-efficacy, anxious individuals may feel more in control of themselves, limiting the impact of anxiety. It has been claimed that mindfulness can also benefit driving performance. For example, Mcclean (2016) presented a mindfulness approach to driving that can increase attentiveness, compassion, cooperation and safety. Additionally, Crundall et al. (2019) found evidence of smoother driving in both driving simulators and naturalistic conditions in a group that practiced meditation/mindfulness compared to a group that did not. These sources assume that a higher level of mindfulness will improve the subjects' usual state of functioning in a number of variables and that these improvements in turn will be beneficial for driving performance. Furthermore, as the transport sector moves towards an increase in autonomy and technology in vehicles, it has also been found that mindfulness may reduce technology engagement while driving, leading to a reduction in crash risk (Koppel et al., 2022).

Although there have been studies which have investigated mindfulness' impact on anxiety and mindfulness' impact on driving performance separately, only one study has investigated mindfulness' impact on anxious drivers. Measuring the impact of mindfulness on lateral car control using a novice driver sample, Valero-Mora et al. (2021) found that although mindfulness techniques can help novice drivers keep calm, resulting in slightly better lateral control of the car, given how small the effect was, it would be unlikely that this effect would be noticeable in real world situations. Therefore, while mindfulness may theoretically help both anxiety and driving performance, more research needs to be conducted to determine the effectiveness of mindfulness training for anxious individuals within the driving context.

Policy implications

The findings of this thesis have potential policy implications, particularly in supporting individuals who struggle with driving anxiety. Currently, the UK government requires individuals to inform the DVLA if their anxiety affects their ability to drive (DVLA, 2024). However, there is no clear explanation provided as to why this declaration is necessary, leaving the responsibility to the individual to assess whether their anxiety impacts their driving performance. The results of this thesis indicate that anxiety does indeed affect driving performance, primarily leading to slip errors and unintentional violations dependent of driving situation. Furthermore, the overall results have suggested that the self-perception of anxiety may be more important as it could lead to further avoidance, leading to loss of skills. The emotional impact of anxiety is as important as the physical implications to performance (e.g. Sachs-Ericsson et al., 2017). Given that the government mandates the declaration of anxiety (DVLA, 2024), a more supportive approach is needed. This should include explaining the potential impact of anxiety on driving, backed by evidence, and offering resources for anxious drivers to seek help. One way to provide support is through public awareness campaigns that offer educational resources on the causes of driving anxiety and strategies for coping (Windsor et al., 2006). Such campaigns could help normalise driving anxiety, encouraging more individuals to report it. Additionally, government agencies should be transparent in treating mental and physical health equally and should raise public awareness of existing collaborations with mental health organisations (Srivastava et al., 2016) to provide further support for anxious drivers.

Another recommendation is for the UK to implement a graduated licensing system to target novice anxious drivers or prevent anxiety from forming in novice drivers. A graduated licensing system involves a phased approach to granting driving privileges, typically including stages such as learner's permits, intermediate licenses, and full licenses (Simpson, 2003). Within this system, new drivers gain experience in less stressful environments before advancing to more complex driving situations, which can help build confidence and reduce anxiety. Such systems have been evaluated in other countries and states; however, the focus is on young drivers rather than anxious driving populations (Kiriakou, 2020; Leal et al., 2007; Mayhew, 2007; Senserrick et al., 2021). A graduated licensing system allows for close monitoring and assessment of drivers' skills and psychological states at various points in their progression towards full licensure (Simpson, 2003). By adopting this system, policymakers can better identify anxiety in drivers during different stages of the licensing process. Early detection of anxiety is crucial, as it enables timely intervention before the anxiety can significantly impact driving performance (Rodwell et al., 2020). One type of intervention would be to allow specialised driving instructors with a driving anxiety background to teach individuals who are struggling. Therefore, the specific needs of anxious drivers can be addressed by, offering practical experience and coping strategies in real driving conditions.

For anxious drivers who have already acquired their full UK license, the policy of flexible working hours, first introduced through COVID-19 (Ni et al., 2024), should be prolonged. This would reduce the need for anxious drivers to drive during peak traffic times, thereby reducing their exposure to stressful driving conditions (Ni et al., 2024; Zontone et al., 2022). As shown by studies one, two and four, other vehicles in close proximity can have an impact on driving performance. By reducing the potential of being in heavy traffic the change of all types of errors can be reduced. It could be argued that the changes in policy due to COVID-19 and the social-distancing initiatives have already implemented these adjustments allowing anxious drivers to benefit (Forbes et al., 2020). However, in recent news, these changes are facing backlash, and private companies are aiming to reverse these policies (Gibson et al., 2023). This would negatively impact anxious drivers; therefore, it would be a recommendation to keep current work practices in the interest of anxious drivers rather than for COVID-19.

It should be noted the policy implications based on driving experience is not based on the concept of expertise. Experience generally refers to the amount of time or the number of instances someone has engaged in a particular activity (Swann et al., 2015). Building up experience is common in driving because it is a daily activity. In other disciplines, for example sports, an athlete may have years of experience in their sport, yet this does not necessarily mean they perform at an elite level (Swann et al., 2015). Expertise, on the other hand, focuses on a level of proficiency or performance achieved through deliberate and structured practice, often aligning with superior cognitive and perceptual abilities specific to the task at hand (Swann et al., 2015). While this may happen when learning to drive, further training ceases once a full license has been obtained.

This distinction is critical because expertise implies a mastery that is not inherently guaranteed by experience alone. An individual may accrue experience without ever reaching expertise if they do not engage in focused practice aimed at improvement (Swann et al., 2015). Conversely, an expert is not merely experienced but has developed advanced skills and strategies, often validated by objective performance criteria within their field (Swann et al., 2015). Recognizing this distinction allows researchers and practitioners to more accurately measure and understand proficiency, acknowledging that while experience may provide exposure, expertise reflects advanced capability and understanding developed through targeted and sustained efforts.

To address the issue of driving anxiety, it is imperative to implement policies that facilitate easier access to professional help for individuals experiencing this condition, regardless of experience level. Empirical evidence indicates a significant gap between the prevalence of driving anxiety and the rate at which affected individuals seek professional assistance (Stephens et al., 2024; Taylor et al., 2007; Zinzow et al., 2013). For instance, Taylor et al. (2007) reported that only 16% of a sample of 50 women experiencing driving anxiety sought professional help specifically for their driving-related fear. While one-third of the sample acknowledged the need for help, the majority (74%) expressed a low likelihood of seeking it. Similarly, Zinzow et al. (2013) found that among 46 recently returned service members, 48% reported feeling anxious while driving, yet less than half (40%) of those with driving anxiety sought professional help. Stephens et al. (2024) highlighted that 22% of their sample did not seek help for their driving anxiety, with non-help seekers predominantly being men who were less likely to recall the origin of their anxiety or attribute it to specific traffic concerns.

Heinig et al. (2021) suggested that the reluctance to seek help may stem from experiences or fears of shame associated with anxiety or the act of seeking help. Stigmatising beliefs, a tendency towards self-reliance, and difficulties in expressing concerns or accessing help are significant barriers to seeking professional assistance (Heinig et al., 2021; Salaheddin & Mason, 2016). The stigma surrounding driving anxiety, as noted by Zinzow et al. (2013), underscores the need to improve attitudes and reduce stigma, particularly in discussions related to anxiety and hyperarousal in ex-servicemen. Increased awareness via educational videos from trusted sources (e.g. Dahodwala et al., 2018; Grilo et al., 2022), alongside increased accessibility to programs to help support driving anxiety may help improve attitude and reduce stigma. An example to improve accessibility is to incorporate driving anxiety into large government schemes which the majority of the public have access to. For example, in the UK, one recommendation would be to include driving anxiety as a condition that the NHS-funded social prescribing scheme could support with. Family and friends play a crucial role in encouraging help-seeking behaviours or serving as a source of support, with social prescribing aiming to reconnect people to their communities to access support (Aughterson et al., 2020). Taylor et al. (2007) found that the most common source of support for individuals with driving anxiety was conversations with family or friends, with 70-78% of participants discussing their anxiety within their personal networks. Current research on facilitating social identification among service users for social prescribing (Bowe et al., 2023; Morgan, 2023) highlights the potential for anxious drivers to connect with supportive community members and develop contacts through such programs. This approach could significantly enhance the support network for individuals with driving anxiety, promoting greater engagement with available resources and reducing the overall impact of this condition on their daily lives.

Limitations of the research

The primary limitation of this thesis was that it was conducted during the COVID-19 pandemic. The pandemic, which resulted in widespread lockdowns from 2020 to 2022, significantly increased general anxiety levels, largely due to the uncertainty surrounding the progression of the disease (Kan et al., 2021; Singh et al., 2022). Moreover, the pandemic substantially altered traffic patterns, as individuals were confined to their homes, reducing their activity within traffic environments and potentially affecting their responses to driving actions (Hudda et al., 2020; Ray et al., 2022). Although there was less traffic, studies have indicated that during the pandemic, there were notable increases in certain risky driving behaviours, including speeding, phone usage, and more severe traffic violations (Katrakazas et al., 2020; Sekadakis et al., 2023).

The timing of data collection also poses a limitation. Data collected toward the end of the pandemic may yield different results compared to data collected at the pandemic's onset (Forbes et al., 2020). For example, during the data collection of study three, special COVID-19 risk assessment had to be conducted to allow for face-to-face testing. The COVID-19 laboratory setting is different to routine usage. The heightened anxiety and potential altered driving behaviours at the beginning of the pandemic could have skewed responses and behaviours in ways that may not reflect typical conditions. Conversely, data collected as restrictions eased may better represent the transition back to normalcy but still capture residual effects of the pandemic.

Given the core focus of this thesis was the impact of anxiety on driving performance, it would be prudent to conduct follow-up measurements once the pandemic's effects have substantially waned. This is especially true of the first three studies which were conducted at the height of COVID-19. The comparison of results with findings from other literature could provide a clearer understanding of the pandemic's long-term impact on driving behaviours and anxiety. Future research should aim to assess these variables in a post-pandemic context to validate and potentially refine the conclusions drawn in this thesis.

Another limitation was the lack of control for gender. The studies for this thesis did find that there were more women in the anxious category than the non-anxious category. This supports current research that driving anxiety has the strongest effect on women (Stephens et al., 2024). However, Tan et al. (2011) highlighted that observed higher levels of driving anxiety among women might be influenced by methodological factors, such as the nature of data collection and the overrepresentation of certain subgroups. These findings suggest that the perceived gender disparity in driving anxiety may not be inherently characteristic of women but rather an artifact of study designs and sample compositions.

There have also been mixed results on age factors. For instance, research indicates that as individuals age, there is a tendency for anxiety and anxiety-related symptoms and behaviours to decrease (Mahoney et al., 2015; Fort at al; 2023). This decline in anxiety with age could be attributed to increased driving experience and confidence over time, leading to a more relaxed approach to driving situations. However, it has also been found that after a certain point, older drivers often develop driving anxiety over time with the potential of driving cessation (Missell-Gray & Simning, 2024; Taylor et al., 2018). This point will be discussed further in the future research section.

Given these mixed results, it is crucial to conduct further studies with diverse samples and employ rigorous comparative analyses to explore the nuances of both age and gender differences in driving-related anxiety and behaviours. Future research should aim to account for potential biases in data collection methods and ensure a balanced representation of various subgroups to provide a more accurate understanding of how these demographic factors influence driving skills, behaviours, and anxiety. This approach will help clarify the true nature of these differences and contribute to more targeted interventions and support for different driver populations.

Future research

One important area for future research is to explore the cyclical nature of anxiety in driving. While it has been established that anxious drivers possess good perceptual and attentional skills, their behavioural responses are often impaired, leading to poor driving performance. When an anxious driver makes an error due to their anxiety, it can trigger panic, increasing the likelihood of further mistakes, particularly when driving alone (Ehlers et al., 2007). This escalation in panic may affect their attentional capacities, potentially resulting in more serious errors (Goodwin et al., 2017).

To prevent this escalation, research is needed to identify the point at which an initial error leads to panic and subsequent mistakes. Taylor et al. (2007) found that anxious drivers committed more driving errors than a control group, with most errors occurring in search techniques, particularly at intersections, as well as during tasks such as entering traffic and maintaining lane position. This increase in errors may be due to the cascading effect of the initial mistake, where panic reduces attention and impairs driving performance. However, a limitation of Taylor et al.'s (2007) study is that the sample consisted entirely of female participants, making it difficult to determine whether the observed visual search patterns and errors were attributable to anxiety or gender. Further research with more diverse samples is needed to clarify these findings.

To measure when the decision-making behaviours, a think aloud task could be conducted where the participant would talk about their thought processing and decision making (Vos et al., 2023). For example, at a T junction the driver may say "I see a car on my left, I will wait for that car to pass then move off". To sync the think aloud task with the environment, microphones in the car could be used to record the think-aloud task while dash cams could be used to record the environment. The use of dashcams would also allow for hazards to be captured and appraised against driver hazard perception skills. Like study four, two route selections should be developed, one which encompasses anxious driving situations and one with no anxious driving situations. This would address the potential limitation of the use of a driving simulator whilst allowing for comparisons between the thesis findings and real world data.

To address the effect of age on driving anxiety, future research should take into consideration the impact of an aging population. In the UK, current legislation does not require older drivers to retake their theory or driving test; they only need to renew their license online after the age of 70 (DVLA, 2024). The combination of medical and lifestyle advancements has led to an increase in the number of older drivers on the road. Current cohorts of drivers exhibit different driving patterns compared to previous generations (Newbold & Scott, 2017). Older drivers who believe they have low mileage underestimate how many miles they drive (Porter et al., 2015). They also continue to rely on private car transport, either as drivers or passengers, to meet their needs (Zeitler et al., 2015). This trend is expected to continue both presently and in the foreseeable future (Taylor et al., 2018). While an increase in the number of drivers on the road naturally contributes to higher rates of driving anxiety, individual factors such as age can also significantly impact driving anxiety levels. Taylor et al. (2018b) found that among adults aged 65 and older, 37.7% (441 individuals) experienced some degree of driving anxiety. Notably, women were more frequently represented among mildly and moderately anxious drivers, and those who were moderately to extremely anxious were more likely to be aged 70 and older. Older adults often report a recent onset of driving anxiety, which is likely associated with retirement, disability, health issues, and personal losses. Others describe a lifelong experience of driving anxiety

(Taylor et al., 2011; Taylor et al., 2018b). For many older individuals, driving becomes a source of stress and insecurity. This type of anxiety or low confidence, rather than the physical effects of ageing, serves as an independent predictor of driving self-regulation (Gwyther & Holland, 2012). Moreover, driving anxiety among older adults may be a normal and expected response that compromise road safety, such as cognitive or visual impairments (Taylor et al., 2018b). These findings highlight the importance of considering age-related factors in understanding and addressing driving anxiety.

Another area which could be an important link to driving anxiety is the concept on confidence. The lack of self-confidence may contribute to driving anxiety and avoidance behaviour, especially in the context of lapses while driving (Baldock et al., 2006; Parker et al., 2001). Driving anxiety and loss of self-confidence have been linked in previous literature. For example, Taylor et al. (2018) revealed that among anxious drivers, 25% stopped driving because they lost confidence in driving, particularly after a collision. However, research on anxiety and self-confidence seem to only be based on older drivers. Other types of confidence were also acknowledged within the thesis. Study one found that the unpredictability of other drivers maintained driving anxiety. This lack of confidence may reflect a form of intolerance of uncertainty which is known to play a major role in anxiety (Fort et al., 2023; Khawaja & Chapman, 2007; Shihata et al., 2016). Therefore, future research should consider the effect of different types of confidence loss for all types of anxious drivers.

Another area of future research would be to examine the impact of driving anxiety on different driving populations, particularly professional drivers. Investigating whether driving anxiety affects professional drivers, such as truck drivers in the logistics sector or taxi drivers in the transportation industry, is essential (Dubey & Gunasekaran, 2015; Huang et al., 2018; Londoño-Kent, 2009; Poó et al., 2018; Shi et al., 2014). As previously discussed, driving anxiety can arise from negative driving experiences and is not solely dependent on MVCs

(Ehlers et al., 1994; Stephens et al., 2024; Taylor, Deane, & Podd, 2000; Taylor et al., 2007). If driving anxiety is prevalent among professional drivers, the repercussions could be more significant than those experienced by private vehicle owners, given the potential impact on personal livelihood and company profits (Olvera et al., 2016; Blasi & Leavitt, 2006; Zoepf et al., 2018). Professional drivers, due to the nature of their work, may be compelled to continue driving despite experiencing anxiety, exacerbating the issue (Zoepf et al., 2018). This persistent anxiety can lead to impaired driving performance and diminished job satisfaction, which in turn can affect overall operational efficiency and economic outcomes for employers. Therefore, future research should focus on assessing the prevalence of driving anxiety among professional drivers and the specific challenges they face. If prevalence of driving anxiety is high, research should also aim to develop tailored interventions that address the unique needs of these professions, considering factors such as job demands, work environment, and the high stakes associated with professional driving.

Concluding remarks

To summarise, this thesis aimed to understand how driving anxiety could impact driving skills and performance using a theoretically driven, mixed methodological approach. Driving anxiety was defined using a multi-dimensional predictive model created by talking to driving anxious individuals. This predictive model was tested, and it was found that driving anxiety has been rising over recent years, particularly after the rise of COVID-19 and was linked to a range of slip, mistake and violation errors. The follow up studies using objective measures highlighted that driving anxiety does have an impact on driving performance, but the extent was limited. Anxiety had no impact on visual attention or hazard perception. Instead, anxiety mainly led to slip errors which posed limited risk to the driver and other road users. Violations were only produced during specific anxious driving situations, but the prevalence was low. There was no difference between groups for serious incidents such as collisions. The attentional control theory deemed to be effective at explaining the self-report research within the thesis, but there were limitations to the theory when using experimental measures. Recommendations to reduce theoretical limitations have been provided. This thesis has established a foundation for understanding driving anxiety's impact on driving performance. Using the mixed methodological approach, a key finding from the thesis is that anxious drivers believe that their anxiety has more control over their driving behaviour than what was objectively measured. Recommendations have been made to address theoretical, practical and policy implications, to improve ACT, reduce anxious beliefs and combat driving anxiety. The implications propose a potential intervention strategy and adjustments to governmental policy to improve driving anxiety awareness. By implementing these recommendations, there is an opportunity to help anxious drivers avoid driving cessation and improve their quality of life.

References

Abdu, R., Shinar, D., & Meiran, N. (2012). Situational (state) anger and driving. *Transportation research part F: traffic psychology and behaviour*, *15*(5), 575-580.

Abdurakhmanov, R. (2022). Determination of traffic congestion and delay of traffic flow at controlled intersections. *The American Journal of Engineering and Technology*, *4*(10), 4-11.

Abele, L., Haustein, S., & Møller, M. (2018). Novice drivers' eye movement patterns in potentially hazardous pedestrian events: Differences between novice drivers with high and low hazard perception skills. *Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria*.

Abend, R., Gold, A. L., Britton, J. C., Michalska, K. J., Shechner, T., Sachs, J. F., Winkler, A. M., Leibenluft, E., Averbeck, B. B., & Pine, D. S. (2020). Anticipatory threat responding: associations with anxiety, development, and brain structure. *Biological psychiatry*, *87*(10), 916-925.

Aberg, L., & Rimmo, P. A. (1998). Dimensions of aberrant driver behaviour. *Ergonomics*, *41*(1), 39-56.

Adams, C. W., (2015). Conducting semi-structured interviews. In K. E. Newcomer, H. P. Hatry & J. S. Wholey (Eds), *Handbook of practical program evaluation* (pp. *492-505)*. Jossey-Bass, San Francisco; CA.

Adeoye-Olatunde, O. A., & Olenik, N. L. (2021). Research and scholarly methods: Semi-structured interviews. *Journal of the american college of clinical pharmacy*, *4*(10), 1358-1367.

Agreas, S. (1985). *Panic: Facing fears, phobias, and anxiety.* NY: W.H. Freeman

Ajzen, I. (1991). The Theory of planned behavior. *Organizational Behavior and Human Decision Processes*.

Al-Ababneh, M. M. (2020). Linking ontology, epistemology and research methodology. *Science & Philosophy*, *8*(1), 75-91.

Alberti, C. F., Shahar, A., & Crundall, D. (2014). Are experienced drivers more likely than novice drivers to benefit from driving simulations with a wide field of view?. *Transportation Research Part F: Traffic Psychology and Behaviour*, *27*, 124-132.

Alderfer, M. A., & Sood, E. (2016). Using qualitative research methods to improve clinical care in pediatric psychology.

Almallah, M., Hussain, Q., Reinolsmann, N., & Alhajyaseen, W. K. (2021). Driving simulation sickness and the sense of presence: Correlation and contributing factors. *Transportation research part F: traffic psychology and behaviour*, *78*, 180-193.

Al-Tit, A. A. (2020). The impact of drivers' personality traits on their risky driving behaviors. *Journal of human behavior in the social environment*, *30*(4), 498-509.

Alyavina, E., Nikitas, A., & Njoya, E. T. (2020). Mobility as a service and sustainable travel behaviour: A thematic analysis study. *Transportation research part F: traffic psychology and behaviour*, *73*, 362-381.

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.

American Psychological Association. (2021). Publication Manual of the American Psychological Association, (2021).

Amick, M. M., Grace, J., & Ott, B. R. (2007). Visual and cognitive predictors of driving safety in Parkinson's disease patients. *Archives of Clinical Neuropsychology*, *22*(8), 957-967.

Andrews, G., Crino, R., Hunt, C., Lampe, L., & Page, A. (1994). *The treatment of anxiety disorders.* Cambridge: Cambridge University Press.

Andrews, G., Crino, R., Hunt, C., Lampe, L., & Page, A. (1994). *The treatment of anxiety disorders.* Cambridge: Cambridge University Press.

Ang, B. H., Jennifer, O., Chen, W. S., & Lee, S. W. H. (2019). Factors and challenges of driving reduction and cessation: A systematic review and meta-synthesis of qualitative studies on self-regulation. *Journal of safety research*, *69*, 101-108.

Angell L., Auflick J, Austria P. A., Kochlar D., Tijerina L., Biever W., Diptiman J., Hogsett J., Kiger S. (2006). *Driver Workload Metrics Project: Final report* (DOT HS 810 635). Washington, DC: National Highway Traffic Safety Administration.

Apolinario, D., Magaldi, R. M., Busse, A. L., Lopes, L. D. C., Kasai, J. Y. T., & Satomi, E. (2009). Cognitive impairment and driving: A review of the literature. *Dementia & Neuropsychologia*, *3*, 283-290.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current directions in psychological science*, *11*(5), 181-185.

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of experimental psychology: General*, *130*(2), 224.

Ashton, J. E., Harrington, M. O., Guttesen, A. Á. V., Smith, A. K., & Cairney, S. A. (2019). Sleep preserves physiological arousal in emotional memory. *Scientific reports*, *9*(1), 5966.

Aughterson, H., Baxter, L., & Fancourt, D. (2020). Social prescribing for individuals with mental health problems: a qualitative study of barriers and enablers experienced by general practitioners. *BMC family practice*, *21*, 1-17.

Automobile Association. (2023). A beginners' guide on how to perform a hill start. https://www.theaa.com/driving-school/driving-lessons/advice/how-to-perform-a-hill-start

AVIVA. (2023). *One in seven motorists say anxiety affects their driving.* Retrieved from One in seven motorists say anxiety affects their driving - Aviva plc

AVSIMULATION. (2024). Retrieved from: https://www.avsimulation.com/en/

Azık, D. (2015). *Self-regulatory driving practices of old and young drivers* (Master's thesis, Middle East Technical University).

Baddeley, A. D. (1972). Selective attention and performance in dangerous environments. *British journal of psychology*, *63*(4), 537-546.

Bahrick, L. E., Lickliter, R., & Todd, J. T. T. (2020). The development of multisensory attention skills: Individual differences, developmental outcomes, and applications.

Baldock, M. R. J., Mathias, J. L., McLean, A. J., & Berndt, A. (2006). Self-regulation of driving and its relationship to driving ability among older adults. *Accident Analysis & Prevention*, *38*(5), 1038-1045.
Baldock, M. R. J., Mathias, J. L., McLean, A. J., & Berndt, A. (2006). Self-regulation of driving and its relationship to driving ability among older adults. *Accident Analysis & Prevention*, *38*(5), 1038-1045.
Ball, H. L. (2019). Conducting online surveys. *Journal of Human Lactation*, *35*(3), 413-417.

Bandura, A. (1986). Social foundations of thought and action. *Englewood Cliffs, NJ*, *1986* (23-28), 2.

Bandura, A. (2004). Health promotion by social cognitive means. *Health education & behavior*, *31*(2), 143-164.

Bar-Haim, Y., Kerem, A., Lamy, D., & Zakay, D. (2010). When time slows down: The influence of threat on time perception in anxiety. *Cognition and emotion*, *24*(2), 255-263.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin, 133*(1), 1–24. https://doi.org/10.1037/0033-2909.133.1.1

Barker, C., Pistrang, N., & Elliott, R. (2002). *Research methods in clinical psychology: An introduction for students and practitioners* (*2nd ed.).* Chichester, England: Wiley. https://doi.org/10.1002/0470013435

Barnard, M. P., & Chapman, P. (2016). Are anxiety and fear separable emotions in driving? A laboratory study of behavioural and physiological responses to different driving environments. *Accident Analysis & Prevention*, *86*, 99-107.

Barnard, M. P., & Chapman, P. (2018). The effects of instruction and environmental demand on state anxiety, driving performance and autonomic activity: Are ego-threatening manipulations effective?. *Transportation research part F: traffic psychology and behaviour*, *55*, 123-135.

Barnard, M. P., & Chapman, P. (2018a). The moderating effect of trait anxiety on anxiety-related thoughts and actions whilst driving. *Personality and individual differences*, *135*, 207-211.

Barnes, E. D., Grills, A. E., & Vaughn, S. R. (2024). Relationships between anxiety, attention, and reading performance in children. *Child Psychiatry & Human Development*, 1-15.

Baron, R. A., & Baron, R. A. (1977). Aggression: definitions and perspectives. *Human aggression*, 1-38.

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., Dai, B., Grothendieck, G., Green, P., & Bolker, M. B. (2015). Package ‘lme4’. *Convergence, 12*(1), 2. https://dk.archive.ubuntu.com/pub/pub/cran/web/packages/lme4/lme4.pdf

Bateson, M., Brilot, B., & Nettle, D. (2011). Anxiety: an evolutionary approach. *The Canadian Journal of Psychiatry*, *56*(12), 707-715.

Bauer, K. M., & Harwood, D. W. (1996). *Statistical models of at-grade intersection accidents*. Department of Transportation. Federal Highway Administration. Report Number FHWA-RD-96-125). 150. Virginia, United States.

Al-Tit, A. A. (2020). The impact of drivers' personality traits on their risky driving behaviors. *Journal of human behavior in the social environment*, *30*(4), 498-509.

Bauer, M. J., Rottunda, S., & Adler, G. (2003). Older women and driving cessation. *Qualitative Social Work*, *2*(3), 309-325.

BeamNG. (2023). *BeamNG.Drive.* Retrieved 2023-06-08 from https://www.beamng.com

Beaudreau, S. A., & O'Hara, R. (2008). Late-life anxiety and cognitive impairment: a review. *The American Journal of Geriatric Psychiatry*, *16*(10), 790-803.

Beck, A. T. (1979). *Cognitive therapy and the emotional disorders*. Penguin.

Beck, A. T., & Emery, G. (1985). *Anxiety disorders and phobias: A cognitive perspective.* NY: Basic Books.

Beck, J. G., & Coffey, S. F. (2007). Assessment and treatment of posttraumatic stress disorder after a motor vehicle collision: Empirical findings and clinical observations. *Professional Psychology: Research and Practice*, *38*(6), 629.

Beck, J. G., Palyo, S. A., Winer, E. H., Schwagler, B. E., & Ang, E. J. (2007). Virtual reality exposure therapy for PTSD symptoms after a road accident: An uncontrolled case series. *Behavior therapy*, *38*(1), 39-48.

Beck, J. G., Palyo, S. A., Winer, E. H., Schwagler, B. E., & Ang, E. J. (2007). Virtual reality exposure therapy for PTSD symptoms after a road accident: An uncontrolled case series. *Behavior therapy*, *38*(1), 39-48. https://doi.org/10.1016/j.beth.2006.04.001

Beh, H. C., & Hirst, R. (1999). Performance on driving-related tasks during music. *Ergonomics*, *42*(8), 1087-1098.

Behan, M., & Wilson, M. R. (2008). State anxiety and visual attention: The role of the quiet eye period in aiming to a far target. *Journal of Sport Sciences, 26*, 207–215.

Bener, A., Lajunen, T. I. M. O., Özkan, T., & Haigney, D. (2006). The effect of mobile phone use on driving style and driving skills. *International Journal of Crashworthiness, 11*(5), 459-465.

Bennetts, R., & Taylor, J. E. (2022). Health and quality of life outcomes of driving Cessation for older people are more complex than we thought. *Clinical Gerontologist*, *45*(4), 821-832.

Ben-Nun, P. (2008). Respondent fatigue. In P. J. Lavrakas (Ed.), *Encyclopaedia of survey research methods* (pp. 743–744). Thousand Oaks, CA: Sage.

Berggren, N., Blonievsky, T., & Derakshan, N. (2015). Enhanced visual detection in trait anxiety. *Emotion*, *15*(4), 477.

Berkowitz, L. (1993). *Aggression: Its causes*, *consequences*, *and control*. New York: McGraw-Hill.

Berthié, G., Lemercier, C., Paubel, P. V., Cour, M., Fort, A., Galéra, C. & Maury, B. (2015). The restless mind while driving: drivers' thoughts behind the wheel. *Accident Analysis & Prevention*, *76*, 159-165.

Bhatt, K., Gore, N., Shah, J., & Arkatkar, S. (2024). Drivers' dilemma at high-speed unsignalised intersections. *Transportation research record*, *2678*(3), 82-97.

Bianchi, A., & Summala, H. (2004). The "genetics" of driving behavior: parents' driving style predicts their children's driving style. *Accident Analysis & Prevention*, *36*(4), 655-659.

Bieling, P. J., Antony, M. M., & Swinson, R. P. (1998). The State-Trait Anxiety Inventory, Trait version: structure and content re-examined. *Behaviour research and therapy*, *36*(7-8), 777-788.

Birenbaum, M. (1986). Effect of dissimulation motivation and anxiety on response pattern appropriateness measures. *Applied Psychological Measurement*, *10*(2), 167-174.

Bishop, S. J. (2009). Trait anxiety and impoverished prefrontal control of attention. *Nature neuroscience*, *12*(1), 92-98.

Björkman, M., Juslin, P., & Winman, A. (1993). Realism of confidence in sensory discrimination: The underconfidence phenomenon. *Perception & psychophysics*, *54*, 75-81.

Blachnio, A., Przepiórka, A., Sullman, M., & Taylor, J. (2013). Polish adaptation of the Driving and Riding Avoidance Scale. *Polish Psychological Bulletin, 44*, 59–66. https://doi.org/10.2478/ppb 2013-0021

Blanchard, E. B., & Hickling, E. J. (2004). *After the crash: Psychological assessment and treatment of survivors of motor vehicle accidents*. American Psychological Association.

Blanchard, E. B., Hickling, E. J., Taylor, A. E., Loos, W. R., & Gerardi, R. J. (1994). Psychological morbidity associated with motor vehicle accidents. *Behaviour research and therapy*, *32*(3), 283–290. https://doi.org/10.1016/0005-7967(94)90123-6

Blanchard, E. B., Hickling, E. J., Vollmer, A. J., Loos, W. R., Buckley, T. C., & Jaccard, J. (1995). Short-term follow-up of post-traumatic stress symptoms in motor vehicle accident victims. *Behaviour Research and Therapy*, *33*(4), 369-377.

Blasi, G., & Leavitt, J. (2006). Driving poor: Taxi drivers and the regulation of the taxi industry in Los Angeles. *Los Angeles: UCLA Institute of Industrial Relations*.

Bobermin, M. P., Silva, M. M., & Ferreira, S. (2021). Driving simulators to evaluate road geometric design effects on driver behaviour: A systematic review. *Accident Analysis & Prevention*, *150*, 105923.

Borden, J. W., Clum, G. A., Broyles, S. E., & Watkins, P. L. (1988). Coping strategies and panic. *Journal of Anxiety Disorders*, *2*(4), 339-352.

Borkovec, T. D. (1985). Worry: A potentially valuable concept. *Behaviour research and therapy*, *23*(4), 481-482.

Borkovec, T. D., & Roemer, L. (1995). Perceived functions of worry among generalised anxiety disorder subjects: Distraction from more emotionally distressing topics?. *Journal of behavior therapy and experimental psychiatry*, *26*(1), 25-30.

Borkovec, T. D., Alcaine, O. M., & Behar, E. (2004). Avoidance theory of worry and generalised anxiety disorder. In R. G. Heimberg, C. L. Turk, & D. S. Mennin (Eds.), *Generalised anxiety disorder: Advances in research and practice* (pp. 77–108). Guilford Press.

Borkovec, T. D., Ray, W. J., & Stober, J. (1998). Worry: A cognitive phenomenon intimately linked to affective, physiological, and interpersonal behavioral processes. *Cognitive therapy and research*, *22*(6), 561-576.

Borowsky A., Shinar D., Oron-Gilad T. (2010). Age, skill, and hazard perception in driving. *Accident Analysis & Prevention*, 42, 1240–1249.

Bouchard, S., Dumoulin, S., Robillard, G., Guitard, T., Klinger, E., Forget, H. & Roucaut, F. X. (2017). Virtual reality compared with in vivo exposure in the treatment of social anxiety disorder: a three-arm randomised controlled trial. *The British Journal of Psychiatry, 210*(4), 276-283.

Bouchard, S., St-Jacques, J., Robillard, G., & Renaud, P. (2008). Anxiety increases the feeling of presence in virtual reality. *Presence: Teleoperators and Virtual Environments*, *17*(4), 376-391.

Boucsein, W. (2012). *Electrodermal activity*. Springer Science & Business Media.

Bourne, E.J. (1990). *The anxiety and phobia workbook.* Oakland, CA: New Harbinger.

Bowe, M., Morgan, T., Harkin, L., & Stevenson, C. (2023, August). Locking and unlocking the social cure: Social prescribing service-user experiences of the barriers to and facilitators of attending recommended groups. In *Annual British Psychological Society Social Psychology Section Conference 2023*.

Bradley, K., & Higenbottam, C. (2003). Cognitive performance: Effect of drug-induced dehydration. *Maintaining Hydration: Issues, Guidelines, and Delivery*, *14*, 1-12.

Braithwaite, J. J., & Watson, D.G. (2015). *Issues surrounding the normalization and standardisation of skin conductance responses* (*SCRs).* Technical Research Note. Selective Attention & Awareness Laboratory (SAAL), Behavioural Brain Sciences Centre, School of Psychology, University of Birmingham©

Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. *Psychophysiology*, *49*(1), 1017-1034.

Brantley, P. J., Waggoner, C. D., Jones, G. N., & Rappaport, N. B. (1987). A daily stress inventory: Development, reliability, and validity. *Journal of behavioral medicine*, *10*, 61-73.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, *11*(4), 589-597.

Braun, V., & Clarke, V. (2021). *Thematic analysis. A practical guide*. Sage

Braun, V., Clarke, V., Boulton, E., Davey, L., & McEvoy, C. (2021). The online survey as a qualitative research tool. *International Journal of Social Research Methodology*, *24*(6), 641-654.

Briggs, G. F., Hole, G. J., & Land, M. F. (2011). Emotionally involving telephone conversations lead to driver error and visual tunnelling. *Transportation research part F: traffic psychology and behaviour*, *14*(4), 313-323.

Briggs, G. F., Hole, G. J., & Turner, J. A. (2018). The impact of attentional set and situation awareness on dual tasking driving performance. *Transportation research part F: traffic psychology and behaviour*, *57*, 36-47.

British Psychological Society (2021). *Code of Ethics and Conduct.* Available from: https://explore.bps.org.uk/content/report-guideline/bpsrep.2021.inf94

Broadbent, D. P., D'Innocenzo, G., Ellmers, T. J., Parsler, J., Szameitat, A. J., & Bishop, D. T. (2023). Cognitive load, working memory capacity and driving performance: A preliminary fNIRS and eye tracking study. *Transportation research part F: traffic psychology and behaviour*, *92*, 121-132.

Brom, D., Kleber, R. J., & Hofman, M. C. (1993). Victims of traffic accidents: Incidence and prevention of post-traumatic stress disorder. *Journal of clinical psychology*, *49*(2), 131-140.

Brosch, T., Pourtois, G., & Sander, D. (2010). The perception and categorisation of emotional stimuli: A review. *Cognition & Emotion, 24*(3), 377–400

Brown, I. D. (1982). Exposure and experience are a confounded nuisance in research on driver behaviour. *Accident Analysis & Prevention*, *14*(5), 345-352.

Brozovich, F., & Heimberg, R. G. (2011). The relationship of post-event processing to self-evaluation of performance in social anxiety. *Behavior Therapy*, *42*(2), 224-235.

Bucsuházy, K., Matuchová, E., Zůvala, R., Moravcová, P., Kostíková, M., & Mikulec, R. (2020). Human factors contributing to the road traffic accident occurrence. *Transportation research procedia*, *45*, 555-561.

Bucsuházy, K., Matuchová, E., Zůvala, R., Moravcová, P., Kostíková, M., & Mikulec, R. (2020). Human factors contributing to the road traffic accident occurrence. *Transportation research procedia*, *45*, 555-561.

Bull, A. (2003). *Traffic Congestion: The Problem and how to Deal with it*. Economic Commission for Latin America and the Caribbean (ECLAC).

Burchfield, S. R. (1979). The stress response: A new perspective. *Psychosomatic Medicine*, *41*(8), 661-672.

Burnett, G. E., Irune, A., & Mowforth, A. (2007). Driving simulator sickness and validity: How important is it to use real car cabins. *Advances in transportation studies*, *13*, 33-42.

Burnett, G., Harvey, C., & Donkor, R. (2017). Driving simulators for research. In *Simulators for transportation human factors* (pp. 19-46). CRC Press.

Burns, P. C. (1998). Wayfinding errors while driving. *Journal of Environmental Psychology, 18*, 209–217.

Bush, J. (2008). Viability of virtual reality exposure therapy as a treatment alternative. *Computers in Human Behavior*, *24*(3), 1032-1040.

Buunk, A. P., & Gibbons, F. X. (2006). Social comparison orientation: a new perspective on those who do and those. *Social comparison and social psychology: Understanding cognition, intergroup relations, and culture*, 15.

Calabrese, E. J., Dhawan, G., Kapoor, R., Iavicoli, I., & Calabrese, V. (2015). What is hormesis and its relevance to healthy aging and longevity?. *Biogerontology*, *16*, 693-707.

Calvo, M. G., & Eysenck, M. W. (1996). Phonological working memory and reading in test anxiety. Memory, 4, 289 –305

Calvo, M. G., Alamo, L., & Ramos, P. M. (1990). Test anxiety, motor performance and learning: Attentional and somatic interference. Personality and individual Differences, 11(1), 29-38.

Cao, S., Samuel, S., Murzello, Y., Ding, W., Zhang, X., & Niu, J. (2022). Hazard perception in driving: a systematic literature review. *Transportation research record*, *2676*(12), 666-690.

Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P. & Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomised controlled trials. *Journal of anxiety disorders*, *61*, 27-36.

Carpenter, M. G., Frank, J. S., Adkin, A. L., Paton, A., & Allum, J. H. J. (2004). Influence of postural anxiety on postural reactions to multi-directional surface rotations. *Journal of neurophysiology*, *92*(6), 3255-3265.

Castaneda, A. E., Tuulio-Henriksson, A., Marttunen, M., Suvisaari, J., & Lönnqvist, J. (2008). A review on cognitive impairments in depressive and anxiety disorders with a focus on young adults. *Journal of affective disorders*, *106*(1-2), 1-27.

Castro, C., Padilla, J. L., Doncel, P., Garcia-Fernandez, P., Ventsislavova, P., Eisman, E., & Crundall, D. (2019). How are distractibility and hazard prediction in driving related? Role of driving experience as moderating factor. *Applied ergonomics*, *81*, 102886.

Castro, C., Padilla, J. L., Roca, J., Benítez, I., García-Fernández, P., Estévez, B. & Crundall, D. (2014). Development and validation of the Spanish hazard perception test. *Traffic injury prevention*, *15*(8), 817-826.

Causer, J., Holmes, P. S., Smith, N. C., & Williams, A. M. (2011). Anxiety, movement kinematics, and visual attention in elite-level performers. *Emotion, 11*, 595–602.

Cellar, D. F., Nelson, Z. C., & Yorke, C. M. (2000). The five-factor model and driving behavior: Personality and involvement in vehicular accidents. *Psychological reports*, *86*(2), 454-456.

Chai, J., Qu, W., Sun, X., Zhang, K., & Ge, Y. (2016). Negativity bias in dangerous drivers. *PloS one*, *11*(1), e0147083.

Chakrabarty, N., & Gupta, K. (2013). Analysis of driver behaviour and crash characteristics during adverse weather conditions. *Procedia-social and behavioral sciences*, *104*, 1048-1057.

Chan, E., Pradhan, A. K., Pollatsek, A., Knodler, M. A., & Fisher, D. L. (2010). Are driving simulators effective tools for evaluating novice drivers' hazard anticipation, speed management, and attention maintenance skills?. *Transportation research part F: traffic psychology and behaviour*, *13*(5), 343-353.

Chan, M., & Singhal, A. (2013). The emotional side of cognitive distraction: Implications for road safety. *Accident Analysis & Prevention*, *50*, 147-154.

Chapman, P., Underwood, G., & Roberts, K. (2002). Visual search patterns in trained and untrained novice drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(2), 157-167.

Chapman, P., van Loon, E., Trawley, S., & Crundall, D. (2007). A comparison of drivers' eye movements in filmed and simulated dangerous driving situations. In *Behavioural research in road safety, 2007: Seventeenth seminar* (pp. 112-23).

Charlton, S. G. (2004). Perceptual and attentional effects on drivers' speed selection at curves. *Accident Analysis & Prevention*, *36*(5), 877-884.

Charlton, S. G. (2009). Driving while conversing: Cell phones that distract and passengers who react. *Accident Analysis & Prevention*, *41*(1), 160-173.

Charlton, S. G., & Starkey, N. J. (2011). Driving without awareness: The effects of practice and automaticity on attention and driving. *Transportation research part F: traffic psychology and behaviour*, *14*(6), 456-471.

Chee, D., Lee, H., & Flakmer, T. (2010). Cognitive overload and its effects on driving performance in people with Parkinson's Disease: A pilot study. Paper delivered at The 12th International Conference on Mobility and Transport for Elderly and Disabled Persons (TRANSED), held in Hong Kong on 2-4 June, 2010.

Cheng, A.S.K., Ng, T.C.K., & Lee, H. C. (2011). A comparison of the hazard perception ability of accident-involved and accident-free motorcycle riders. *Accident Analysis and Prevention, 43*(4), 1464–1471.

Choi, H. H., Van Merriënboer, J. J., & Paas, F. (2014). Effects of the physical environment on cognitive load and learning: Towards a new model of cognitive load. *Educational psychology review*, *26*, 225-244.

Cisler, J. M., & Koster, E. H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. *Clinical psychology review*, *30*(2), 203-216.

Cisler, J. M., Bacon, A. K., & Williams, N. L. (2009). Phenomenological characteristics of attentional biases towards threat: A critical review. *Cognitive therapy and research*, *33*, 221-234.

Clapp, J. D., Baker, A. S., Litwack, S. D., Sloan, D. M., & Beck, J. G. (2014). Properties of the Driving Behavior Survey among individuals with motor vehicle accident-related posttraumatic stress disorder. *Journal of anxiety disorders*, *28*(1), 1-7.

Clapp, J. D., Olsen, S. A., Beck, J. G., Palyo, S. A., Grant, D. M., Gudmundsdottir, B., & Marques, L. (2011). The driving behavior survey: Scale construction and validation. *Journal of anxiety disorders*, *25*(1), 96-105.

Clapp, J. D., Olsen, S. A., Danoff-Burg, S., Hagewood, J. H., Hickling, E. J., Hwang, V. S., & Beck, J. G. (2011a). Factors contributing to anxious driving behavior: The role of stress history and accident severity. *Journal of anxiety disorders*, *25*(4), 592-598.

Clarke, P., & MacLeod, C. (2013). The impact of anxiety on cognitive task performance. *Secondary influences on neuropsychological test performance*, 93-116.

Classen, S., & Evans, D. (2017). Overview of simulators by type, characteristics, and attributes. In S. Classen (Ed.), *Driving simulation for assessment, intervention, and training* (pp. 27–40). American Occupational Therapy Association Press.

Cocks, A. J., Jackson, R. C., Bishop, D. T., & Williams, A. M. (2016). Anxiety, anticipation and contextual information: A test of attentional control theory. *Cognition and Emotion*, *30*(6), 1037-1048.

Cocks, A. J., Jackson, R. C., Bishop, D. T. and Williams, A. M. (2015) *Anxiety, anticipation and contextual information: A test of attentional control theory.* Cognition and Emotion, 30 (6). 1037-1048. DOI: https://doi.org/10.1080/02699931.2015.1044424

Cohen, D., & Crabtree, B. (2006). Qualitative research guidelines project. Robert

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Collette, F., & Van der Linden, M. (2002). Brain imaging of the central executive component of working memory. *Neuroscience & Biobehavioral Reviews*, *26*(2), 105-125.

Collins, M. D. (2024). Train driver selection: The impact of cognitive ability on train driving performance. *International Journal of Selection and Assessment*, *32*(2), 249-260.

Conner, M., & Lai, F. (2005). *Evaluation of the effectiveness of the National Driver Improvement Scheme*.

Constantinou, E., Georgiou, D., Karekla, M., & Panayiotou, G. (2021). Subjective distress and physiological reactivity during anxiety-evoking imagery in social anxiety. *Personality and individual Differences*, *182*, 111095.

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature reviews neuroscience*, *3*(3), 201-215.

Costa, R. T. D., Carvalho, M. R. D., Ribeiro, P., & Nardi, A. E. (2018). Virtual reality exposure therapy for fear of driving: analysis of clinical characteristics, physiological response, and sense of presence. *Brazilian Journal of Psychiatry*, *40*, 192-199. https://doi.org/10.1590/1516-4446-2017-2270

Cowan, N., Elliott, E. M., Saults, J. S., Morey, C. C., Mattox, S., Hismjatullina, A., & Conway, A. R. (2005). On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes. *Cognitive psychology*, *51*(1), 42-100.

Cox, D. J., Owens, J. M., Barnes, L., Moncrief, M., Boukhechba, M., Buckman, S. & Wotring, B. (2020). A pilot study comparing newly licensed drivers with and without autism and experienced drivers in simulated and on-road driving. *Journal of autism and developmental disorders*, *50*, 1258-1268.

Craft, R. H., & Preslopsky, B. (2009). Driver distraction and inattention in the USA large truck and national motor vehicle crash causation studies. In: *First international conference on driver distraction and inattention*, September 28–29, 2009. Gothenburg, Sweden.

Craske, M. G. (1999). *Anxiety disorders: psychological approaches to theory and treatment*. Westview Press.

Craske, M. G. (2003). Origins of phobias and anxiety disorders: Why more women than men? Oxford: Elsevier.

Crowe, S. F., Matthews, C., & Walkenhorst, E. (2007). Relationship between worry, anxiety and thought suppression and the components of working memory in a non-clinical sample. *Australian Psychologist*, *42*(3), 170-177.

Crundall, D. (2016). Hazard prediction discriminates between novice and experienced drivers. *Accident Analysis & Prevention*, *86*, 47-58.

Crundall, D., Chapman, P., Trawley, S., Collins, L., Van Loon, E., Andrews, B., & Underwood, G. (2012). Some hazards are more attractive than others: Drivers of varying experience respond differently to different types of hazard. *Accident Analysis & Prevention*, *45*, 600-609.

Crundall, D., Chapman, P., Trawley, S., Collins, L., Van Loon, E., Andrews, B., & Underwood, G. (2012). Some hazards are more attractive than others: Drivers of varying experience respond differently to different types of hazard. *Accident Analysis & Prevention*, *45*, 600-609.

Crundall, D., Goodge, T., Kroll, V., van Loon, E., Vernon, M., & Ventsislavova, P. (2021). A comparison of virtual reality and non-virtual reality approaches to hazard perception training and testing: does a 360-degree environment provide tangible benefits?. RAC Foundation

Crundall, D. E., & Underwood, G. (1998). Effects of experience and processing demands on visual information acquisition in drivers. *Ergonomics*, *41*(4), 448-458.

Culot, C., Corlazzoli, G., Fantini-Hauwel, C., & Gevers, W. (2021). The relation between task-relatedness of anxiety and metacognitive performance. *Consciousness and cognition*, *94*, 103191.

Cunningham, W. A., & Brosch, T. (2012). Motivational salience: Amygdala tuning from traits, needs, values, and goals. *Current Directions in Psychological Science*, *21*(1), 54-59.

Curl, A. L., Stowe, J. D., Cooney, T. M., & Proulx, C. M. (2014). Giving up the keys: How driving cessation affects engagement in later life. *The Gerontologist*, *54*(3), 423-433.

D'Agati, E., Curatolo, P., & Mazzone, L. (2019). Comorbidity between ADHD and anxiety disorders across the lifespan. *International Journal of Psychiatry in Clinical Practice*, *23*(4), 238-244.

da Costa, R. T. D., Carvalho, M. R. D., Ribeiro, P., & Nardi, A. E. (2018). Virtual reality exposure therapy for fear of driving: analysis of clinical characteristics, physiological response, and sense of presence. *Brazilian Journal of Psychiatry*, *40*, 192-199. https://doi.org/10.1590/1516-4446-2017-2270

da Costa, R. T., de Carvalho, M. R., Cantini, J., da Rocha Freire, R. C., & Nardi, A. E. (2014). Demographics, clinical characteristics and quality of life of Brazilian women with driving phobia. *Comprehensive psychiatry*, *55*(2), 374-379.

da Silva Cezar, B. G., & Maçada, A. C. G. (2023). Cognitive Overload, Anxiety, Cognitive Fatigue, Avoidance Behavior and Data Literacy in Big Data environments. *Information Processing & Management*, *60*(6), 103482.

Dahodwala, M., Geransar, R., Babion, J., de Grood, J., & Sargious, P. (2018). The impact of the use of video-based educational interventions on patient outcomes in hospital settings: a scoping review. *Patient Education and Counseling*, *101*(12), 2116-2124.

Daniel-Watanabe, L., & Fletcher, P. C. (2022). Are fear and anxiety truly distinct?. *Biological psychiatry global open science*, *2*(4), 341-349.

Dargay, J., Gately, D., & Sommer, M. (2007). Vehicle ownership and income growth, worldwide: 1960-2030. *The energy journal*, *28*(4), 143-170.

Davis, M., Walker, D. L., Miles, L., & Grillon, C. (2010). Phasic vs sustained fear in rats and humans: role of the extended amygdala in fear vs anxiety. *Neuropsychopharmacology*, *35*(1), 105-135.

Davis, M., Walker, D. L., Miles, L., & Grillon, C. (2010). Phasic vs sustained fear in rats and humans: role of the extended amygdala in fear vs anxiety. *Neuropsychopharmacology*, *35*(1), 105-135.

Dawson, M. E., Schell, A. M., & Filion, D. L. (2001). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (2nd ed., pp. 200–223). Cambridge Press, Cambridge. DOI:10.1017/CBO9780511546396.007

De Craen, S., Twisk, D. A. M., Hagenzieker, M. P., Elffers, H., & Brookhuis, K. A. (2007, May). Do young novice drivers overestimate their driving skills. In *Young researchers seminar in SWOW, Brno, Czech Republic*.

de L Horne, D. J. (1993). Traumatic stress reactions to motor vehicle accidents. In *International handbook of traumatic stress syndromes* (pp. 499-506). Boston, MA: Springer US.

de Winter, J. C., & Dodou, D. (2010). The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. *Journal of safety research*, *41*(6), 463-470.

de Winter, J. C., Dodou, D., & Stanton, N. A. (2015). A quarter of a century of the DBQ: some supplementary notes on its validity with regard to accidents. *Ergonomics*, *58*(10), 1745-1769.

Deffenbacher, J. L. (2016). A review of interventions for the reduction of driving anger. *Transportation research part F: traffic psychology and behaviour*, *42*, 411-421.

Deffenbacher, J. L., Huff, M. E., Lynch, R. S., Oetting, E. R., & Salvatore, N. F. (2000). Characteristics and treatment of high-anger drivers. *Journal of counseling psychology*, *47*(1), 5.

Deffenbacher, J. L., Lynch, R. S., Filetti, L. B., Dahlen, E. R., & Oetting, E. R. (2003). Anger, aggression, risky behavior, and crash-related outcomes in three groups of drivers. *Behaviour research and therapy*, *41*(3), 333-349.

Degraeve, B., Granié, M. A., Pravossoudovitch, K., & Monaco, G. L. (2015). Social representations associated with men and women drivers among French adolescents and adults. Effects of the perceiver's age, sex, and socioeconomic status. *Transportation research part F: traffic psychology and behaviour*, *34*, 1-17.

DeJonckheere, M., & Vaughn, L. M. (2019). Semistructured interviewing in primary care research: a balance of relationship and rigour. *Family Medicine and Community Health*, *7*(2).

Del Campo, V. L., Morán, J. F. O., Cagigal, V. M., Martín, J. M., Pagador, J. B., & Hornero, R. (2024). The use of the eye-fixation-related potential to investigate visual perception in professional domains with high attentional demand: a literature review. *Neurological Sciences*, *45*(5), 1849-1860.

Delahanty, D. L., Herberman, H. B., Craig, K. J., Hayward, M. C., Fullerton, C. S., Ursano, R. J., & Baum, A. (1997). Acute and chronic distress and posstraumatic stress disorder as a function of responsibility for serious motor vehicle accidents. *Journal of Consulting and Clinical Psychology*, *65*(4), 560.

Deniaud, C., Honnet, V., Jeanne, B., & Mestre, D. (2015). The concept of "presence" as a measure of ecological validity in driving simulators. *Journal of Interaction Science*, *3*, 1-13.

Department of Transport. (2021). *The Highway Code*. https://www.gov.uk/guidance/the-highway-code/road-users-requiring-extra-care-204-to-225

Department of Transport. (2023). *Reported road casualties Great Britain, annual report: 2022*. Reported road casualties Great Britain, annual report: 2022 - (gov.uk)

Department of Transport. (2023). *Reported road casualties Great Britain: casualties and deprivation factsheet (England)*. Reported road casualties Great Britain: casualties and deprivation factsheet (England) - (gov.uk)

Derakshan, N., & Eysenck, M. W. (2009). Anxiety, processing efficiency, and cognitive performance: New developments from attentional control theory. *European Psychologist*, *14*(2), 168-176.

DeRose, K. (1999). Contextualism: An explanation and defense. *The Blackwell Guide to epistemology* (pp. 187-205).

Devlin, M., Mason, K., & Yeh, L. C. (2008). *Presenting Ethnicity: Comparing Prioritised and Total Response Ethnicity in Descriptive Analyses of New Zealand Health Monitor Surveys*. Ministry of Health.

Dewar, R. E., Olson, P. L., & Alexander, G. J. (2002). Perception and information processing. *Human factors in traffic safety*, 11-32.

Dickerson, A., Schold Davis, E., & Carr, D. B. (2018). Driving decisions: distinguishing evaluations, providers and outcomes. *Geriatrics*, *3*(2), 25.

Dijkstra, N., Mazor, M., Kok, P., & Fleming, S. (2021). Mistaking imagination for reality: Congruent mental imagery leads to more liberal perceptual detection. *Cognition*, *212*, 104719.

Dissanayake, S., & Amarasingha, N. (2014). Safety experience of young drivers in comparison to experienced drivers. In *T&DI Congress 2014: Planes, Trains, and Automobiles* (pp. 344-355).

Dobson, A., Brown, W. J., & Ball, J. (1998). *Women behind the wheel: Driving behaviour and road crash involvement* (No. CR179).

Dodge. Y. (2006). The Oxford Dictionary of Statistical Terms. Oxford University Press. Oxford. ISBN 0-19-920613-9.

Dogan, D., Bogosyan, S., & Acarman, T. (2019). Evaluation of driver stress level with survey, galvanic skin response sensor data, and force-sensing resistor data. *Advances in Mechanical Engineering, 11*(*12)*. https://doi:10.1177/1687814019891555

Dolan, R. J. (2002). Emotion, cognition, and behavior. *science*, *298*(5596), 1191-1194.

Donker, T., van Straten, A., Marks, I., & Cuijpers, P. (2011). Quick and easy self-rating of Generalised Anxiety Disorder: validity of the Dutch web-based GAD-7, GAD-2 and GAD-SI. *Psychiatry research*, *188*(1), 58-64.

Doody, O., & Noonan, M. (2013). Preparing and conducting interviews to collect data. *Nurse researcher*, *20*(5), 1-10.

Dragutinovic, N., & Twisk, D. (2006). The effectiveness of road safety education: A literature review. *SWOV Institute for Road Safety Research*.

Driskell, J. (2022). Pathways to Anxiety. *All About Anxiety: An Introductory Guide to Neuroscience, Assessment, and Intervention*.

Driving and Vehicle Licensing Agency. (2024). Anxiety and Driving. Retrieved from: https://www.gov.uk/anxiety-and-driving

Droździel, P., Tarkowski, S., Rybicka, I., & Wrona, R. (2020). Drivers' reaction time research in the conditions in the real traffic. *Open Engineering*, *10*(1), 35-47.

Drummond, A. E. (2000). Paradigm lost! Paradigm gained? An Australian's perspective on the novice driver problem. Presented at the Novice Drivers Conference, Bristol, UK.

Du, N., Kim, J., Zhou, F., Pulver, E., Tilbury, D. M., Robert, L. P. & Yang, X. J. (2020). Evaluating effects of cognitive load, takeover request lead time, and traffic density on drivers' takeover performance in conditionally automated driving. In *12th international conference on automotive user interfaces and interactive vehicular applications* (pp. 66-73).

Dubey, R., & Gunasekaran, A. (2015). The role of truck driver on sustainable transportation and logistics. *Industrial and commercial training*, *47*(3), 127-134.

Dula, C. S., Adams, C. L., Miesner, M. T., & Leonard, R. L. (2010). Examining relationships between anxiety and dangerous driving. *Accident Analysis & Prevention*, *42*(6), 2050-2056.

Duncan, J., Williams. P., & Brown, 1. (1991). Components of driving skill: experience does not mean expertise. *Ergonomics, 34*,919-937.

Dunning, D., Johnson, K., Ehrlinger, J., & Kruger, J. (2003). Why people fail to recognize their own incompetence. *Current Directions in Psychological Science, 12*, 83-87.

Dutke, S., & Stöber, J. (2001). Test anxiety, working memory, and cognitive performance: Supportive effects of sequential demands. *Cognition & Emotion*, *15*(3), 381-389.

Eboli, L., Mazzulla, G., & Pungillo, G. (2016). Combining speed and acceleration to define car users' safe or unsafe driving behaviour. *Transportation research part C: emerging technologies*, *68*, 113-125.

EDA DATA ANALYSIS & CORRECTION. (2016). *Biopac*. Retrieved from http://www.andrewengell.com/wiki/lib/exe/fetch.php?media = kpnl:biopac:biopac-eda-webinar-pt-1-eur-q-and-a.pdf

Edwards, E. J., Edwards, M. S., & Lyvers, M. (2015). Cognitive trait anxiety, situational stress, and mental effort predict shifting efficiency: Implications for attentional control theory. *Emotion*, *15*(3), 350.

Egloff, B., & Hock, M. (2001). Interactive effects of state anxiety and trait anxiety on emotional Stroop interference. *Personality and Individual Differences*, *31*(6), 875-882.

Ehlers, A., Hackmann, A., & Michael, T. (2004). Intrusive re-experiencing in post-traumatic stress disorder: Phenomenology, theory, and therapy. *Memory*, *12*(4), 403-415.

Ehlers, A., Hofmann, S. G., Herda, C. A., & Roth, W. T. (1994). Clinical characteristics of driving phobia. *Journal of Anxiety Disorders*, *8*(4), 323-339.

Ehlers, A., Mayou, R. A., & Bryant, B. (1998). Psychological predictors of chronic posttraumatic stress disorder after motor vehicle accidents. *Journal of abnormal psychology*, *107*(3), 508.

Ehlers, A., Taylor, J. E., Ehring, T., Hofmann, S. G., Deane, F. P., Roth, W. T., & Podd, J. V. (2007). The driving cognitions questionnaire: Development and preliminary psychometric properties. *Journal of anxiety disorders*, *21*(4), 493-509.

Ehrlinger, J., & Dunning, D. (2003). How chronic self-views influence (and potentially mislead) estimates of performance. Journal of Personality and Social Psychology, 84, 5-17.

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia, 45*(1), 15–31.

Elander, J., West, R., & French, D. (1993) *Behavioral correlates of individual differences in road traffic crash risk: an examination of methods and findings. Psychological Bulletin, 113*(2), 279–294.

Elflien. J. (2024). Deadliest animals worldwide by annual number of human deaths as of 2022. *Statista.* https://www.statista.com/statistics/448169/deadliest-creatures-in-the-world-by-number-of-human-deaths/

Elliman, N. A., Green, M. W., Rogers, P. J., & Finch, G. M. (1997). Processing-efficiency theory and the working-memory system: Impairments associated with sub-clinical anxiety. *Personality and Individual differences*, *23*(1), 31-35.

Ellis, A. (1962). Reason and emotion in psychotherapy.

Elphinston, R. A., Vaezipour, A., Fowler, J. A., Russell, T. G., & Sterling, M. (2023). Psychological therapy using virtual reality for treatment of driving phobia: a systematic review. *Disability and rehabilitation*, *45*(10), 1582-1594.

Emmel, N., Monaghan, M., Manzano, A., & Greenhalgh, J. (2018). Doing realist research. *Doing Realist Research*, 1-272.

Emmelkamp, P. M. G. (1982). *Phobic and obsessive-compulsive disorders: Theory, research, and practice.* NY.: Plenum.

Endler, N. S., & Kocovski, N. L. (2001). State and trait anxiety revisited. *Journal of anxiety disorders*, *15*(3), 231-245.

Endriulaitienė, A., Šeibokaitė, L., Markšaitytė, R., Slavinskienė, J., & Arlauskienė, R. (2020). Changes in beliefs during driver training and their association with risky driving. *Accident Analysis & Prevention*, *144*, 105583.

Endsley, M. R. (2021). Situation awareness. *Handbook of human factors and ergonomics*, 434-455.

Engelberg, J. K., Hill, L. L., Rybar, J., & Styer, T. (2015). Distracted driving behaviors related to cell phone use among middle-aged adults. *Journal of Transport & Health, 2*(3), 434-440.

Engström, J., Johansson, E., & Östlund, J. (2005). Effects of visual and cognitive load in real and simulated motorway driving. Transportation Research Part F: Traffic Psychology and Behaviour, 8(2), 97-120.

Engström, J., Markkula, G., Victor, T., & Merat, N. (2017). Effects of cognitive load on driving performance: The cognitive control hypothesis. *Human factors*, *59*(5), 734-764.

Evans, D., & Akinwuntan, E. (2017). Driving simulation as a clinical intervention tool. In S. Classen (Ed.), *Driving simulation for assessment, intervention, and training* (*pp. 133–141)*. American Occupational Therapy Association Press.

Evans, J. R., & Mathur, A. (2005). The value of online surveys. *Internet research, 15*(2), 195-219.

Evans, J. R., & Mathur, A. (2018). The value of online surveys: A look back and a look ahead. *Internet research*, *28*(4), 854-887.

Evans, L. (2004). *Traffic Safety. Science Serving Society.* Bloomfield Hills, Michigan.

Eysenck, M. W. (1992). *Anxiety: The cognitive perspective.* Hove, UK: Erlbaum.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition & emotion*, *6*(6), 409-434.

Eysenck, M. W., & Derakshan, N. (2011). New perspectives in attentional control theory. *Personality and Individual Differences*, *50*(7), 955-960.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion*, *7*(2), 336.

Faber, M., Radvansky, G. A., & D'Mello, S. K. (2018). Driven to distraction: A lack of change gives rise to mind wandering. *Cognition*, *173*, 133-137.

Fairclough, S. H., Tattersall, A. J., & Houston, K. (2006). Anxiety and performance in the British driving test. *Transportation Research Part F: Traffic Psychology and Behaviour*, *9*(1), 43-52.

Fan, J., McCandliss, B. D., Fossella, J., Flombaum, J. I., & Posner, M. I. (2005). The activation of attentional networks. *Neuroimage*, *26*(2), 471-479.

Farhane-Medina, N. Z., Luque, B., Tabernero, C., & Castillo-Mayén, R. (2022). Factors associated with gender and sex differences in anxiety prevalence and comorbidity: A systematic review. *Science Progress*, *105*(4), 00368504221135469.

Fazlıoğulları, O. (2012). Scientific research paradigms in social sciences. *International Journal of Educational Policies*, *6*(1), 41-55.

Febriandirza, A., Chaozhong, W., Zhong, M., Hu, Z., & Zhang, H. (2017). The Effect of Natural Sounds and Music on Driving Performance and Physiological. *Engineering letters*, *25*(4).

Fell, J., Chaieb, L., & Hoppe, C. (2023). Mind wandering in anxiety disorders: a status report. *Neuroscience & Biobehavioral Reviews*, 105432.

Figner, B., & Murphy, R. O. (2011). Using skin conductance in judgment and decision making research. *A handbook of process tracing methods for decision research*, 163-184.

Filstead, W. J. (1979). Qualitative methods: A needed perspective in evaluation research. *Qualitative and quantitative methods in evaluation research*, *1*.

Fine, A., Nasiri, K., Fotinos, K., Anand, L., Furtado, M., Armata, R. S., Badali, K., Mincer, J., Mincer, M., Epstein, I., Cameron, C., Guthrie, A., Cook, S., Laidlow, B., Sternat, T., & Katzman, M. A. (2018). Examining predictors of help-seeking behaviours in patients with mood and anxiety symptoms. *Psychiatry Research, 265*, 190–197. https://doi.org/10.1016/j.psychres.2018.04.040

Finn, P., & Bragg, B. W. (1986). Perception of the risk of an accident by young and older drivers. *Accident Analysis & Prevention*, *18*(4), 289-298.

Fisa, R., Musukuma, M., Sampa, M., Musonda, P., & Young, T. (2022). Effects of interventions for preventing road traffic crashes: an overview of systematic reviews. *BMC public health*, *22*(1), 513.

Fischer, C., Heider, J., Schröder, A., & Taylor, J. E. (2020). “Help! I’m afraid of driving!” review of driving fear and its treatment. *Cognitive Therapy and Research*, *44*, 420-444.

Fischhoff, B., Gonzalez, R. M., Lerner, J. S., & Small, D. A. (2005). Evolving judgments of terror risks: foresight, hindsight, and emotion. *Journal of Experimental Psychology: Applied*, *11*(2), 124.

Fisher, D. L., Pollatsek, A. P., & Pradhan, A. (2006). Can novice drivers be trained to scan for information that will reduce their likelihood of a crash?. *Injury prevention*, *12*(1), i25-i29.

Fisher, R. A. (1919). XV.—The correlation between relatives on the supposition of Mendelian inheritance. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, *52*(2), 399-433.

Flaskerud (2022) Catastrophising at 3 a.m., *Issues in Mental Health Nursing,* DOI: 10.1080/01612840.2022.2140538

Foa, E. B., & Meadows, E. A. (1997). Psychosocial treatments for posttraumatic stress disorder: A critical review. *Annual review of psychology*, *48*(1), 449-480.

Foa, E. B., & Meadows, E. A. (1997). Psychosocial treatments for posttraumatic stress disorder: A critical review. *Annual review of psychology, 48*(1), 449-480.

Forbes, S., Birkett, H., Evans, L., Chung, H., & Whiteman, J. (2020). Managing employees during the COVID-19 pandemic: Flexible working and the future of work.

Forster, S., Nunez Elizalde, A. O., Castle, E., & Bishop, S. J. (2015). Unraveling the anxious mind: anxiety, worry, and frontal engagement in sustained attention versus off-task processing. *Cerebral Cortex*, *25*(3), 609-618.

Fort, A., Collette, B., Evennou, M., Jallais, C., Charbotel, B., Stephens, A. N., & Hidalgo-Muñoz, A. (2021). Avoidance and personal and occupational quality of life in French people with driving anxiety. *Transportation research part F: traffic psychology and behaviour*, *80*, 49-60.

Fort, A., Evennou, M., Jallais, C., Charbotel, B., & Hidalgo-Muñoz, A. (2023). A prevalence study of driving anxiety in France. *Journal of Transport & Health*, *32*, 101657.

Francis, J. J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M. P., & Grimshaw, J. M. (2010). What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychology and health*, *25*(10), 1229-1245.

Freeman, J., Wishart, D., Davey, J., Rowland, B., & Williams, R. (2009). Utilising the driver behaviour questionnaire in an Australian organisational fleet setting: can it identify risky drivers?. *Journal of the Australasian College of Road Safety*, *20*(2), 38-45.

Freuli, F., De Cet, G., Gastaldi, M., Orsini, F., Tagliabue, M., Rossi, R., & Vidotto, G. (2020). Cross-cultural perspective of driving style in young adults: Psychometric evaluation through the analysis of the Multidimensional Driving Style Inventory. *Transportation research part F: traffic psychology and behaviour*, *73*, 425-432.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: a latent-variable analysis. *Journal of experimental psychology: General*, *133*(1), 101.

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: current use, calculations, and interpretation. *Journal of experimental psychology: General*, *141*(1), 2.

Fuchs, C., & Diamantopoulos, A. (2009). Using single-item measures for construct measurement in management research: Conceptual issues and application guidelines. *Die Betriebswirtschaft*, *69*(2), 195.

Funahashi, S., & Andreau, J. M. (2013). Prefrontal cortex and neural mechanisms of executive function. *Journal of Physiology-Paris*, *107*(6), 471-482.

Gabrielsson, A., & Lindström, E. (2001). The influence of musical structure on emotional expression. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion: Theory and research* (pp. 223–248). New York: Oxford University Press.

Gallo, J. J., Rebok, G. W., & Lesikar, S. E. (1999). The driving habits of adults aged 60 years and older. *Journal of the American Geriatrics Society*, *47*(3), 335-341.

Garner, A. A., Fine, P. R., Franklin, C. A., Sattin, R. W., & Stavrinos, D. (2011). Distracted driving among adolescents: challenges and opportunities. *Injury Prevention*, *17*(4), 285-285.

Garrity, R. D., & Demick, J. (2001). Relations among personality traits, mood states, and driving behaviors. *Journal of Adult Development, 8*(2), 109- 118.

Geen, R. G. (1998). Processes and personal variables in affective aggression. In *Human aggression* (pp. 1-21). Academic Press.

Gelgele, H. L., & Wang, K. (1998). An expert system for engine fault diagnosis: development and application. *Journal of Intelligent Manufacturing*, *9*, 539-545.

George, D., & Mallery, P. (2019). *IBM SPSS statistics 26 step by step: A simple guide and reference*. Routledge.

Gibson, C. B., Gilson, L. L., Griffith, T. L., & O'Neill, T. A. (2023). Should employees be required to return to the office?. *Organizational Dynamics*, *52*(2), 100981.

Gil-Carvajal, J. C., Jo, E. S., Park, D. C., Song, W., & Jeong, C. H. (2024). Driving simulator using virtual reality tools combining sound, vision, vibration, and motion. *Applied Acoustics*, *224*, 110137

Glaser, B., & Strauss, A. (1967). *The Discovery of grounded theory: Strategies for*

Godley, S. T., Triggs, T. J., & Fildes, B. N. (2002). Driving simulator validation for speed research. *Accident analysis & prevention*, *34*(5), 589-600.

Goodman, F. R., Kelso, K. C., Wiernik, B. M., & Kashdan, T. B. (2021). Social comparisons and social anxiety in daily life: An experience-sampling approach. *Journal of abnormal psychology*, *130*(5), 468.

Goodwin, H., Yiend, J., & Hirsch, C. R. (2017). Generalised Anxiety Disorder, worry and attention to threat: A systematic review. *Clinical psychology review*, *54*, 107-122.

Goodwin, R. D., Weinberger, A. H., Kim, J. H., Wu, M., & Galea, S. (2020). Trends in anxiety among adults in the United States, 2008–2018: Rapid increases among young adults. *Journal of psychiatric research*, *130*, 441-446.

Gössling, S., Cohen, S. A., & Hares, A. (2016). Inside the black box: EU policy officers' perspectives on transport and climate change mitigation. *Journal of Transport Geography*, *57*, 83-93.

Gotardi, G. C., Polastri, P. F., Schor, P., Oudejans, R. R., van der Kamp, J., Savelsbergh, G. J. & Rodrigues, S. T. (2019). Adverse effects of anxiety on attentional control differ as a function of experience: A simulated driving study. *Applied ergonomics*, *74*, 41-47.

Gotardi, G., Schor, P., van der Kamp, J., Navarro, M., Orth, D., Savelsbergh, G. & Rodrigues, S. T. (2018). The influence of anxiety on visual entropy of experienced drivers. In *Proceedings of the 3rd Workshop on Eye Tracking and Visualization* (pp. 1-4).

Grafton, B., Southworth, F., Watkins, E., & MacLeod, C. (2016). Stuck in a sad place: Biased attentional disengagement in rumination. *Emotion*, *16*(1), 63.

Granié, M. A., & Papafava, E. (2011). Gender stereotypes associated with vehicle driving among French preadolescents and adolescents. *Transportation Research Part F: Traffic Psychology and Behaviour*, *14*(5), 341-353.

Gravetter, F. J., & Wallnau, L. B. (2014). Introduction to the t statistic. *Essentials of statistics for the behavioral sciences*, *8*(252).

Greco, A., Valenza, G., Scilingo, E. P., Greco, A., Valenza, G., & Scilingo, E. P. (2016). Modeling for the Analysis of the EDA. *Advances in Electrodermal Activity Processing with Applications for Mental Health: From Heuristic Methods to Convex Optimization*, 19-33.

Green, M., & Senders, J. W. (1999). *Human error in road accidents.*

Greenberg, J., Tijerina, L., Curry, R., Artz, B., Cathey, L., Kochhar, D. & Grant, P. (2003). Driver distraction: Evaluation with event detection paradigm. *Transportation Research Record*, *1843*(1), 1-9.

Gregory, R. L. (1968). Perceptual illusions and brain models. *Proceedings of the Royal Society of London. Series B. Biological Sciences*, *171*(1024), 279-296.

Grilo, A. M., Ferreira, A. C., Ramos, M. P., Carolino, E., Pires, A. F., & Vieira, L. (2022). Effectiveness of educational videos on patient's preparation for diagnostic procedures: Systematic review and Meta-Analysis. *Preventive medicine reports*, *28*, 101895.

Groarke, J. M., Groarke, A., Hogan, M. J., Costello, L., & Lynch, D. (2020). Does listening to music regulate negative affect in a stressful situation? Examining the effects of self-selected and researcher-selected music using both silent and active controls. *Applied Psychology: Health and Well-Being*, *12*(2), 288-311.

Groeger, J. A. (2000). *Understanding driving: Applying cognitive psychology to a complex everyday task*. Psychology Press.

Groeger, J. A. (2013). *Understanding driving: Applying cognitive psychology to a complex everyday task*. Routledge.

Grös, D. F., Antony, M. M., Simms, L. J., & McCabe, R. E. (2007). Psychometric properties of the state-trait inventory for cognitive and somatic anxiety (STICSA): comparison to the state-trait anxiety inventory (STAI). *Psychological assessment*, *19*(4), 369.

Gross, E., & Stone, G. P. (1964). Embarrassment and the analysis of role requirements. *American Journal of Sociology*, *70*(1), 1-15.

Gross, P. R., & Eifert, G. H. (1990). Components of generalised anxiety: The role of intrusive thoughts vs worry. *Behaviour research and therapy*, *28*(5), 421-428.

Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: an integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience*, *14*(7), 488-501.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*, *2*(163-194), 105.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field methods*, *18*(1), 59-82.

Gugerty, L. (1997). Situation awareness during driving: Explicit and implicit knowledge in dynamic spatial memory. *Journal of Experimental Psychology: Applied, 3*, 42–66

Guo, Y., Sun, Q., Su, Y., Guo, Y., & Wang, C. (2021). Can driving condition prompt systems improve passenger comfort of intelligent vehicles? A driving simulator study. *Transportation research part F: traffic psychology and behaviour*, *81*, 240-250.

Gupta, L., Goswami, S., & Kumar, R. (2021). Analysis of driver behaviours towards road safety measures using DBQ in the Indian context. *Transactions on transport sciences*, *12*(1).

Gwyther, H., & Holland, C. (2012). The effect of age, gender and attitudes on self-regulation in driving. *Accident Analysis & Prevention*, *45*, 19-28.

Gwyther, H., & Holland, C. (2014). Feelings of vulnerability and effects on driving behaviour–A qualitative study. *Transportation research part F: traffic psychology and behaviour*, *24*, 50-59.

Haddington, P. (2010). Turn-taking for turntaking: Mobility, time, and action in the sequential organization of junction negotiations in cars. *Research on Language and Social Interaction*, *43*(4), 372-400.

Haleem, K., & Abdel-Aty, M. (2010). Examining traffic crash injury severity at unsignalised intersections. *Journal of safety research*, *41*(4), 347-357.

Hallion, L. S., & Ruscio, A. M. (2011). A meta-analysis of the effect of cognitive bias modification on anxiety and depression. *Psychological bulletin*, *137*(6), 940.

Hancock, G. M., Hancock, P. A., & Janelle, C. M. (2012). The impact of emotions and predominant emotion regulation technique on driving performance. *Work*, *41*, 3608-3611.

Handley, A. K., Egan, S. J., Kane, R. T., & Rees, C. S. (2014). The relationships between perfectionism, pathological worry and generalised anxiety disorder. *BMC psychiatry*, *14*(1), 1-8.

Hardy, L., Beattie, S., & Woodman, T. (2007). Anxiety-induced performance catastrophes: Investigating effort required as an asymmetry factor. British journal of psychology, 98(1), 15-31.

Hartanto, A., & Yang, H. (2022). Testing theoretical assumptions underlying the relation between anxiety, mind wandering, and task-switching: A diffusion model analysis. *Emotion*, *22*(3), 493.

Harvey, A. R., & Carden, R. L. (2009). Driving error and anxiety related to iPod mp3 player use in a simulated driving experience. *Perceptual and motor skills*, *109*(1), 159-167.

Hashempour, S., & Mehrad, A. (2014). The effect of anxiety and emotional intelligence on students' learning process. *Journal of Education & Social Policy*, *1*(2), 115-122.

Haustein, S., Humpe, A., & Gössling, S. (2022). Risky and anxious-aggressive drivers: A key barrier to traffic safety legislation in Germany. *Transportation research part F: traffic psychology and behaviour*, *89*, 84-96.

Hays, D. G., & Wood, C. (2011). Infusing qualitative traditions in counseling research designs. *Journal of Counseling & Development*, *89*(3), 288-295.

He, W., Wang, X., Xu, C., Zheng, Z., & Mao, Y. (2022). Hazard perception in driving style based on virtual reality technology PREPRINT (Version 1). *Research Square*. Available at https://doi.org/10.21203/rs.3.rs-1440454/v1

Heidinger, J., Bernhardt, L., & Franke, T. (2023, September). Ecosimlab-A Low-Cost Driving Simulator Environment for Examining Human Factors in Vehicle Energy Efficiency. In *Adjunct Proceedings of the 15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 66-70).

Heinig, I., Wittchen, H. U., & Knappe, S. (2021). Help-seeking behavior and treatment barriers in anxiety disorders: Results from a representative German community survey. *Community Mental Health Journal, 57*(8), 1505–1517. https://doi.org/10.1007/s10597-020-00767-5

Helland, A., Lydersen, S., Lervåg, L. E., Jenssen, G. D., Mørland, J., & Slørdal, L. (2016). Driving simulator sickness: Impact on driving performance, influence of blood alcohol concentration, and effect of repeated simulator exposures. *Accident Analysis & Prevention*, *94*, 180-187.

Helman, S., & Reed, N. (2015). Validation of the driver behaviour questionnaire using behavioural data from an instrumented vehicle and high-fidelity driving simulator. *Accident Analysis & Prevention*, *75*, 245-251.

Hempel, M. E., Taylor, J. E., Connolly, M. J., Alpass, F. M., & Stephens, C. V. (2017). Scared behind the wheel: What impact does driving anxiety have on the health and wellbeing of young older adults? *International Psychogeriatrics, 29*(6), 1–8. https://doi.org/10.1017/S1041610216002271

Hickman, J. S., Hanowski, R. J., & Bocanegra, J. (2010). *Distriaction in Commercial Trucks and Buses: Assessing Prevalence and Risk in Conjunction with Crashes and Near-*

crashes. US Department of Transportation, Federal Motor Carrier Safety Administration, Office of Analysis, Research and Technology.

Hidalgo-Muñoz, A. R., Evennou, M., Collette, B., Stephens, A. N., Jallais, C., & Fort, A. (2021). Cognitive and body manifestations of driving anxiety according to different onsets. *Anxiety, Stress, & Coping*, *34*(6), 778-793.

Hidalgo-Muñoz, A. R., Jallais, C., Evennou, M., & Fort, A. (2023). Driving anxiety and anxiolytics while driving: Their impacts on behaviour and cognition behind the wheel. *Heliyon*.

Hilakivi, I., Veilahti, J., Asplund, P., Sinivuo, J., Laitinen, L., & Koskenvuo, K. (1989). A sixteen-factor personality test for predicting automobile driving accidents of young drivers. *Accident Analysis & Prevention*, *21*(5), 413-418.

Hill, A., Horswill, M. S., Whiting, J., & Watson, M. O. (2019). Computer-based hazard perception test scores are associated with the frequency of heavy braking in everyday driving. *Accident Analysis & Prevention*, *122*, 207-214.

Hill, J. D., & Boyle, L. N. (2007). Driver stress as influenced by driving maneuvers and roadway conditions. *Transportation Research Part F: Traffic Psychology and Behaviour*, *10*(3), 177-186.

Hinds, J. A., & Sanchez, E. R. (2022). The role of the hypothalamus–pituitary–adrenal (HPA) axis in test-induced anxiety: assessments, physiological responses, and molecular details. *Stresses*, *2*(1), 146-155.

Hjelmborg, J. V., Iachine, I., Skytthe, A., Vaupel, J. W., McGue, M., Koskenvuo, M. & Christensen, K. (2006). Genetic influence on human lifespan and longevity. *Human genetics*, *119*, 312-321.

Hoehn-Saric, R. (2007). Physiologic responses in anxiety. *Current Psychiatry Reviews*, *3*(3), 196-204.

Hoehn-Saric, R., & McLeod, D. R. (2000). Anxiety and arousal: physiological changes and their perception. *Journal of affective disorders*, *61*(3), 217-224.

Hoel, J., Jaffard, M., Boujon, C., & Van Elslande, P. (2011). Different forms of attentional disturbances involved in driving accidents. *IET intelligent transport systems*, *5*(2), 120-126.

Hoffman, D. L., Dukes, E. M., & Wittchen, H. U. (2008). Human and economic burden of generalised anxiety disorder. *Depression and anxiety*, *25*(1), 72-90.

Hoffman, Y., & Rosenbloom, T. (2016). Driving experience moderates the effect of implicit versus explicit threat priming on hazard perception test. *Accident Analysis & Prevention*, *92*, 82-88.

Hölig, C., & Berti, S. (2010). To switch or not to switch: Brain potential indices of attentional control after task-relevant and task-irrelevant changes of stimulus features. *Brain research*, *1345*, 164-175.

Home Office. (2006). *The Emergency Workers* (*Obstruction) Act.* https://www.gov.uk/government/publications/the-emergency-workers-obstruction-act-2006

Hood, H. K., & Antony, M. M. (2012). Evidence-based assessment and treatment of specific phobias in adults. *Intensive one-session treatment of specific phobias*, 19-42.

Hood, H. K., & Antony, M. M. (2012). Evidence-based assessment and treatment of specific phobias in adults. *Intensive one-session treatment of specific phobias,* 19-42.

Hopko, D. R., Ashcraft, M. H., Gute, J., Ruggiero, K. J., & Lewis, C. (1998). Mathematics anxiety and working memory: Support for the existence of a deficient inhibition mechanism. *Journal of anxiety disorders*, *12*(4), 343-355.

Horrey, W. J., & Wickens, C. D. (2007). In-vehicle glance duration: distributions, tails, and model of crash risk. *Transportation research record*, *2018*(1), 22-28.

Horrey, W. J., Wickens, C. D., & Consalus, K. P. (2006). Modeling drivers' visual attention allocation while interacting with in-vehicle technologies. *Journal of Experimental Psychology: Applied*, *12*(2), 67.

Horswill, M. S. (2016). Hazard perception in driving. *Current Directions in Psychological Science*, *25*(6), 425-430.

Horswill, M. S. (2016). Hazard perception in driving. *Current Directions in Psychological Science*, *25*(6), 425-430.

Horswill, M. S., & Helman, S. (2003). A behavioral comparison between motorcyclists and a matched group of non-motorcycling car drivers: factors influencing accident risk. *Accident Analysis and Prevention, 35*(4), 589-597.

Horswill, M. S., & McKenna, F. P. (1999). The development, validation, and application of a video-based technique for measuring an everyday risk-taking behaviour: drivers' speed choice. Journal of Applied Psychology, 84(6), 977- 985.

Horswill, M. S., Hill, A., & Wetton, M. (2015). Can a video-based hazard perception test used for driver licensing predict crash involvement? *Accident Analysis and Prevention, 82*(23), 213–219.

Horvers, A., Tombeng, N., Bosse, T., Lazonder, A. W., & Molenaar, I. (2021). Detecting emotions through electrodermal activity in learning contexts: A systematic review. *Sensors*, *21*(23), 7869.

Huang, Y. W., Lin, P. C., & Wang, J. (2018). The influence of bus and taxi drivers' public self-consciousness and social anxiety on aberrant driving behaviors. *Accident Analysis & Prevention*, *117*, 145-153.

Huang, Y., & May, A. D. (1991). Accident prediction models and applications for signalised junctions. *Intersections without traffic signals II.* Springer. 282-296.

Hudda, N., Simon, M. C., Patton, A. P., & Durant, J. L. (2020). Reductions in traffic-related black carbon and ultrafine particle number concentrations in an urban neighborhood during the COVID-19 pandemic. *Science of the Total Environment*, *742*, 140931.

Hughes, G. M., Rudin-Brown, C. M., & Young, K. L. (2013). A simulator study of the effects of singing on driving performance. *Accident Analysis & Prevention*, *50*, 787-792.

Hull, M., and Christie, R. (1992), ‘Hazard perception test: The Geelong trial and future development’, in Proceedings of the National Road Safety Seminar, Wellington, New Zealand.

Huo, D., Ma, J., & Chang, R. (2020). Lane-changing-decision characteristics and the allocation of visual attention of drivers with an angry driving style. *Transportation research part F: traffic psychology and behaviour*, *71*, 62-75.

Hurvich, M. (2000). Fear of being overwhelmed and psychoanalytic: theories of anxiety. *Psychoanalytic review*, *87*(5), 615-649.

Ikeda, M., Iwanaga, M., & Seiwa, H. (1996). Test anxiety and working memory system. *Perceptual and motor skills*, *82*(3_suppl), 1223-1231.

Inhoff, A. W., & Radach, R. (1998). Definition and computation of oculomotor measures in the study of cognitive processes. *Eye guidance in reading and scene perception*, 29-53.

Institute for Government Analysis. (2022). Timeline of UK government coronavirus lockdowns and restrictions. *Institute for Government.* Retrieved from: https://www.instituteforgovernment.org.uk/data-visualisation/timeline-coronavirus-lockdowns

Isler, R. B., Starkey, N. J., & Sheppard, P. (2011). Effects of higher-order driving skill training on young, inexperienced drivers’ on-road driving performance. *Accident Analysis & Prevention*, *43*(5), 1818-1827.

Jamshed, S. (2014). Qualitative research method-interviewing and observation. *Journal of basic and clinical pharmacy, 5*(4), 87.

Jann, B., & Coutts, E. (2017). Social Status and Peer-Punishment: Findings from Two Road Traffic Field Experiments. *Social Dilemmas, Institutions, and the Evolution of Cooperation*, 259-277.

Jeon, M., Walker, B. N., & Yim, J. B. (2014). Effects of specific emotions on subjective judgment, driving performance, and perceived workload. *Transportation research part F: traffic psychology and behaviour*, *24*, 197-209.

Jonah, B. A. (1997). Sensation seeking and risky driving: a review and synthesis of the literature. *Accident Analysis & Prevention*, *29*(5), 651-665.

Jones, M. P., Chapman, P., & Bailey, K. (2014). The influence of image valence on visual attention and perception of risk in drivers. *Accident Analysis & Prevention*, *73*, 296-304.

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: Developing a framework for a qualitative semi-structured interview guide. *Journal of advanced nursing*, *72*(12), 2954-2965.

Kan, F. P., Raoofi, S., Rafiei, S., Khani, S., Hosseinifard, H., Tajik, F. & Ghashghaee, A. (2021). A systematic review of the prevalence of anxiety among the general population during the COVID-19 pandemic. *Journal of affective disorders, 293*, 391-398.

Katrakazas, C., Michelaraki, E., Sekadakis, M., & Yannis, G. (2020). A descriptive analysis of the effect of the COVID-19 pandemic on driving behavior and road safety. *Transportation research interdisciplinary perspectives, 7*, 100186.

Katyal, S., & Fleming, S. M. (2024). Gender and anxiety reveal distinct computational sources of underconfidence. https://doi.org/10.31234/osf.io/5w2vd

Katyal, S., Huys, Q. J., Dolan, R., & Fleming, S. M. (2023). How underconfidence is maintained in the face of reality. *PsyARXiv Preprints.* https://doi.org/10.31234/osf.io/qcg92

Kaussner, Y., Kuraszkiewicz, A. M., Schoch, S., Markel, P., Hoffmann, S., Baur-Streubel, R., Kenntner-Mabiala, R., & Pauli, P. (2020). Treating patients with driving phobia by virtual reality exposure therapy–A pilot study. *PLoS One, 15*(1), e0226937–14. https://doi.org/10.1371/journal.pone.0226937

Kazdin, A. E. (2000). Encyclopedia of psychology: 8 volume set. In *Am Psychol Assoc* (Vol. 2011, p. 4128).

Kegelaers, J., & Oudejans, R. R. (2024). Pressure makes diamonds? A narrative review on the application of pressure training in high-performance sports. *International Journal of Sport and Exercise Psychology*, *22*(1), 141-159.

Kelsey, M., Palumbo, R. V., Urbaneja, A., Akcakaya, M., Huang, J., Kleckner, I. R., Barrett, L. F., Quigley, K., Sejdic, E., & Goodwin, M. S. (2017, May 5). *Artifact detection in electrodermal activity using sparse recovery* [Paper presentation]. Compressive Sensing VI: From Diverse Modalities to Big Data Analytics. https://doi.org/10.1117/12.2264027

Kenow, L. J., & Williams, J. M. (1992). Relationship between anxiety, self-confidence, and evaluation of coaching behaviors. *The Sport Psychologist*, *6*(4), 344-357.

Kessler, R. C., Mickelson, K. D., & Williams, D. R. (1999). The prevalence, distribution, and mental health correlates of perceived discrimination in the United States. *Journal of health and social behavior*, 208-230.

Kessler, R. C., Mickelson, K. D., & Williams, D. R. (1999). The prevalence, distribution, and mental health correlates of perceived discrimination in the United States. *Journal of health and social behavior*, 208-230.

Keusch, F. (2013). The role of topic interest and topic salience in online panel web surveys. *International Journal of Market Research*, *55*(1).

Khan, K., Zaidi, S. B., & Ali, A. (2020). Evaluating the nature of distractive driving factors towards road traffic accident. *Civil Engineering Journal*, *6*(8), 1555-1580.

Khawaja, N. G., & Chapman, D. (2007). Cognitive predictors of worry in a non-clinical population. *Clinical Psychologist*, *11*(1), 24-32.

Kinnear, N., Kelly, S. W., Stradling, S., & Thomson, J. (2013). Understanding how drivers learn to anticipate risk on the road: A laboratory experiment of affective anticipation of road hazards. *Accident Analysis & Prevention*, *50*, 1025-1033.

Kiriakou, S. (2020). Graduated Driver Licensing: California Program. *Casebook of Traumatic Injury Prevention*, 351-362.

Kirkwood, T. B. (2017). Why and how are we living longer?. *Experimental physiology*, *102*(9), 1067-1074.

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of higher education*, *6*(5), 26-41.

Knott, M., Kim, S. H., Vander Veen, A., Angeli, E., Evans, E., Knight, W. & Alvarez, L. (2021). Driving simulator, virtual reality, and on-road interventions for driving-related anxiety: a systematic review. *Occupational Therapy in Mental Health*, *37*(2), 178-205.

Knox, S., & Burkard, A. W. (2014). Qualitative research interviews: An update. In *Quantitative and qualitative methods in psychotherapy research* (pp. 342-354). Routledge.

Koch, H., Knight, A., Payne, L., & Thorns, T. (2011). Continuing Professional Development: Managing travel phobia and anxiety. *British Journal of Wellbeing*, *2*(4), 41-44.

Koch, W. J., & Taylor, S. (1995). Assessment and treatment of motor vehicle accident victims. *Cognitive and Behavioral Practice*, *2*(2), 327-342.

Konstantopoulos, P., Chapman, P., & Crundall, D. (2010). Driver's visual attention as a function of driving experience and visibility. Using a driving simulator to explore drivers' eye movements in day, night and rain driving. *Accident analysis & prevention*, *42*(3), 827-834.

Korstjens, I., & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. *European Journal of General Practice*, *24*(1), 120-124.

Korthouwer, A., Noordberg, D., & Treur, J. (2021). Desensitization Due to Overstimulation: A Second-Order Adaptive Network Model. In *Computational Science–ICCS 2021: 21st International Conference, Krakow, Poland, June 16–18, 2021, Proceedings, Part II 21* (pp. 238-249). Springer International Publishing.

Kottenhoff, H. (1961). Interrelations of steering skill measures in neurotic and other patients. *Perceptual and Motor Skills, 12*, 289-290.

Koustanaï, A., Cavallo, V., Delhomme, P., & Mas, A. (2012). Simulator training with a forward collision warning system: Effects on driver-system interactions and driver trust. *Human factors*, *54*(5), 709-721.

Kraus, J., Scholz, D., Messner, E. M., Messner, M., & Baumann, M. (2020). Scared to trust?–predicting trust in highly automated driving by depressiveness, negative self-evaluations and state anxiety. *Frontiers in Psychology*, *10*, 2917.

Krause, A. E., Scott, W. G., Flynn, S., Foong, B., Goh, K., Wake, S. & Garvey, D. (2023). Listening to music to cope with everyday stressors. *Musicae Scientiae*, *27*(1), 176-192.

Krumhansl, C. L. (1997). An exploratory study of musical emotions and psychophysiology. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *51*(4), 336.

Krumhansl, C. L. (2002). Music: A link between cognition and emotion. *Current directions in psychological science*, *11*(2), 45-50.

Krumpal, I. (2013). Determinants of social desirability bias in sensitive surveys: a literature review. *Quality & Quantity*, *47*(4), 2025-2047.

Kuch, K., Cox, B. J., Evans, R., & Shulman, I. (1994). Phobias, panic, and pain in 55 survivors of road vehicle accidents. *Journal of Anxiety Disorders*, *8*(2), 181-187.

Kuhl, J., & Beckmann, J. (Eds.). (2012). *Action control: From cognition to behavior*. Springer Science & Business Media.

Kwan, T. Y. W. (2001). *Speed and the probability of a collision* (Doctoral dissertation, University of British Columbia).

Lajunen, T., & Özkan, T. (2011). Self-report instruments and methods. In *Handbook of traffic psychology* (pp. 43-59). Academic Press.

Lajunen, T., & Summala, H. (1995). Driving experience, personality, and skill and safety-motive dimensions in drivers' self-assessments. *Personality and Individual Differences, 19*(3), 307–318. https://doi.org/10.1016/0191- 8869(95)00068-H

Lajunen, T., Corry, A., Summala, H., & Hartley, L. (1998). Cross-cultural differences in drivers' self-assessments of their perceptual-motor and safety skills: Australians and Finns. *Personality and Individual differences*, *24*(4), 539-550.

Lajunen, T., Parker, D., & Summala, H. (2004). The Manchester driver behaviour questionnaire: a cross-cultural study. *Accident Analysis & Prevention*, *36*(2), 231-238.

Lajunen, T., Sullman, M. J., & Gaygısız, E. (2022). Self-assessed driving skills and risky driver behaviour among young drivers: a cross-sectional study. *Frontiers in psychology*, *13*, 840269.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in psychology, 4*, 863.

Land, M., & Horwood, J. (1995). Which parts of the road guide steering?. *Nature*, *377*(6547), 339-340.

Lang, Y., Wei, L., Xu, F., Zhao, Y., & Yu, L. F. (2018, March). Synthesising personalised training programs for improving driving habits via virtual reality. In *2018 IEEE conference on virtual reality and 3D user interfaces* (*VR)* (pp. 297-304). IEEE.

Larue, G. S., Blackman, R., & Freeman, J. (2019). Impact of hesitations on risky driver behaviour at railway level crossings. In *Proceedings of the 20th Congress of the International Ergonomics Association* (*IEA 2018) Volume VI: Transport Ergonomics and Human Factors* (*TEHF), Aerospace Human Factors and Ergonomics 20* (pp. 62-69). Springer International Publishing.

Laurier, E. (2005). Searching for a parking space. Intellectica, 41–42(2–3), 101–116.

Lawton, R., Parker, D., Manstead, A. S., & Stradling, S. G. (1997). The role of affect in predicting social behaviors: The case of road traffic violations. *Journal of applied social psychology*, *27*(14), 1258-1276.

Lazarus, R. S. (1984). *Stress, appraisal, and coping* (Vol. 464). Springer.

Leal, N., Watson, B., Armstrong, K., & King, M. (2007). Enhancing road safety for young drivers: How Graduated Driver Licensing initiatives can complement “anti-hooning” legislation. *and Subtitle*, 339.

Ledesma, R. D., Montes, S. A., Poó, F. M., & López-Ramón, M. F. (2010). Individual differences in driver inattention: the attention-related driving errors scale. *Traffic injury prevention*, *11*(2), 142-150.

LeDoux, J. (2015). *Anxious: The modern mind in the age of anxiety*. Simon and Schuster. Oneworld Publications. London.Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current directions in psychological science*, *11*(5), 181-185.

Lee, G., Choi, B., Jebelli, H., Ryan Ahn, C., & Lee, S. (2020). Noise reference signal–based denoising method for EDA collected by multimodal biosensor wearable in the field. *Journal of Computing in Civil Engineering*, *34*(6), 04020044.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear-end collisions in a high-fidelity driving simulator. *Human factors*, *44*(2), 314-334.

Lee, J. D., Regan, M. A., & Horrey, W. J. (2020). Workload, distraction, and automation. *Handbook of Human Factors for Automated, Connected, and Intelligent Vehicles*, 107-125.

Lee, Y. C., Lee, J. D., & Boyle, L. N. (2007). Visual attention in driving: The effects of cognitive load and visual disruption. *Human Factors*, *49*(4), 721-733.

Lemonnier, S., Brémond, R., & Baccino, T. (2014). Discriminating cognitive processes with eye movements in a decision-making driving task. *Journal of Eye Movement Research*, *7*(4).

Lenth, R. V., Bolker, B., Buerkner, P., Giné-Vázquez, I., Herve, M., Jung, M., Love, J., Miguez, F., Riebl, H., & Singmann, H. (2023). emmeans: Estimated Marginal Means, aka Least-Squares Means (1.8.7) [Computer software]. https://cran.rproject.org/web/packages/emmeans/index.html

Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. *Journal of personality and social psychology*, *81*(1), 146.

Leung, C. J., Yiend, J., Trotta, A., & Lee, T. M. (2022). The combined cognitive bias hypothesis in anxiety: A systematic review and meta-analysis. *Journal of Anxiety Disorders*, *89*, 102575.

Levine, B. A., & Wolpe, J. (1980). In vivo desensitization of a severe driving phobia through radio contact. *Journal of Behavior Therapy and Experimental Psychiatry*, *11*(4), 281-282.

Li, W., Guan, J., & Shi, W. (2021). Increasing the load on executive working memory reduces the search performance in the natural scenes: Evidence from eye movements. *Current Psychology*, 1-14.

Li, X., Oviedo-Trespalacios, O., Rakotonirainy, A., & Yan, X. (2019). Collision risk management of cognitively distracted drivers in a car-following situation. *Transportation research part F: traffic psychology and behaviour*, *60*, 288-298.

Li, Y., Yuan, W., Zhang, S., Yan, W., Shen, Q., Wang, C., & Yang, M. (2024). Choose your simulator wisely: A review on open-source simulators for autonomous driving. *IEEE Transactions on Intelligent Vehicles*.

Lichtenstein-Vidne, L., Okon-Singer, H., Cohen, N., Todder, D., Aue, T., Nemets, B., & Henik, A. (2017). Attentional bias in clinical depression and anxiety: the impact of emotional and non-emotional distracting information. *Biological psychology*, *122*, 4-12.

Lim, P. C., Sheppard, E., & Crundall, D. (2014). A predictive hazard perception paradigm differentiates driving experience cross-culturally. *Transportation research part F: traffic psychology and behaviour*, *26*, 210-217.

Lim, T., Stephens, A. N., & Sheppard, D. (2022). Personality and demographic differences in the perceived risks of potentially timid driving behaviours. *Transportation research part F: traffic psychology and behaviour*, *88*, 197-207.

Liu, N., Nikitas, A., & Parkinson, S. (2020). Exploring expert perceptions about the cyber security and privacy of Connected and Autonomous Vehicles: A thematic analysis approach. *Transportation research part F: traffic psychology and behaviour*, *75*, 66-86.

Liu, S., Zhao, W., Shanks, D. R., Hu, X., Luo, L., & Yang, C. (2024). Effects of Test Anxiety on Self-Testing and Learning Performance. *Educational Psychology Review*, *36*(2), 1-38.

Lloyd, C. E. (2023). Stories matter: A novel approach to exploring perceptions, discourses, and the symbolic social order in pastoral psychology. *Pastoral Psychology*, *72*(2), 317-336.

LoBue, V. (2014). Deconstructing the snake: the relative roles of perception, cognition, and emotion on threat detection. *Emotion*, *14*(4), 701.

Lochbaum, M., Stoner, E., Hefner, T., Cooper, S., Lane, A. M., & Terry, P. C. (2022). Sport psychology and performance meta-analyses: A systematic review of the literature. *PloS one*, *17*(2), e0263408.

Londoño-Kent, P. (2009), *Freight Transport for Development Toolkit: Road Freight* , World Bank, Washington, DC.

Love, S., Larue, G. S., & Rowland, B. (2024). Development and validation of the Driver Attention Regulation Scale: A measure of the perceived ability to regulation attention on the road. *Transportation research part F: traffic psychology and behaviour*, *102*, 199-212.

Love, S., Truelove, V., Rowland, B., & Kannis-Dymand, L. (2022). Metacognition and self-regulation on the road: A qualitative approach to driver attention and distraction. *Applied Cognitive Psychology*, *36*(6), 1312-1324.

Löwe, B., Decker, O., Müller, S., Brähler, E., Schellberg, D., Herzog, W., & Herzberg, P. Y. (2008). Validation and standardization of the Generalised Anxiety Disorder Screener (GAD-7) in the general population. *Medical care*, *46*(3), 266-274.

Lowe, M. L., Loveland, K. E., & Krishna, A. (2019). A quiet disquiet: Anxiety and risk avoidance due to nonconscious auditory priming. *Journal of Consumer Research*, *46*(1), 159-179.

Lucidi, F., Giannini, A. M., Sgalla, R., Mallia, L., Devoto, A., & Reichmann, S. (2010). Young novice driver subtypes: relationship to driving violations, errors and lapses. *Accident Analysis & Prevention*, *42*(6), 1689-1696.

Lucidi, F., Girelli, L., Chirico, A., Alivernini, F., Cozzolino, M., Violani, C., & Mallia, L. (2019). Personality traits and attitudes toward traffic safety predict risky behavior across young, adult, and older drivers. *Frontiers in psychology*, *10*, 536.

Machin, M. A., & Sankey, K. S. (2008). Relationships between young drivers' personality characteristics, risk perceptions, and driving behaviour. *Accident analysis & prevention*, *40*(2), 541-547.

Mackenzie, A. K. (2016). *Eye movements and driving: insights into methodology, individual differences and training* (Doctoral dissertation, University of St Andrews).

Mackenzie, A. K., & Harris, J. M. (2017). A link between attentional function, effective eye movements, and driving ability. *Journal of experimental psychology: human perception and performance*, *43*(2), 381.

Madill, A., Jordan, A., & Shirley, C. (2000). Objectivity and reliability in qualitative analysis: Realist, contextualist and radical constructionist epistemologies. *British journal of psychology*, *91*(1), 1-20.

Magee, J. C., & Teachman, B. A. (2012). Distress and recurrence of intrusive thoughts in younger and older adults. *Psychology and aging*, *27*(1), 199.

Mahoney, A. E., Hobbs, M. J., Newby, J. M., Williams, A. D., Sunderland, M., & Andrews, G. (2016). The Worry Behaviors Inventory: Assessing the behavioral avoidance associated with generalised anxiety disorder. *Journal of Affective Disorders*, *203*, 256-264.

Mahoney, C. T., Segal, D. L., & Coolidge, F. L. (2015). Anxiety sensitivity, experiential avoidance, and mindfulness among younger and older adults: Age differences in risk factors for anxiety symptoms. *The International Journal of Aging and Human Development, 81*(4), 217-240.

Majeed, N. M., Chua, Y. J., Kothari, M., Kaur, M., Quek, F. Y., Ng, M. H. & Hartanto, A. (2023). Anxiety disorders and executive functions: A three-level meta-analysis of reaction time and accuracy. *Psychiatry Research Communications*, *3*(1), 100100.

Malone, S., & Brünken, R. (2020). Studying gaze behavior to compare three different hazard perception tasks. *Human factors*, *62*(8), 1286-1303.

Maloney, E. A., Sattizahn, J. R., & Beilock, S. L. (2014). Anxiety and cognition. *Wiley Interdisciplinary Reviews: Cognitive Science*, *5*(4), 403-411.

Mann, R. E., Asbridge, M., Stoduto, G., Smart, R. G., Goldbloom, D. S., Vingilis, E. R., & Wickens, C. M. (2010). Psychological distress and collision involvement among adult drivers. *Stress and Health: Journal of the International Society for the Investigation of Stress*, *26*(2), 127-134.

Mäntylä, T., Karlsson, M. J., & Marklund, M. (2009). Executive control functions in simulated driving. *Applied neuropsychology*, *16*(1), 11-18.

Mao, Y., Wang, X., He, W., & Pan, G. (2023). Improving hazard perception for drivers based on driving styles with visual alerts. *Transportation research part F: traffic psychology and behaviour*, *97*, 367-382.

Marottoli, R. A., & Richardson, E. D. (1998). Confidence in, and self-rating of, driving ability among older drivers. *Accident Analysis & Prevention*, *30*(3), 331-336.

Marottoli, R. A., de Leon, C. F. M., Glass, T. A., Williams, C. S., Cooney, L. M., Jr., & Berkman, L. F. (2000). Consequences of driving cessation: Decreased out-of-home activity levels. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences,55*, S334–S340.

Mars, L., Arroyo, R., & Ruiz, T. (2016). Qualitative research in travel behavior studies. *Transportation research procedia*, *18*, 434-445.

Martín-delosReyes, L. M., Jiménez-Mejías, E., Martínez-Ruiz, V., Moreno-Roldán, E., Molina-Soberanes, D., & Lardelli-Claret, P. (2019). Efficacy of training with driving simulators in improving safety in young novice or learner drivers: A systematic review. *Transportation research part F: traffic psychology and behaviour*, *62*, 58-65.

Martin, I., & Venables, P. H. (Eds.). (1980). Techniques in psychophysiology. Chichester, United Kingdom: Wiley.

Martins, L. A., Schiavo, A., Paz, L. V., Xavier, L. L., & Mestriner, R. G. (2024). Neural Underpinnings of Fine Motor Skills Under Stress and Anxiety: A Review. *Physiology & Behavior*, 114593.

Martinussen, L. M., Hakamies-Blomqvist, L., Møller, M., Özkan, T., & Lajunen, T. (2013). Age, gender, mileage and the DBQ: The validity of the Driver Behavior Questionnaire in different driver groups. *Accident Analysis & Prevention*, *52*, 228-236.

Martinussen, L. M., Møller, M., & Prato, C. G. (2014). Assessing the relationship between the Driver Behavior Questionnaire and the Driver Skill Inventory: Revealing sub-groups of drivers. *Transportation research part F: traffic psychology and behaviour, 26*, 82-91.

Massie, D. L., Campbell, K. L., & Williams, A. F. (1995). Traffic accident involvement rates by driver age and gender. *Accident Analysis & Prevention*, *27*(1), 73-87.

Mathew, R. J., Weinman, M. L., Semchuk, K. M., & Levin, B. L. (1982). Driving phobia in the city of Houston: A pilot study. *The American journal of psychiatry*.

Mathews, A., & Mackintosh, B. (1998). A cognitive model of selective processing in anxiety. *Cognitive therapy and research*, *22*(6), 539-560.

Mathews, A., Fox, E., Yiend, J., & Calder, A. (2003). The face of fear: Effects of eye gaze and emotion on visual attention. *Visual cognition*, *10*(7), 823-835.

Matthews, G. (2001). A transactional model of driver stress. *Stress, workload, and fatigue*, 133-163.

Matthews, G. (2002). Towards a transactional ergonomics for driver stress and fatigue. *Theoretical Issues in Ergonomics Science*, *3*(2), 195-211.

Matthews, G., Dorn, L., Hoyes, T.W., Davies, D.R., Glendon, A.I., & Taylor, R.G. (1998) Driver stress and performance on a driving simulator. *Human Factors, 40*, 136-149.

Matthews, M. L. & Moran, A. R. (1986). Age differences in male drivers' perception of accident risk: the role of perceived driving ability. Accident Analysis and Prevention, 18, 299-313

Maurin, M., Bracco, M., Le Pape, S., Lienhart, N., Bossard, C., Doron, J., & Martinent, G. (2024). Attentional Fo*CI* and Coping Strategies During Matches of Young Fencers in a Training Center: A Naturalistic Video-Assisted Study. *The Sport Psychologist*, *1*(aop), 1-13.

Mayhew, D. R. (2007). Driver education and graduated licensing in North America: Past, present, and future. *Journal of safety research*, *38*(2), 229-235.

Mayou, R. A., Simkin, S., & Threlfall, J. (1991). The effects of road traffic accidents on driving behaviour. *Injury*, *22*(5), 365-368.

McCartt, A. T., Shabanova, V. I., & Leaf, W. A. (2003). Driving experience, crashes and traffic citations of teenage beginning drivers. *Accident Analysis & Prevention*, *35*(3), 311-320.

McClean, S. (2016). *Learning to drive into the now: PRND*. Author's Republic.

McEvoy, P. M., Grove, R., & Slade, T. (2011). Epidemiology of anxiety disorders in the Australian general population: findings of the 2007 Australian National Survey of Mental Health and Wellbeing. *Australian & New Zealand Journal of Psychiatry*, *45*(11), 957-967.

McKenna F. P., Crick J. L. (1991). *Hazard perception in drivers: A methodology for testing and training* (Report No. CR313). Berkshire, UK: Transport Research Laboratory.

McKenna, F., & Crick, J. (1991a). Experience and expertise in hazard perception. In *Behavioural Research in Road Safety. Proceedings of a Seminar Held at Nottingham University, 26-27 September 1990* (No. PA 2038/91).

McManus, S., Bebbington, P. E., Jenkins, R., & Brugha, T. (2016). *Mental health and wellbeing in england: The adult psychiatric morbidity survey 2014*. NHS digital.

McNaughton, N., & Gray, J. A. (2000). Anxiolytic action on the behavioural inhibition system implies multiple types of arousal contribute to anxiety. *Journal of affective disorders*, *61*(3), 161-176.

Megías, A., Maldonado, A., Catena, A., Di Stasi, L. L., Serrano, J., & Cándido, A. (2011). Modulation of attention and urgent decisions by affect-laden roadside advertisement in risky driving scenarios. *Safety Science*, *49*(10), 1388-1393.

Mellings, T. M., & Alden, L. E. (2000). Cognitive processes in social anxiety: The effects of self-focus, rumination and anticipatory processing. *Behaviour research and therapy*, *38*(3), 243-257.

Menelas, B. A. J., Haidon, C., Ecrepont, A., & Girard, B. (2018). Use of virtual reality technologies as an Action-Cue Exposure Therapy for truck drivers suffering from Post-Traumatic Stress Disorder. *Entertainment computing*, *24*, 1-9.

Meng, F., Wong, S. C., Yan, W., Li, Y. C., & Yang, L. (2019). Temporal patterns of driving fatigue and driving performance among male taxi drivers in Hong Kong: A driving simulator approach. *Accident Analysis & Prevention*, *125*, 7-13.

Mercado-Diaz, L. R., Veeranki, Y. R., Marmolejo-Ramos, F., & Posada-Quintero, H. F. (2024). EDA-Graph: Graph Signal Processing of Electrodermal Activity for Emotional States Detection. *IEEE Journal of Biomedical and Health Informatics*.

Michell, J. (2003). The quantitative imperative: Positivism, naïve realism and the place of qualitative methods in psychology. *Theory & Psychology*, *13*(1), 5-31.

Michon, J. A. (1985). A critical view of driver behavior models: What do we know, what should we do?. In L. Evans & R. C. Schwing (Eds.), *Human Behavior and Traffic Safety* (pp. 485–524). Springer.

Michon, J. A. (1985). A critical view of driver behavior models: what do we know, what should we do?. In *Human behavior and traffic safety* (pp. 485-524). Boston, MA: Springer US.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual review of neuroscience*, *24*(1), 167-202.

Milleville-Pennel, I., & Charron, C. (2015). Driving for real or on a fixed-base simulator: is it so different? An explorative study. *Presence*, *24*(1), 74-91.

Mills, K. L., Hall, R. D., McDonald, M., and Rolls, G. W. P. (1998), 'The effects of hazard perception training on the development of novice driver skills', Research Report. London: Department for Transport, UK. Available at: http://www.dft.gov.uk.

Miloyan, B., Bulley, A., & Suddendorf, T. (2019). Anxiety: here and beyond. *Emotion Review*, *11*(1), 39-49.

Mirón-Juárez, C. A., García-Hernández, C., Ochoa-Ávila, E., & Díaz-Grijalva, G. R. (2020). Approaching to a structural model of impulsivity and driving anger as predictors of risk behaviors in young drivers. *Transportation research part F: traffic psychology and behaviour*, *72*, 71-80.

Missell-Gray, R., & Simning, A. (2024). Driving cessation and late-life depressive and anxiety symptoms: Findings from the national health and aging trends study. *Clinical Gerontologist*, *47*(2), 224-233.

Mitsopoulos-Rubens, E., Triggs, T., & Regan, M. (2009, June). Comparing the gap acceptance and turn time patterns of novice with experienced drivers for turns across traffic. In *Driving assessment conference* (Vol. 5, No. 2009). University of Iowa.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex frontal lobe tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49- 100.

Mogg, K., & Bradley, B. P. (2016). Anxiety and attention to threat: Cognitive mechanisms and treatment with attention bias modification. *Behaviour research and therapy*, *87*, 76-108.

Mogg, K., & Bradley, B. P. (2018). Anxiety and threat-related attention: Cognitive-motivational framework and treatment. *Trends in cognitive sciences*, *22*(3), 225-240.

Mogg, K., McNamara, J., Powys, M., Rawlinson, H., Seiffer, A., & Bradley, B. P. (2000). Selective attention to threat: A test of two cognitive models of anxiety. *Cognition & Emotion*, *14*(3), 375-399.

Mohamad, N. A. (2022). Stress and anxiety on the road: The silent victims and their sufferings. *Journal of Advanced Vehicle System*, *13*(1), 57-69.

Molnar, L. J., Eby, D. W., Charlton, J. L., Langford, J., Koppel, S., Marshall, S., & Man-Son-Hing, M. (2013). Reprint of “Driving avoidance by older adults: Is it always self-regulation?”. *Accident Analysis & Prevention*, *61*, 272-280.

Morgan, J. F., & Hancock, P. A. (2011). The effect of prior task loading on mental workload: An example of hysteresis in driving. *Human factors*, *53*(1), 75-86.

Morgan, T. (2023). A social identity approach to social prescribing: developing a community prescribing toolkit to minimise disengagement by facilitating social identification PhD thesis. *Nottingham Trent University.* https://irep.ntu.ac.uk/id/eprint/51733

Moták, L., Gabaude, C., Bougeant, J. C., & Huet, N. (2014). Comparison of driving avoidance and self-regulatory patterns in younger and older 107 drivers. *Transportation research part F: traffic psychology and behaviour, 26*, 18-27

Mourant, R. R., & Rockwell, T. H. (1970). Visual Information Seeking of Novice Drivers. SAE Technical Paper Series.

Muela, I., Chica, A. B., Garcia-Fernandez, P., & Castro, C. (2021). Visual attention in realistic driving situations: Attentional capture and hazard prediction. *Applied ergonomics*, *90*, 103235.

Mueller, J. A. (2015). Driving in a simulator versus on-road: The effect of increased mental effort while driving on real roads and a driving simulator PhD thesis. *Montana State University.*

Muir-Cochrane, E., O'Kane, D., & Harrison, K. (2017). The person who experiences anxiety. In *Psychiatric and Mental Health Nursing* (pp. 215-224). Routledge.

Mullen, R., & Hardy, L. (2000). State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, *18*(10), 785-799.

Mullen, R., Faull, A., Jones, E. S., & Kingston, K. (2012). Attentional focus and performance anxiety: Effects on simulated race-driving performance and heart rate variability. *Frontiers in psychology*, *3*, 426.

Munjack, D. J. (1984). The onset of driving phobias. *Journal of Behavior Therapy and Experimental Psychiatry*, *15*(4), 305-308.

Muttart, J. W., & Fisher, D. L. (2016). The differences in hazard mitigation responses implemented by novice and experienced drivers. In *Handbook of Teen and Novice Drivers* (pp. 105-124). CRC Press.

Naatanen, R., & Summala, H. (1974). A model for the role of motivational factors in drivers' decision-making. Accident Analysis & Prevention, 6(3-4), 243-261.

Naito, A., Miyajima, C., Nishino, T., Kitaoka, N., & Takeda, K. (2009, November). Driver evaluation based on classification of rapid decelerating patterns. In *2009 IEEE International Conference on Vehicular Electronics and Safety* (*ICVES)* (pp. 108-112). IEEE.

Najmi, S., Kuckertz, J. M., & Amir, N. (2012). Attentional impairment in anxiety: inefficiency in expanding the scope of attention. *Depression and anxiety*, *29*(3), 243-249.

Najström, M., & Jansson, B. (2006). Unconscious responses to threatening pictures: Interactive effect of trait anxiety and social desirability on skin conductance responses. *Cognitive behaviour therapy*, *35*(1), 11-18.

Najström, M., & Jansson, B. (2007). Skin conductance responses as predictor of emotional responses to stressful life events. *Behaviour research and therapy*, *45*(10), 2456-2463.

Nassif, Y., & Wells, A. (2014). Attention training reduces intrusive thoughts cued by a narrative of stressful life events: A controlled study. *Journal of clinical psychology*, *70*(6), 510-517.

National Advanced Driving Simulator. (2020). University of Iowa. Retrieved from: https://www.nads-sc.uiowa.edu/userweb/veit/NADSMiniSim_TechnicalDescription.pdf

National Institute for Health and Care Excellence. (2019). Generalised anxiety disorder and panic disorder in adults: management. Assessed from: https://www.ncbi.nlm.nih.gov/books/NBK552847/

Naveh, Y., Weiss, P., & Ratzon, N. Z. (2014). Affordable driving simulation for use in a rehabilitation setting: preliminary findings. *Israeli J. Occup. Ther*, *23*.

Navon, M., & Taubman–Ben-Ari, O. (2019). Driven by emotions: The association between emotion regulation, forgivingness, and driving styles. *Transportation research part F: traffic psychology and behaviour*, *65*, 1-9.

Nayak, M. S. D. P., & Narayan, K. A. (2019). Strengths and weakness of online surveys. *IOSR Journal of Humanities and Social Science*, *24*(5), 31-38.

Neerincx, M.A. (2003). Cognitive task load design: model, methods and examples. In: E. Hollnagel (ed.), Handbook of Cognitive Task Design. Chapter 13 (pp. 283-305). Mahwah, NJ: Lawrence Erlbaum Associates Notes

New, J., Cosmides, L., & Tooby, J. (2007). Category-specific attention for animals reflects ancestral priorities, not expertise. Proceedings of the National Academy of Sciences of the United States of America, 104(42), 16598–16603.

Newbold, K. B., & Scott, D. M. (2017). Driving over the life course: the automobility of Canada's millennial, generation X, baby boomer and greatest generations. *Travel behaviour and society*, *6*, 57-63.

Newman, M. G., & Llera, S. J. (2011). A novel theory of experiential avoidance in generalised anxiety disorder: A review and synthesis of research supporting a contrast avoidance model of worry. *Clinical psychology review*, *31*(3), 371-382.

Ni, J., Chen, J., Xie, W., & Shao, Y. (2024). The impacts of the traffic situation, road conditions, and driving environment on driver stress: a systematic review. *Transportation research part F: traffic psychology and behaviour*, *103*, 141-162.

Nieuwenhuys, A., & Oudejans, R. R. (2012). Anxiety and perceptual-motor performance: toward an integrated model of concepts, mechanisms, and processes. *Psychological research*, *76*, 747-759.

Nieuwenhuys, A., & Oudejans, R. R. D. (2011). Training with anxiety: Short- and long-term effects on police officers' shooting behavior under pressure. *Cognitive Processing, 12*, 277–288.

Nieuwenhuys, A., Pijpers, J. R., Oudejans, R. R. D., & Bakker, F. C. (2008). The influence of anxiety on visual attention in climbing. *Journal of Sport & Exercise Psychology, 30*, 171–185.

Niezgoda, M., Kamiński, T., Kruszewski, M., & Tarnowski, A. (2013). Self-reported drivers' behaviour: an application of DBQ in Poland. *Journal of KONES*, *20*(1), 233-238.

Nilsson, R. (2000). Drivers' impressions of front and rear gaps in queues. *Ergonomics*, *43*(12), 1985-2000.

Niranjan, S., Gabaldon, J., Hawkins, T. G., Gupta, V. K., & McBride, M. (2022). The influence of personality and cognitive failures on distracted driving behaviors among young adults. *Transportation research part F: traffic psychology and behaviour*, *84*, 313-329.

Nodehi, Z., Mehdizadeh, H., Azad, A., Mehdizadeh, M., Reyhanian, E., Saberi, Z. S., & Taghizadeh, G. (2021). Anxiety and cognitive load affect upper limb motor control in Parkinson's disease during medication phases. *Annals of the New York Academy of Sciences*, *1494*(1), 44-58.

Nola, R., & Irzik, G. (2006). *Philosophy, science, education and culture* (Vol. 28). Springer Science & Business Media.

Nordfjærn, T., & Rundmo, T. (2013). Road traffic safety beliefs and driver behaviors among personality subtypes of drivers in the Norwegian population. *Traffic injury prevention*, *14*(7), 690-696.

Norman, D. A. (1983). Design rules based on analyses of human error. *Communications of the ACM*, *26*(4), 254-258.

Normann, N., & Morina, N. (2018). The efficacy of metacognitive therapy: A systematic review and meta-analysis. *Frontiers in Psychology, 9*, 2211.

Notebaert, L., Georgiades, J. V., Herbert, M., Grafton, B., Parsons, S., Fox, E., & MacLeod, C. (2020). Trait anxiety and the alignment of attentional bias with controllability of danger. *Psychological Research, 84*(3), 743–756. https://doi.org/10.1007/s00426-018-1081-9

Notebaert, L., Masschelein, S., Wright, B., & MacLeod, C. (2016). To risk or not to risk: Anxiety and the calibration between risk perception and danger mitigation. *Journal of experimental psychology: learning, memory, and cognition*, *42*(6), 985.

Noteboom, J. T., Barnholt, K. R., & Enoka, R. M. (2001). Activation of the arousal response and impairment of performance increase with anxiety and stressor intensity. *Journal of applied physiology*.

Nuthmann, A. (2017). Fixation durations in scene viewing: Modeling the effects of local image features, oculomotor parameters, and task. *Psychonomic bulletin & review*, *24*(2), 370-392.

O'Brien, F., Bible, J., Liu, D., & Simons-Morton, B. G. (2017). Do young drivers become safer after being involved in a collision?. *Psychological science*, *28*(4), 407-413.

Öhman, A. (1993). Fear and anxiety as emotional phenomena: Clinical phenomenology, evolutionary perspectives, and information-processing mechanisms.

Öhman, A. (2002). Automaticity and the amygdala: Nonconscious responses to emotional faces. *Current directions in psychological science*, *11*(2), 62-66.

Öhman, A. (2005). The role of the amygdala in human fear: automatic detection of threat. *Psychoneuroendocrinology*, *30*(10), 953-958.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: detecting the snake in the grass. *Journal of experimental psychology: general*, *130*(3), 466.

Ojsteršek, T. C., & Topolšek, D. (2019). Influence of drivers' visual and cognitive attention on their perception of changes in the traffic environment. European Transport Research Review, 11(1), 1-9

Okon-Singer, H. (2018). The role of attention bias to threat in anxiety: mechanisms, modulators and open questions. *Current opinion in behavioral sciences*, *19*, 26-30.

Olsen, E. C., Lee, S. E., & Simons-Morton, B. G. (2007). Eye Movement Patterns for Novice Teen Drivers. Transportation Research Record: Journal of the Transportation Research Board, 2009(1), 8-14.

Olson, R. L., Hanowski, R. J., Hickman, J. S., & Bocanegra, J. (2009). *Driver distraction in commercial vehicle operations* (No. FMCSA-RRT-09-042). United States. Department of Transportation. Federal Motor Carrier Safety Administration.

Oltedal, S., & Rundmo, T. (2006). The effects of personality and gender on risky driving behaviour and accident involvement. *Safety science, 44*(7), 621- 628.

Olvera, L. D., Guézéré, A., Plat, D., & Pochet, P. (2016). Earning a living, but at what price? Being a motorcycle taxi driver in a Sub-Saharan African city. *Journal of transport geography*, *55*, 165-174.

Omran, Y. H., Sadeghi-Bazargani, H., Yarmohammadian, M. H., & Atighechian, G. (2023). Driving hazard perception tests: a systematic review. *Bulletin of Emergency & Trauma*, *11*(2), 51.

Oreg, S., & Bayazit, M. (2009). Prone to bias: Development of a bias taxonomy from an individual differences perspective. *Review of General Psychology*, *13*(3), 175-193.

Ortuño-Sierra, J., Garcia-Velasco, L., Inchausti, F., Debbane, M., & Fonseca-Pedrero, E. (2016). New approaches on the study of the psychometric properties of the STAI. *Actas espanolas de psiquiatria*, *44*(3), 83-92.

Ouimet, A. J., Gawronski, B., & Dozois, D. J. (2009). Cognitive vulnerability to anxiety: A review and an integrative model. *Clinical psychology review*, *29*(6), 459-470.

Özbozdağlı, S. (2021). The effects of intentional and unintentional mind wandering and perceptual load on driving performance PhD thesis. *Middle East Technical University*.

Özkan, B., Azık, D., & Öz, B. (2024). Impact of Stereotype Threat on Evaluating Female Drivers' Skills. *Trends in Psychology*, 1-18.

Özkan, T., & Lajunen, T. (2011). Person and environment: Traffic culture. In *Handbook of traffic psychology* (pp. 179-192). Academic Press.

Özkan, T., Lajunen, T. and Summala, H. (2006) Driver Behaviour Questionnaire: A Follow-Up Study. *Accident Analysis & Prevention, 38*, 386-395. https://doi.org/10.1016/j.aap.2005.10.012

Özkan, T., Lajunen, T., Chliaoutakis, J. E., Parker, D., & Summala, H. (2006a). Cross-cultural differences in driving skills: A comparison of six countries. *Accident Analysis and Prevention, 38*(5), 1011e1018.

Özkan, T., Lajunen, T., Chliaoutakis, J. E., Parker, D., & Summala, H. (2006b). Cross-cultural differences in driving behaviours: A comparison of six countries. *Transportation research part F: traffic psychology and behaviour*, *9*(3), 227-242.

Paiva, K. M., Cardoso, M. R. A., & Zannin, P. H. T. (2019). Exposure to road traffic noise: Annoyance, perception and associated factors among Brazil's adult population. *Science of the Total Environment*, *650*, 978-986.

Palomba, D., Sarlo, M., Angrilli, A., Mini, A., & Stegagno, L. (2000). Cardiac responses associated with affective processing of unpleasant film stimuli. *International journal of psychophysiology*, *36*(1), 45-57.

Park, G. D., Allen, R. W., Rosenthal, T. J., & Fiorentino, D. (2005, September). Training effectiveness: How does driving simulator fidelity influence driver performance?.

In *Proceedings of the human factors and ergonomics society annual meeting* (Vol. 49, No. 25, pp. 2201-2205). Sage CA: Los Angeles, CA: SAGE Publications.

Parker, D., Macdonald, L., Sutcliffe, P., & Rabbitt, P. (2001). Confidence and the older driver. *Ageing & Society*, *21*(2), 169-182.

Parker, D., Reason, J. T., Manstead, A. S., & Stradling, S. G. (1995). Driving errors, driving violations and accident involvement. *Ergonomics*, *38*(5), 1036-1048.

Parrott, D. J., Zeichner, A., & Evces, M. (2005). Effect of trait anger on cognitive processing of emotional stimuli. *The Journal of General Psychology*, *132*(1), 67-80.

Payne, R. B., & Corley, T. J. (1994). Motivational effects of anxiety on psychomotor performance. *Perceptual and Motor Skills, 79,* 1507-1521.

Pêcher, C., Lemercier, C., & Cellier, J. M. (2009). Emotions drive attention: Effects on driver's behaviour. *Safety Science*, *47*(9), 1254-1259.

Pellichero, A., Lafont, S., Paire-Ficout, L., Fabrigoule, C., & Chavoix, C. (2021). Barriers and facilitators to social participation after driving cessation among older adults: A cohort study. *Annals of Physical and Rehabilitation Medicine*, *64*(2), 101373.

Pelz, D. C., & Krupat, E. (1974). Caution profile and driving record of undergraduate males. Accident Analysis & Prevention, 6(1), 45–58.

Penedo, T., Rodrigues, S. T., Gotardi, G. C., Simieli, L., Barela, J. A., Polastri, P. F., & Barbieri, F. A. (2023). Gaze behavior data in the vitrine of human movement science: considerations on eye-tracking technique. *Brazilian Journal of Motor Behavior*, *17*(4), 75-88.

Peng, G., & Qing, L. (2016). A new macro model of traffic flow by incorporating both timid and aggressive driving behaviors. *Modern Physics Letters B*, *30*(29), 1650351.

Peretz, I. (2001). Listen to the brain: A biological perspective on musical emotions. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion: Theory and research* (pp. 105–134). New York: Oxford University Press.

Peschard, V., & Philippot, P. (2017). Overestimation of threat from neutral faces and voices in social anxiety. *Journal of Behavior Therapy and Experimental Psychiatry*, *57*, 206-211.

Peterman, D. R. (2013, April). Federal traffic safety programs: An overview. *Library of Congress*. Congressional Research Service.

Petersen, G. B., Petkakis, G., & Makransky, G. (2022). A study of how immersion and interactivity drive VR learning. *Computers & Education*, *179*, 104429.

Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual review of neuroscience*, *35*(1), 73-89.

Pettigrew, S., Nelson, J. D., & Norman, R. (2020). Autonomous vehicles and cycling: Policy implications and management issues. *Transportation research interdisciplinary perspectives*, *7*, 100188.

Philip, P., Sagaspe, P., Taillard, J., Valtat, C., Moore, N., Akerstedt, T. & Bioulac, B. (2019). Fatigue, sleep restriction and driving performance. Accident Analysis & Prevention, 123, 309-324.

Picard, R. W., Vyzas, E., & Healey, J. (2001). Toward machine emotional intelligence: Analysis of affective physiological state. *IEEE transactions on pattern analysis and machine intelligence*, *23*(10), 1175-1191.

Pickering, D., Hall, R. D., & Grimmer, M. (1986). Accidents at Rural T-Junctions Research Report 65. *Transport and Road Research Laboratory, Department of Transport Crowthorne, Berkshire, England*.

Pollatsek, A., Fisher, D. L., & Pradhan, A. (2006). Identifying and remedying failures of selective attention in younger drivers. *Current Directions in Psychological Science*, *15*(5), 255-259.

Poó, F. M., Ledesma, R. D., & López, S. S. (2018). The taxi industry: Working conditions and health of drivers, a literature review. *Transport reviews*, *38*(3), 394-411.

Pop-Jordanova, N., & Pop-Jordanov, J. (2020). Electrodermal activity and stress assessment. *Prilozi*, *41*(2), 5-15.

Porter, M. M., Smith, G. A., Cull, A. W., Myers, A. M., Bédard, M., Gélinas, I. & Vrkljan, B. H. (2015). Older driver estimates of driving exposure compared to in-vehicle data in the Candrive II study. *Traffic injury prevention*, *16*(1), 24-27.

Posner, M. I. (2012). Attentional networks and consciousness. *Frontiers in psychology*, *3*, 64.

Posner, M. I., Rothbart, M. K., Sheese, B. E., & Tang, Y. (2007). The anterior cingulate gyrus and the mechanism of self-regulation. *Cognitive, Affective, & Behavioral Neuroscience, 7*(4), 391-395.

Pourabdian, S., & Azmoon, H. (2013). The relationship between trait anxiety and driving behavior with regard to self-reported Iranian accident involving drivers. *International journal of preventive medicine*, *4*(10), 1115.

Pourabdian, S., Azmoon, H., Mirlohi, A. H., & Hassnzadeh, A. (2014). Effect of state anxiety on driver behavior with regard to self-reported in Iranian drivers. *International Journal of Environmental Health Engineering*, *3*(1), 18.

Powers, M. B., Halpern, J. M., Ferenschak, M. P., Gillihan, S. J., & Foa, E. B. (2010). A meta-analytic review of prolonged exposure for posttraumatic stress disorder. *Clinical psychology review, 30*(6), 635-641.

Prabhakharan, P., Bennett, J. M., Hurden, A., & Crundall, D. (2024). The efficacy of hazard perception training and education: a systematic review and meta-analysis. *Accident Analysis & Prevention*, *202*, 107554.

Pronin, E., & Wegner, D. M. (2006). Manic thinking: Independent effects of thought speed and thought content on mood. Psychological Science, 17, 807–813.

Pronin, E., Jacobs, E., & Wegner, D. M. (2008). Psychological effects of thought acceleration. *Emotion*, *8*(5), 597.

Psychlab. (2017). Skin Conductance Explained. Retrieved from: http://psychlab.com/SC_explained.html

Qin, B., Huang, G., Yang, Q., Zhao, M., Chen, H., Gao, W., & Yang, M. (2019). Vortioxetine treatment for generalised anxiety disorder: a meta-analysis of anxiety, quality of life and safety outcomes. *BMJ open*, *9*(11), e033161.

qualitative research. Chicago, IL: Aldine Atherton.

Qualtrics. (2020). Received from: https://www.qualtrics.com/.

Quimby, A. R., & Watts, G. R. (1981). *Human factors and driving performance* (No. LR 1004 Monograph).

Rachman, S. J., & Wilson, G. T. (2013). The effects of psychological therapy: International series in experimental psychology (Vol. 24). Elsevier.

Raknes, S., Pallesen, S., Himle, J. A., Bjaastad, J. F., Wergeland, G. J., Hoffart, A. & Haugland, B. S. M. (2017). Quality of life in anxious adolescents. *Child and adolescent psychiatry and mental health*, *11*, 1-11.

Ranney, T. A. (1994). Models of driving behavior: a review of their evolution. *Accident analysis & prevention*, *26*(6), 733-750.

Rapoport, M. J., Chee, J. N., Prabha, T., Dow, J., Gillespie, I., Koppel, S. & Tant, M. (2023). A systematic review of the risks of motor vehicle crashes associated with psychiatric disorders. *The Canadian Journal of Psychiatry*, *68*(4), 221-240.

Rashid, S., & Yadav, S. S. (2020). Impact of Covid-19 pandemic on higher education and research. *Indian Journal of Human Development*, *14*(2), 340-343.

Ratering, C., Van Der Heijden, R., & Martens, K. (2024). Moving around with an anxiety disorder. *Transportation research part F: traffic psychology and behaviour*, *100*, 493-506.

Rauscher, F. H., Shaw, G. L., & Ky, K. N. (1993). Music and spatial task performance. *Nature, 365*, 611.

Ray, R. L., Singh, V. P., Singh, S. K., Acharya, B. S., & He, Y. (2022). What is the impact of COVID-19 pandemic on global carbon emissions?. *Science of The Total Environment*, *816*, 151503.

Reason, J., Manstead, A., Stradling, S., Baxter, J., & Campbell, K. (1990). Errors and violations on the roads: a real distinction?. *Ergonomics*, *33*(10-11), 1315-1332.

Recarte, M. A., & Nunes, L. M. (2003). Mental workload while driving: Effects on visual search, discrimination, and decision making. Journal of Experimental Psychology: Applied, 9(2), 119-137.

Reimer, B., D'Ambrosio, L. A., Coughlin, J. F., Kafrissen, M. E., & Biederman, J. (2006). Using self-reported data to assess the validity of driving simulation data. *Behavior research methods*, *38*(2), 314-324.

Reinhard, R. T., Kleer, M., & Dreßler, K. (2019). The impact of individual simulator experiences on usability and driving behavior in a moving base driving simulator. *Transportation research part F: traffic psychology and behaviour*, *61*, 131-140.

responses. *Transportation research part F: traffic psychology and behaviour*, *15*(3), 319-332.

Richards, H. J., Benson, V., Donnelly, N., & Hadwin, J. A. (2013). Exploring the function of selective attention and hypervigilance for threat in anxiety. *Clinical psychology review*, *34*(1), 1-13. doi: 10.1016/j.cpr.2013.10.006

Richards, H. J., Benson, V., Donnelly, N., & Hadwin, J. A. (2014). Exploring the function of selective attention and hypervigilance for threat in anxiety. *Clinical psychology review*, *34*(1), 1-13.

Rickels, K., & Rynn, M. A. (2001). What is generalised anxiety disorder?. *Journal of Clinical Psychiatry*, *62*, 4-14.

Riggle, E. D., Rostosky, S. S., & Reedy, C. S. (2005). Online surveys for BGLT research: Issues and techniques. *Journal of homosexuality*, *49*(2), 1-21.

Rimmö, P. A., & Hakamies-Blomqvist, L. (2002). Older drivers' aberrant driving behaviour, impaired activity, and health as reasons for self-imposed driving limitations. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(1), 47-62.

Ringhand, M., & Vollrath, M. (2019). Effect of complex traffic situations on route choice behaviour and driver stress in residential areas. *Transportation research part F: traffic psychology and behaviour*, *60*, 274-287.

Robinson, O. J., Charney, D. R., Overstreet, C., Vytal, K., & Grillon, C. (2012). The adaptive threat bias in anxiety: amygdala–dorsomedial prefrontal cortex coupling and aversive amplification. *Neuroimage*, *60*(1), 523-529.

Robinson, O. J., Letkiewicz, A. M., Overstreet, C., Ernst, M., & Grillon, C. (2011). The effect of induced anxiety on cognition: threat of shock enhances aversive processing in healthy individuals. *Cognitive, Affective, & Behavioral Neuroscience*, *11*(2), 217-227.

Robinson, O. J., Vytal, K., Cornwell, B. R., & Grillon, C. (2013). The impact of anxiety upon cognition: perspectives from human threat of shock studies. *Frontiers in human neuroscience*, *7*, 203.

Rodwell, D., Larue, G. S., Bates, L., & Haworth, N. (2020). What, who, and when? The perceptions that young drivers and parents have of driving simulators for use in driver education. *Safety*, *6*(4), 46.

Roidl, E., Frehse, B., & Höger, R. (2014). Emotional states of drivers and the impact on speed, acceleration and traffic violations—A simulator study. *Accident Analysis & Prevention*, *70*, 282-292.

Rosebrock, L. E., Hoxha, D., Norris, C., Cacioppo, J. T., & Gollan, J. K. (2016). Skin conductance and subjective arousal in anxiety, depression, and comorbidity. *Journal of Psychophysiology*.

Rossi, V., & Pourtois, G. (2017). Someone's lurking in the dark: The role of state anxiety on attention deployment to threat-related stimuli. *Biological psychology*, *122*, 21-32.

Rovetto, F. M. (1983). In vivo desensitization of a severe driving phobia through radio contact with telemonitoring of neurophysiological reactions. *Journal of behavior therapy and experimental psychiatry*, *14*(1), 49-54.

Rowden, P., Matthews, G., Watson, B., & Biggs, H. (2011). The relative impact of work-related stress, life stress and driving environment stress on driving outcomes. *Accident Analysis & Prevention*, *43*(4), 1332-1340.

Ryba, T. V., Wiltshire, G., North, J., & Ronkainen, N. J. (2022). Developing mixed methods research in sport and exercise psychology: Potential contributions of a critical realist perspective. *International Journal of Sport and Exercise Psychology*, *20*(1), 147-167.

Sachs-Ericsson, N. J., Sheffler, J. L., Stanley, I. H., Piazza, J. R., & Preacher, K. J. (2017). When emotional pain becomes physical: adverse childhood experiences, pain, and the role of mood and anxiety disorders. *Journal of clinical psychology*, *73*(10), 1403-1428.

Sachs-Ericsson, N. J., Sheffler, J. L., Stanley, I. H., Piazza, J. R., & Preacher, K. J. (2017). When emotional pain becomes physical: adverse childhood experiences, pain, and the role of mood and anxiety disorders. *Journal of clinical psychology, 73*(10), 1403-1428.

Sagberg, F. (2006). Driver health and crash involvement: A case-control study. *Accident Analysis & Prevention*, *38*(1), 28-34.

Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in human behavior*, *69*, 371-380.

Sainsbury, P., & Gibson, J. G. (1954). Symptoms of anxiety and tension and the accompanying physiological changes in the muscular system. *Journal of Neurology, Neurosurgery, and Psychiatry*, *17*(3), 216.

Salaheddin, K., & Mason, B. (2016). Identifying barriers to mental health help-seeking among young adults in the UK: A cross-sectional survey. *British Journal of General Practice, 66*(651), e686–e692. https://doi.org/10.3399/bjgp16X687313

Salayev, A. (2020). *Anxiety and Its Effects on Driving Performance Under Heavy Cognitive Load*. California State University, Long Beach.

Salvia, E., Petit, C., Champely, S., Chomette, R., Di Rienzo, F., & Collet, C. (2016). Effects of age and task load on drivers' response accuracy and reaction time when responding to traffic lights. *Frontiers in aging neuroscience*, *8*, 169.

Sander, D., Grafman, J., & Zalla, T. (2003). The human amygdala: an evolved system for relevance detection. *Reviews in the Neurosciences*, *14*(4), 303-316.

Sandu, A., & Unguru, E. (2017). Several conceptual clarifications on the distinction between constructivism and social constructivism. *Postmodern Openings/Deschideri Postmoderne*, *8*(2).

Sarason, S. B., & Lorentz, E. M. (1998). Crossing boundaries: Collaboration, coordination, and the redefinition of resources. Jossey-Bass Inc., Publishers, 350 Sansome Street, San Francisco, CA 94104-1310.

Sârbescu, P., & Rusu, A. (2021). Personality predictors of speeding: Anger-Aggression and Impulsive-Sensation Seeking. A systematic review and meta-analysis. *Journal of safety research*, *77*, 86-98.

Sari, B. A., Koster, E. H. W., Derakshan, N., Sari, B. A., Koster, E. H. W., & The, N. D. (2016). The effects of active worrying on working memory capacity. Cognition and Emotion, 31, 995–1003. http://dx.doi.org/10.1080/02699931.2016.1170668

Sari, B. A., Koster, E. H., & Derakshan, N. (2017). The effects of active worrying on working memory capacity. *Cognition and Emotion*, *31*(5), 995-1003.

Saunders, M. N., Lewis, P., Thornhill, A., & Bristow, A. (2015). *Understanding research philosophy and approaches to theory development*. In: Research Methods for Buisness Students: Eight Edition. Pearson Education Limited, United Kingdom.

Savage, S. W., Potter, D. D., & Tatler, B. W. (2013). Does preoccupation impair hazard perception? A simultaneous EEG and Eye Tracking study. Transportation Research Part F: Traffic Psychology and Behaviour, 17, 52-62.

Saviola, F., Pappaianni, E., Monti, A., Grecucci, A., Jovicich, J., & De Pisapia, N. (2020). Trait and state anxiety are mapped differently in the human brain. *Scientific Reports*, *10*(1), 1-11.

Scavone, A., Kadziolka, M. J., & Miller, C. J. (2020). State and trait mindfulness as predictors of skin conductance response to stress. *Applied Psychophysiology and Biofeedback*, *45*, 221-228.

Schäfer, J., Naumann, E., Holmes, E., Tuschen-Caffier, B. & Samson, A. (2016). Emotion Regulation Strategies in Depressive and Anxiety Symptoms in Youth: A Meta-Analytic Review. Journal of Youth and Adolescence.

Schmidt, L. A., & Trainor, L. J. (2001). Frontal brain electrical activity (EEG) distinguishes valence and intensity of musical emotions. *Cognition & Emotion*, *15*(4), 487-500.

Schmidt-Daffy, M. (2012). Velocity versus safety: Impact of goal conflict and task difficulty on drivers' behaviour, feelings of anxiety, and electrodermal responses. *Transportation research part F: traffic psychology and behaviour*, *15*(3), 319-332.

Schmidt-Daffy, M. (2013). Fear and anxiety while driving: Differential impact of task demands, speed and motivation. *Transportation Research Part F: Traffic Psychology and Behaviour*, *16*, 14-28.

Schultz, M. (1979). How to stop stalling, *Popular Mechanics*, 128–130, ISSN 0032-4558

Scialfa C. T., Deschenes M. C., Ference J., Boone J., Horswill M. S., Wetton M. (2011). A hazard perception test for novice drivers. *Accident Analysis & Prevention*, 43, 204–208.

Scott-Parker, B. (2015). Experiences of teen drivers and their advice for the learner license phase. *Traffic injury prevention*, *16*(2), 109-115.

Scott-Parker, B. (2017). Emotions, Behaviour, and the Adolescent Driver: A Literature Review. Transportation Research Part F: Traffic Psychology and Behaviour, 50, 1–37. https://doi.org/10.1016/j.trf.2017.06.019

Scott-Parker, B. J. (2012). *A comprehensive investigation of the risky driving behaviour of young novice drivers* (Doctoral dissertation, Queensland University of Technology).

Scott-Parker, B., De Regt, T., Jones, C., & Caldwell, J. (2020). The situation awareness of young drivers, middle-aged drivers, and older drivers: Same but different?. *Case studies on transport policy*, *8*(1), 206-214.

Scott-Parker, B., Jones, C. M., Rune, K., & Tucker, J. (2018). A qualitative exploration of driving stress and driving discourtesy. *Accident Analysis & Prevention*, *118*, 38-53.

Sekadakis, M., Katrakazas, C., Michelaraki, E., Ziakopoulos, A., & Yannis, G. (2023). COVID-19 and driving behavior: Which were the most crucial influencing factors?. *Data science for transportation*, *5*(3), 16.

Seli, P., Beaty, R. E., Marty-Dugas, J., & Smilek, D. (2019). Depression, anxiety, and stress and the distinction between intentional and unintentional mind wandering. *Psychology of Consciousness: Theory, Research, and Practice*, *6*(2), 163.

Seligman, M. E. (1971). Phobias and preparedness. Behavior Therapy, 2(3), 307–320.

Senserrick, T. M. (2006). Reducing young driver road trauma: guidance and optimism for the future. *Injury Prevention, 12*(suppl 1), i56-i60.

Senserrick, T., Boufous, S., Olivier, J., & Hatfield, J. (2021). At what stages of licensing do graduated driver licensing systems reduce crashes? Example from Queensland, Australia. *Accident Analysis & Prevention*, *152*, 105989.

Shahar, A. (2009). Self-reported driving behaviors as a function of trait anxiety. *Accident Analysis & Prevention*, *41*(2), 241-245.

Shahar, A., Alberti, C. F., Clarke, D., & Crundall, D. (2010). Hazard perception as a function of target location and the field of view. *Accident Analysis and Prevention, 42*(6), 1577-1584.

Shangguan, Q., Fu, T., & Liu, S. (2020). Investigating rear-end collision avoidance behavior under varied foggy weather conditions: A study using advanced driving simulator and survival analysis. *Accident Analysis & Prevention*, *139*, 105499.

Sharma, P. K., & Kumra, R. (2022). Relationship between mindfulness, depression, anxiety and stress: Mediating role of self-efficacy. *Personality and Individual Differences*, *186*, 111363.

Shi, J., Tao, L., Li, X., Xiao, Y., & Atchley, P. (2014). A survey of taxi drivers' aberrant driving behavior in Beijing. *Journal of Transportation Safety & Security, 6*, 34–43.

Shi, R., Sharpe, L., & Abbott, M. (2019). A meta-analysis of the relationship between anxiety and attentional control. *Clinical psychology review*, *72*, 101754.

Shields, G. S., Sazma, M. A., & Yonelinas, A. P. (2016). The effects of acute stress on core executive functions: A meta-analysis and comparison with cortisol. *Neuroscience & Biobehavioral Reviews*, *68*, 651-668.

Shihata, S., McEvoy, P. M., Mullan, B. A., & Carleton, R. N. (2016). Intolerance of uncertainty in emotional disorders: What uncertainties remain?. *Journal of anxiety disorders*, *41*, 115-124.

Shinar. D. (2007), Traffic Safety and Human Behaviour. Bingley, U.K.: Emerald.

Shoham, S. G., Rahav, G., Markovski, R., Chard, F., & Baruch, I. (1984). “Anxious” and “reckless” drivers. *Deviant Behaviour, 5*, 181-191.

Shoham, S. G., Rahav, G., Markovski, R., Chard, F., & Baruch, I. (1984). 'Anxious' and 'Reckless' Drivers. *Deviant Behaviour*, *5*, 181.

Showraki, M., Showraki, T., & Brown, K. (2020). Generalised anxiety disorder: revisited. *Psychiatric Quarterly*, *91*, 905-914.

Sibrava, N. J., & Borkovec, T. D. (2006). The cognitive avoidance theory of worry. *Worry and its psychological disorders: Theory, assessment and treatment*, 239-256.

Silverstone, T. (1988). The influence of psychiatric disease and its treatment on driving performance. *International Clinical Psychopharmacology, 3*(*Suppl.*), 59-66.

Simpson, H. M. (2003). The evolution and effectiveness of graduated licensing. *Journal of Safety Research*, *34*(1), 25-34.

Singh, V., Gupta, K., Agarwal, A., & Chakrabarty, N. (2022). Psychological impacts on the travel behaviour post Covid-19. *Asian Transport Studies*, *8*, 100087.

Slavinskienė, J., & Endriulaitienė, A. (2024). Cognitive and motivational antecedents of different driving styles in a sample of Lithuanian drivers. *Safety*, *10*(1), 27.

Sloboda, J. A., & Howe, M. J. (1992). Transitions in the early musical careers of able young musicians: Choosing instruments and teachers. *Journal of Research in Music Education*, *40*(4), 283-294.

Sloboda, J. A., & Juslin, P. N. (2001). Psychological perspectives on music and emotion. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion: Theory and research* (pp. 71– 104). New York: Oxford University Press.

Smith, S. S., Horswill, M. S., Chambers, B., & Wetton, M. (2009). Hazard perception in novice and experienced drivers: The effects of sleepiness. *Accident Analysis & Prevention*, *41*(4), 729-733.

Smith, W. G. (2008). Does gender influence online survey participation? A record-linkage analysis of university faculty online survey response behavior. *Online submission*.

Sobh, R., & Perry, C. (2006). Research design and data analysis in realism research. *European Journal of marketing*, *40*(11/12), 1194-1209.

Solomon, D. H. (1974). *Accidents on main rural highways: related to speed, driver, and vehicle*. US Department of Transportation, Federal Highway Administration.

Spicer, (1964) cited in Pelz, D. C. & Krupat, E. (1974). Caution profile and driving record of undergraduate males. Accident Analysis and Prevention, 6, 45-58.

Spielberger, C. D. (1970). Manual for the State-Trait Anxiety Inventory (self-evaluation questionnaire). (*No Title)*.

Spielberger, C. D. (1983). State-trait anxiety inventory for adults. *Mind Garden*.

Spielberger, C. D., & Sydeman, S. J. (1994). State-Trait Anxiety Inventory and State-Trait Anger Expression Inventory. In M. E. Maruish (Ed.), *The Use of Psychological Testing for Treatment Planning and Outcome Assessment* (pp. 292-321). Hillsdale, NJ, USA: L. Erlbaum Associates. http://dx.doi.org/10.1002/9780470479216.corpsy0943

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalised anxiety disorder: the GAD-7. *Archives of internal medicine*, *166*(10), 1092-1097.

Srivastava, K., Chatterjee, K., & Bhat, P. S. (2016). Mental health awareness: The Indian scenario. *Industrial psychiatry journal*, *25*(2), 131-134.

Stapel, J., Mullakkal-Babu, F. A., & Happee, R. (2019). Automated driving reduces perceived workload, but monitoring causes higher cognitive load than manual driving. *Transportation research part F: traffic psychology and behaviour*, *60*, 590-605.

Starr, L. R., & Davila, J. (2012). Responding to anxiety with rumination and hopelessness: mechanism of anxiety-depression symptom co-occurrence?. *Cognitive therapy and research*, *36*, 321-337.

Staub, A. (2011). The effect of lexical predictability on distributions of eye fixation durations. *Psychonomic bulletin & review*, *18*, 371-376.

Stefanopoulou, E., Hirsch, C. R., Hayes, S., Adlam, A., & Coker, S. (2014). Are attentional control resources reduced by worry in generalised anxiety disorder?. *Journal of abnormal psychology*, *123*(2), 330.

Steg, L., & van Brussel, A. (2009). Accidents, aberrant behaviours, and speeding of young moped riders. *Transportation research part F: traffic psychology and behaviour*, *12*(6), 503-511.

Stein, D. J., Hollander, E., & Rothbaum, B. O. (Eds.). (2009). *Textbook of anxiety disorders*. American Psychiatric Pub.

Stein, M. B., & Stein, D. J. (2008). Social anxiety disorder. *The lancet*, *371*(9618), 1115-1125.

Steinhauser, K., Leist, F., Maier, K., Michel, V., Pärsch, N., Rigley, P. & Steinhauser, M. (2018). Effects of emotions on driving behavior. *Transportation research part F: traffic psychology and behaviour*, *59*, 150-163.

Stephens, A. N., & Groeger, J. A. (2009). Situational specificity of trait influences on drivers' evaluations and driving behaviour. *Transportation research part F: traffic psychology and behaviour*, *12*(1), 29-39.

Stephens, A. N., Collette, B., Hidalgo-Munoz, A., Fort, A., Evennou, M., & Jallais, C. (2024). Help-seeking for driving anxiety: Who seeks help and how beneficial is this perceived to be?. *Transportation Research Part F: Traffic Psychology and Behaviour*, *105*, 182-195.

Stephens, A. N., Collette, B., Hidalgo-Munoz, A., Fort, A., Evennou, M., & Jallais, C. (2020). The impacts of anxiety over driving on self-reported driving avoidance, work performance and quality of life. *Journal of Transport & Health*, *19*, 100929.

Stephens, A. N., Young, K. L., Logan, D. B., & Lenné, M. G. (2015). The need for speed? The relationships between driver traits and speed choices during a naturalistic drive. *Procedia Manufacturing*, *3*, 3200-3207.

Sternberg, R. (1996). *Cognitive Psychology* (2nd Ed). Harcourt Brace College Publishers.

Stewart, A. E., & Peter, C. C. S. (2004). Driving and riding avoidance following motor vehicle crashes in a non-clinical sample: Psychometric properties of a new measure. *Behaviour research and therapy*, *42*(8), 859-879.

Stout, D. M., Shackman, A. J., Johnson, J. S., & Larson, C. L. (2015). Worry is associated with impaired gating of threat from working memory. *Emotion, 15*(1), 6–11. https://doi.org/10.1037/emo0000015

Strogatz, D., Mielenz, T. J., Johnson, A. K., Baker, I. R., Robinson, M., Mebust, S. P. & Li, G. (2020). Importance of driving and potential impact of driving cessation for rural and urban older adults. *The Journal of Rural Health*, *36*(1), 88-93.

Strohmaier, S. (2020). The relationship between doses of mindfulness-based programs and depression, anxiety, stress, and mindfulness: A dose-response meta-regression of randomized controlled trials. *Mindfulness, 11*(6), 1315-1335.

Strohmaier, S., Jones, F. W., & Cane, J. E. (2021). Effects of length of mindfulness practice on mindfulness, depression, anxiety, and stress: A randomised controlled experiment. *Mindfulness*, *12*, 198-214.

Stutts, J., Feaganes, J., Reinfurt, D., Rodgman, E., Hamlett, C., Gish, K., & Staplin, L. (2005). Driver's exposure to distractions in their natural driving environment. *Accident Analysis & Prevention*, *37*(6), 1093-1101.

Sucha, M., Sramkova, L., & Risser, R. (2014). The Manchester driver behaviour questionnaire: self-reports of aberrant behaviour among Czech drivers. *European transport research review*, *6*, 493-502.

Sullman, M. J., Meadows, M. L., & Pajo, K. B. (2002). Aberrant driving behaviours amongst New Zealand truck drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(3), 217-232.

Sümer, N., Ayvasik, A. B., & Er, N. (2005, June). Cognitive and psychomotor correlates of self-reported driving skills and behavior. In *Driving Assessment Conference* (Vol. 3, No. 2005). University of Iowa.

Sümer, N., Lajunen, T., & Özkan, T. (2005). Big five personality traits as the distal predictors of road accident. *Traffic and transport psychology: Theory and application*, *215*, 215-227.

Sümer, N., Özkan, T., & Lajunen, T. (2006). Asymmetric relationship between driving and safety skills. *Accident Analysis & Prevention, 38*(4), 703-711.

Summala, H. (1988). Risk control is not risk adjustment: The zero-risk theory of driver behaviour and its implications. *Ergonomics*, *31*(4), 491-506.

Summala, H. (2000). Automatization, automation, and modeling of driver's behavior. *Recherche-Transports-Sécurité*, *66*, 35-45.

Summerfield, C., Egner, T., Greene, M., Koechlin, E., Mangels, J., & Hirsch, J. (2006). Predictive codes for forthcoming perception in the frontal cortex. *Science*, *314*(5803), 1311-1314.

Sussman, T. J., Jin, J., & Mohanty, A. (2016). Top-down and bottom-up factors in threat-related perception and attention in anxiety. *Biological psychology*, *121*, 160-172.

Svetina, M. (2016). The reaction times of drivers aged 20 to 80 during a divided attention driving. *Traffic injury prevention*, *17*(8), 810-814.

Swann, C., Moran, A., & Piggott, D. (2015). Defining elite athletes: Issues in the study of expert performance in sport psychology. *Psychology of sport and exercise*, *16*, 3-14.

Takeda, Y., Sugai, M., & Yagi, A. (2001). Eye fixation related potentials in a proof reading task. *International Journal of Psychophysiology*, *40*(3), 181-186.

Talisman, N. W. (2021). Anxiety and Fear: Distinctions and Similarities PhD Thesis. *The George Washington University.*

Tan, J., Ma, Z., Gao, X., Wu, Y., & Fang, F. (2011). Gender difference of unconscious attentional bias in high trait anxiety individuals. *PloS one, 6*(5), e20305

Tapiro, H., Oron-Gilad, T., & Parmet, Y. (2020). Pedestrian distraction: The effects of road environment complexity and age on pedestrian's visual attention and crossing behavior. *Journal of safety research*, *72*, 101-109.

Taruffi, L. (2021). Mind-wandering during personal music listening in everyday life: Music-evoked emotions predict thought valence. *International journal of environmental research and public health*, *18*(23), 12321.

Taubman-Ben-Ari, O. (2008). The Israeli Driver's Profile. *A report prepared for the Israeli Ministry of Transportation–The National Authority for Road Safety*.

Taubman-Ben-Ari, O., Mikulincer, M., & Gillath, O. (2004). The multidimensional driving style inventory—scale construct and validation. *Accident Analysis & Prevention*, *36*(3), 323-332. Taubman-Ben-Ari

Taylor, J. E. (2011). Mental health and driving. In *Handbook of traffic psychology* (pp. 165-178). Academic Press.

Taylor, J. E. (2018). The extent and characteristics of driving anxiety. *Transportation Research Part F: Traffic Psychology and Behaviour, 58*,70–79. https://doi.org/10.1016/j.trf. 2018.05.031

Taylor, J. E., & Deane, F. P. (1999). Acquisition and severity of driving-related fears. *Behaviour Research and Therapy*, *37*(5), 435-449.

Taylor, J. E., & Sullman, M. J. (2009). What does the driving and riding avoidance scale (DRAS) measure?. *Journal of Anxiety Disorders*, *23*(4), 504-510.

Taylor, J. E., Connolly, M. J., Brookland, R., & Samaranayaka, A. (2018). Understanding driving anxiety in older adults. *Maturitas*, *118*, 51-55.

Taylor, J. E., Deane, F. P., & Podd, J. (2007a). Diagnostic features, symptom severity, and help-seeking in a media-recruited sample of women with driving fear. *Journal of Psychopathology and Behavioral Assessment*, *29*(2), 81-91.

Taylor, J. E., Deane, F. P., & Podd, J. (2008). The relationship between driving anxiety and driving skill: A review of human factors and anxiety-performance theories to clarify future research needs. *New Zealand Journal of Psychology, 37*(1), 28-37.

Taylor, J. E., Deane, F. P., & Podd, J. V. (2000). Determining the focus of driving fears. *Journal of anxiety disorders*, *14*(5), 453-470.

Taylor, J. E., Deane, F. P., & Podd, J. V. (2007). Driving fear and driving skills: Comparison between fearful and control samples using standardised on-road assessment. *Behaviour research and therapy*, *45*(4), 805-818.

Taylor, J. E., Deane, F. P., & Podd, J. V. (2007b). Driving fear and driving skills: Comparison between fearful and control samples using standardised on-road assessment. *Behaviour research and therapy*, *45*(4), 805-818.

Taylor, J. E., Stephens, A. N., & Sullman, M. J. (2021). Psychometric properties of the Driving Cognitions Questionnaire, Driving Situations Questionnaire, and Driving Behavior Survey. *Transportation research part F: traffic psychology and behaviour*, *76*, 202-214.

Taylor, J. E., Sullman, M. J., & Stephens, A. N. (2018). Measuring anxiety-related avoidance with the Driving and Riding Avoidance Scale (DRAS). *European Journal of Psychological Assessment*.

Taylor, J., & Deane, F. P. (2000). Comparison and characteristics of motor vehicle accident (MVA) and non-MVA driving fears. *Journal of Anxiety Disorders*, *14*(3), 281-298.

Taylor, J., Deane, F., & Podd, J. (2002). Driving-related fear: A review. *Clinical psychology review*, *22*(5), 631-645.

Taylor, L., Watkins, S. L., Marshall, H., Dascombe, B. J., & Foster, J. (2016). The impact of different environmental conditions on cognitive function: a focused review. *Frontiers in physiology*, *6*, 372.

Taylor, S., & Koch, W. J. (1995). Anxiety disorders due to motor vehicle accidents: Nature and treatment. *Clinical Psychology Review*, *15*(8), 721-738.

Techer, F., Jallais, C., Corson, Y., Moreau, F., Ndiaye, D., Piechnick, B., & Fort, A. (2017). Attention and driving performance modulations due to anger state: Contribution of electroencephalographic data. *Neuroscience letters*, *636*, 134-139.

Thayer, J. F., & Levenson, R. W. (1983). Effects of music on psychophysiological responses to a stressful film. *Psychomusicology: A Journal of Research in Music Cognition*, *3*(1), 44.

Tobias, M. R., & Ito, T. A. (2021). Anxiety increases sensitivity to errors and negative feedback over time. *Biological psychology*, *162*, 108092.

Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of personality and social psychology*, *65*(2), 248.

Traficante, S., Tinella, L., Lopez, A., Koppel, S., Ricciardi, E., Napoletano, R. & Caffò, A. O. (2024). "Regulating my anxiety worsens the safety of my driving": The synergistic influence of spatial anxiety and Self-regulation on driving behavior. *Accident Analysis & Prevention*, *208*, 107768.

Treat, J. R. (1980). A study of precrash factors involved in traffic accidents. *HSRI Research review*.

Trichopoulou, A., Orfanos, P., Norat, T., Bueno-de-Mesquita, B., Ocké, M. C., Peeters, P. H. & Trichopoulos, D. (2005). Modified Mediterranean diet and survival: EPIC-elderly prospective cohort study. *Bmj*, *330*(7498), 991.

Trick, L. M., Brandigampola, S., & Enns, J. T. (2012). How fleeting emotions affect hazard perception and steering while driving: The impact of image arousal and valence. *Accident Analysis & Prevention*, *45*, 222-229.

Trick, L. M., Enns, J. T., Mills, J., & Vavrik, J. (2004). Paying attention behind the wheel: A framework for studying the role of attention in driving. *Theoretical Issues in Ergonomics Science*, *5*(5), 385-424.

Tsai, Y. C., Lu, H. J., Chang, C. F., Liang, W. K., Muggleton, N. G., & Juan, C. H. (2017). Electrophysiological and behavioral evidence reveals the effects of trait anxiety on contingent attentional capture. *Cognitive, Affective, & Behavioral Neuroscience*, *17*, 973-983. https://doi.org/10.3758/s13415-017-0526-8

Tubey, R. J., Rotich, J. K., & Bengat, J. K. (2015). Research Paradigms: Theory and Practice. Research on Humanities and Social Sciences, 5(5), 224-229.

Ulleberg, P., & Rundmo, T. (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety Science, 41*, 427-443.

Underwood, G., Chapman, P., Bowden, K., & Crundall, D. (2002). Visual search while driving: skill and awareness during inspection of the scene. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(2), 87-97.

Underwood, G., Crundall, D., & Chapman, P. (2011). Driving simulator validation with hazard perception. *Transportation research part F: traffic psychology and behaviour*, *14*(6), 435-446.

Unsworth, C. A., & Baker, A. (2014). Driver rehabilitation: A systematic review of the types and effectiveness of interventions used by occupational therapists to improve on-road fit ness-to-drive. *Accident; Analysis and Prevention, 71*, 106–114. https://doi.org/10.1016/j.aap.2014.04.017

Upahita, D. P., Wong, Y. D., & Lum, K. M. (2018). Effect of driving experience and driving inactivity on young driver's hazard mitigation skills. *Transportation research part F: traffic psychology and behaviour*, *59*, 286-297.

Useche, S. A., Cendales, B., Alonso, F., Pastor, J. C., & Montoro, L. (2019). Validation of the Multidimensional Driving Style Inventory (MDSI) in professional drivers: How does it work in transportation workers?. *Transportation research part F: traffic psychology and behaviour*, *67*, 155-163.

Üzümcüoğlu, Y., Özkan, T., Wu, C., & Zhang, H. (2020). Traffic climate and driver behaviors: The moderating role of driving skills in Turkey and China. *Journal of safety research, 75*, 87-98

Valero-Mora, P. M., Martí-Belda-Bertolín, A., & Sánchez-García, M. (2021). Keep calm, pay attention, and carry on: Anxiety and consciousness mediate the effect of, mindfulness on driving performance in young drivers. *Transportation research part F: traffic psychology and behaviour*, *83*, 22-32.

van Beek, J. H., Kirkwood, T. B., & Bassingthwaighte, J. B. (2016). Understanding the physiology of the ageing individual: computational modelling of changes in metabolism and endurance. *Interface Focus*, *6*(2), 20150079.

Van Bockstaele, B., Verschuere, B., Tibboel, H., De Houwer, J., Crombez, G., & Koster, E. H. (2014). A review of current evidence for the causal impact of attentional bias on fear and anxiety. *Psychological bulletin*, *140*(3), 682.

Ventsislavova, P. (2019). *Development of a cross-cultural hazard perception test PhD Thesis*. Nottingham Trent University (United Kingdom). Retrieved from: https://irep.ntu.ac.uk/id/eprint/38105/

Ventsislavova, P., & Crundall, D. (2018). The hazard prediction test: A comparison of free-response and multiple-choice formats. *Safety Science*, *109*, 246-255.

Ventsislavova, P., Crundall, D., Baguley, T., Castro, C., Gugliotta, A., Garcia-Fernandez, P. & Li, Q. (2019). A comparison of hazard perception and hazard prediction tests across China, Spain and the UK. *Accident Analysis & Prevention*, *122*, 268-286.

Vickers, J. N., & Williams, A. M. (2007). Performing under pressure: The effects of physiological arousal, cognitive anxiety, and gaze control in biathlon. *Journal of Motor Behavior, 39*, 381–394.

Victor, T., Dozza, M., Bärgman, J., Boda, C. N., Engström, J., Flannagan, C. & Markkula, G. (2015). *Analysis of naturalistic driving study data: Safer glances, driver inattention, and crash risk* (No. SHRP 2 Report S2-S08A-RW-1).

Vigneau, F., & Cormier, S. (2008). The factor structure of the State-Trait Anxiety Inventory: an alternative view. *Journal of personality assessment*, *90*(3), 280-285.

Vingilis, E., Larkin, E., Stoduto, G., Parkinson-Heyes, A., & McLellan, B. (1996). Psychosocial sequelae of motor vehicle collisions: a follow-up study. *Accident Analysis & Prevention*, *28*(5), 637-645.

Vivas, E., Nascimento, M., & Rocha, S. (2021). The performance anxiety influence on the motor coordination levels: A literature mini-review. *Int. J. Educ. Res*, *3*, 1-5.

Vos, J., de Winter, J., Farah, H., & Hagenzieker, M. (2023). Which visual cues do drivers use to anticipate and slow down in freeway curve approach? An eye-tracking, think-aloud on-road study. *Transportation research part F: traffic psychology and behaviour*, *94*, 190-211.

Vytal, K. E., Cornwell, B. R., Letkiewicz, A. M., Arkin, N. E., & Grillon, C. (2013). The complex interaction between anxiety and cognition: insight from spatial and verbal working memory. *Frontiers in human neuroscience*, *7*, 93.

Wald, J., & Taylor, S. (2000). Efficacy of virtual reality exposure therapy to treat driving phobia: a case report. *Journal of behavior therapy and experimental psychiatry*, *31*(3-4), 249-257. https://doi.org/10.1016/S0005-7916(01)00009-X

Walklin, L. (1993). *Instructional techniques and practice for driving instructors* (2nd ed.). Cheltenham, England: Stanley Thornes.

Wallis, T. S., & Horswill, M. S. (2007). Using fuzzy signal detection theory to determine why experienced and trained drivers respond faster than novices in a hazard perception test. *Accident Analysis & Prevention*, *39*(6), 1177-1185.

Walsh, A. T., Carmel, D., & Grimshaw, G. M. (2019). Reward elicits cognitive control over emotional distraction: Evidence from pupillometry. *Cognitive, Affective, & Behavioral Neuroscience*, *19*, 537-554.

Walshe, D. G., Lewis, E. J., Kim, S. I., O'Sullivan, K., & Wiederhold, B. K. (2003). Exploring the use of computer games and virtual reality in exposure therapy for fear of driving following a motor vehicle accident. *Cyberpsychology & Behavior: The Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society, 6*(3), 329–334. https://doi.org/10.1089/109493103322011641

Wang, D., Lin, B., Huang, Y., Chong, Z. Y., Du, J., Yuan, Q. & Xu, W. (2024). Exploring Neural Correlates between Anxiety and Inhibitory Ability: Evidence from Task‐Based fNIRS. *Depression and Anxiety*, *2024*(1), 8680134.

Wardlaw, C. (2014). Get the most out of your car: How to drive a manual transmission. *Daily News*, New York.

Wass, S. V., Smith, T. J., & Johnson, M. H. (2013). Parsing eye-tracking data of variable quality to provide accurate fixation duration estimates in infants and adults. *Behavior research methods*, *45*, 229-250.

Watts, G. R., & Quimby, A. R. (1979). Design and Validation of a Driving Simulator for use in Perceptual Studies (No. 907). Transport Research Laboratory.

Watts, J. M. J. (1975). Anxiety and the habituation of the skin conductance response. *Psychophysiology*, *12*(5), 596-601.

Weinberg, A., Kujawa, A., & Riesel, A. (2022). Understanding trajectories to anxiety and depression: Neural responses to errors and rewards as indices of susceptibility to stressful life events. *Current Directions in Psychological Science*, *31*(2), 115-123.

Wells, A. (2013). Advances in Metacognitive Therapy. *International Journal of Cognitive Therapy, 6*(2), 186–201. https://doi.org/10.1521/ijct.2013.6.2.186

Wells, P., Tong, S., Sexton, B., Grayson, G., & Jones, E. (2008). Cohort II: a study of learner and new drivers: Volume 1 (Road Safety Research Report No. 81). London: Department for Transport.

West, R., French, D., Kemp, R., & Elander, J. (1993). Direct observation of driving, self reports of driver behaviour, and accident involvement. *Ergonomics*, *36*(5), 557-567.

Wetton, M. A., Hill, A., & Horswill, M. S. (2011). The development and validation of a hazard perception test for use in driver licensing. *Accident Analysis and Prevention, 43*(5), 1759–1770.

Wetton, M. A., Horswill, M. S., Hatherly, C., Wood, J. M., Pachana, N. A., & Anstey, K. J. (2010). The development and validation of two complementary measures of drivers' hazard perception ability. Accident Analysis and Prevention, 42(4), 1232–1239.

White, E. J., & Grant, D. M. (2017). Electrocortical consequences of image processing: The influence of working memory load and worry. Psychiatry Research: Neuroimaging, 261, 1– 8. http://dx.doi .org/10.1016/j.pscychresns.2017.01.003

White, E. J., Grant, D. M., Taylor, D. L., Kraft, J. D., & Frosio, K. E. (2021). The influence of state worry on covert selective attention and working memory for threatening stimuli: An ERP study. *Psychology & Neuroscience*, *14*(1), 94.

White, H. R., & Labouvie, E. W. (1989). Towards the assessment of adolescent problem drinking. *Journal of studies on alcohol, 50*(1), 30-37.

Whitmore, M. J., Kim-Spoon, J., & Ollendick, T. H. (2014). Generalised anxiety disorder and social anxiety disorder in youth: Are they distinguishable?. *Child Psychiatry & Human Development*, *45*, 456-463.

Wickens, C. D., & Alexander, A. L. (2009). Attentional tunneling and task management in synthetic vision displays. *The international journal of aviation psychology*, *19*(2), 182-199.

Wickens, C. M., Mann, R. E., Stoduto, G., Ialomiteanu, A., Smart, R. G., & Rehm, J. (2013). The impact of probable anxiety and mood disorder on self-reported collisions: A population study. *Journal of affective disorders*, *145*(2), 253-255.

Wickens, C. M., Toplak, M. E., & Wiesenthal, D. L. (2008). Cognitive failures as predictors of driving errors, lapses, and violations. *Accident Analysis & Prevention*, *40*(3), 1223-1233.

Williams, M. (2003). The problem of representation: Realism and operationalism in survey research. *Sociological research online*, *8*(1), 81-91.

Willig, C. (2008). A phenomenological investigation of the experience of taking part inExtreme sports'. *Journal of health psychology*, *13*(5), 690-702.

Wilson, E., & MacLeod, C. (2003). Contrasting two accounts of anxiety-linked attentional bias: selective attention to varying levels of stimulus threat intensity. *Journal of abnormal Psychology*, *112*(2), 212.

Wilson, M. R., Wood, G., & Vine, S. J. (2009). Anxiety, attentional control, and performance impairment in penalty kicks. *Journal of Sport & Exercise Psychology, 31*, 761–775.

Wilson, M., Smith, N. C., Chattington, M., Ford, M., & Marple-Horvat, D. E. (2006). The role of effort in moderating the anxiety–performance relationship: Testing the prediction of processing efficiency theory in simulated rally driving. *Journal of sports sciences*, *24*(11), 1223-1233.

Windsor, T. D., Walker, J. G., Caldwell, M. H., & Anstey, K. J. (2006). *Health knowledge related to driving, and driving associated anxiety: A public health approach to driving in later life.* A Report from Research Funded by the NRMA ACT Road Safety Trust, Prepared by the Ageing Research Unit. Centre for Mental Health Research. Australian National University.

Wittchen, H. U., Zhao, S., Kessler, R. C., & Eaton, W. W. (1994). DSM-III-R generalised anxiety disorder in the National Comorbidity Survey. *Archives of general psychiatry*, *51*(5), 355-364.

Wohleber, R. W., & Matthews, G. (2014, September). Individual differences in driver over-confidence: implications for stress, error and managing impairments. In *Proceedings of the human factors and ergonomics society annual meeting* (Vol. 58, No. 1, pp. 999-1003). Sage CA: Los Angeles, CA: SAGE Publications.

Wohleber, R. W., & Matthews, G. (2016). Multiple facets of overconfidence: Implications for driving safety. *Transportation research part F: traffic psychology and behaviour*, *43*, 265-278.

Wolitzky-Taylor, K. B., Horowitz, J. D., Powers, M. B., & Telch, M. J. (2008). Psychological approaches in the treatment of specific phobias: A meta-analysis. *Clinical psychology review, 28*(6), 1021-1037.

Wong, I. Y., Mahar, D., & Titchener, K. (2015). Driven by distraction: Investigating the effects of anxiety on driving performance using the Attentional Control Theory. *Journal of Risk Research*, *18*(10), 1293-1306.

Wood Johnson Foundation. http://www.qualres.org/

World Health Organization. (1992). *The ICD-10 classification of mental and behavioural disorders: clinical descriptions and diagnostic guidelines*. World Health Organization.

World Health Organization. (2017). *Depression and other common mental disorders: global health estimates* (No. WHO/MSD/MER/2017.2). World Health Organization.

World Health Organization. (2020). Global Plan for the Decade of Action for Road Safety 2021-2030. Retrieved from: https://cdn.who.int/media/docs/default-source/documents/health-topics/road-traffic-injuries/global-plan-for-road-safety

World Health Organization. (2023). Road Traffic Injuries. Retrieved from: https://www.who.int/https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries

Wright, T. J., Samuel, S., Borowsky, A., Zilberstein, S., & Fisher, D. L. (2016, September). Experienced drivers are quicker to achieve situation awareness than inexperienced drivers in situations of transfer of control within a Level 3 autonomous environment. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 60, No. 1, pp. 270-273). Sage CA: Los Angeles, CA: Sage Publications.

Wright, T. J., Samuel, S., Borowsky, A., Zilberstein, S., & Fisher, D. L. (2016, September). Experienced drivers are quicker to achieve situation awareness than inexperienced drivers in situations of transfer of control within a Level 3 autonomous environment. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 60, No. 1, pp. 270-273). Sage CA: Los Angeles, CA: Sage Publications.

Wynne, R. A., Beanland, V., & Salmon, P. M. (2019). Systematic review of driving simulator validation studies. *Safety science*, *117*, 138-151.

Xiao, Q. L., Ding, Y. Q., Cao, X. X., Chen, W. Y., Lian, S. L., & Zhu, X. W. (2024). Mobile phone addiction and emptiness among Chinese college students: the chain mediating role of attention control and self-concept clarity. *Current Psychology*, 1-14.

Xie, B., Liu, H., Alghofaili, R., Zhang, Y., Jiang, Y., Lobo, F. D. & Yu, L. F. (2021). A review on virtual reality skill training applications. *Frontiers in Virtual Reality*, *2*, 645153.

Xu, J., Liu, J., Sun, X., Zhang, K., Qu, W., & Ge, Y. (2018). The relationship between driving skill and driving behavior: Psychometric adaptation of the Driver Skill Inventory in China. *Accident Analysis & Prevention, 120*, 92- 100.

Yang, J., Liu, C., Chu, P., Wen, X., & Zhang, Y. (2021). Exploration of the relationships between hazard perception and eye movement for young drivers. *Journal of advanced transportation*, *2021*(1), 6642999.

Yang, L., Li, X., Guan, W., & Jiang, S. (2022). Assessing the relationship between driving skill, driving behavior and driving aggressiveness. *Journal of Transportation Safety & Security, 14*(5), 737-753.

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit formation. *Journal of Comparative Neurology and Psychology, 18,* 459-482.

Yinon, Y., & Levian, E. (1988). Presence of other drivers as a determinant of traffic violations. In T. Rothengatter & R. de Bruin (Eds.), *Road user behaviour: Theory and research* (pp. 274-278). Assen, The Netherlands: van Gorcum.

Yoon, K. L., & Zinbarg, R. E. (2008). Interpreting neutral faces as threatening is a default mode for socially anxious individuals. *Journal of abnormal psychology*, *117*(3), 680.

Young, R. A., & Collin, A. (2004). Introduction: Constructivism and social constructionism in the career field. *Journal of vocational behavior*, *64*(3), 373-388.

Yu, Z., Guindani, M., Grieco, S. F., Chen, L., Holmes, T. C., & Xu, X. (2022). Beyond t test and ANOVA: applications of mixed-effects models for more rigorous statistical analysis in neuroscience research. Neuron, 110(1), 21–35. https://doi.org/10.1016/j.neuron.2021.10.030

Yuan, Y., Fang, J., & Wang, Q. (2018). Incrementally perceiving hazards in driving. *Neurocomputing*, *282*, 202-217.

Yuda, E., Yoshida, Y., Ueda, N., Kaneko, I., Miura, Y., & Hayano, J. (2020). Effects of aging on foot pedal responses to visual stimuli. *Journal of physiological anthropology*, *39*, 1-7.

Zawilinski, L. (2020). Hypervigilance. Encyclopedia of Personality and Individual Differences, 2101-2103.

Zeidner, M. (2008). Anxiety revisited: theory, research, applications. G. Boyle, D. Saklofske, & G., Matthews (Eds.), *Handbook of Personality Assessment*, 1, 423–446.

Zeitler, E., & Buys, L. (2015). Mobility and out-of-home activities of older people living in suburban environments: ‘Because I'm a driver, I don't have a problem'. *Ageing & Society*, *35*(4), 785-808.

Zhang, F., Huang, C., Yan, W., Ouyang, H., & Liu, W. (2024). Attentional bias modification and attention control training in PTSD: a systematic review and meta-analysis. *Therapeutic Advances in Psychopharmacology*, *14*, 20451253241243260.

Zhao, J., Yun, M., Zhang, H. M., & Yang, X. (2015). Driving simulator evaluation of drivers’ response to intersections with dynamic use of exit-lanes for left-turn. *Accident Analysis & Prevention*, *81*, 107-119.

Zinzow, H. M., & Jeffirs, S. M. (2018). Driving aggression and anxiety: Intersections, assessment, and interventions. *Journal of Clinical Psychology*, *74*(1), 43-82. https://doi.org/https://doi.org/10.1002/jclp.22494

Zinzow, H. M., Brooks, J., & Stern, E. B. (2013). Driving-related anxiety in recently deployed service members: Cues, mental health correlates, and help-seeking behavior. *Military Medicine, 178*(3), e357–e361. https://doi.org/10.7205/MILMED-D-12-00303

Zoepf, S. M., Chen, S., Adu, P., & Pozo, G. (2018). The economics of ride-hailing: Driver revenue, expenses and taxes. *CEEPR WP*, *5*(2018), 1-38.

Zöller, I., Abendroth, B., & Bruder, R. (2019). Driver behaviour validity in driving simulators–Analysis of the moment of initiation of braking at urban intersections. *Transportation research part F: traffic psychology and behaviour*, *61*, 120-130.

Zontone, P., Affanni, A., Piras, A., & Rinaldo, R. (2022). Exploring physiological signal responses to traffic-related stress in simulated driving. *Sensors*, *22*(3), 939.

Zorowitz, S., Momennejad, I., & Daw, N. D. (2020). Anxiety, avoidance, and sequential evaluation. *Computational Psychiatry*, *4*, 1-17.

Zou, J. B., & Abbott, M. J. (2012). Self-perception and rumination in social anxiety. *Behaviour Research and Therapy*, *50*(4), 250-257.

Zou, X., Vu, H. L., & Huang, H. (2020). Fifty years of accident analysis & prevention: A bibliometric and scientometric overview. *Accident Analysis & Prevention*, *144*, 105568.

Zuell, C., Menold, N., & Körber, S. (2015). The influence of the answer box size on item nonresponse to open-ended questions in a web survey. *Social Science Computer Review*, *33*(1), 115-122.

Appendix

Appendix A

Appendix A contains a link to a folder that contains ethics, participant information sheets, consent forms and debriefs, recruitment, anonymised raw and cleaned data and outputs for each study. All the materials can be accessed via the following link: [Thesis Outputs]. The outputs are in separate folders named after each experiment.

Informed consent and debrief forms for each experiment have been placed in the respective ethics folder containing sub-folders for each study.

Appendix B

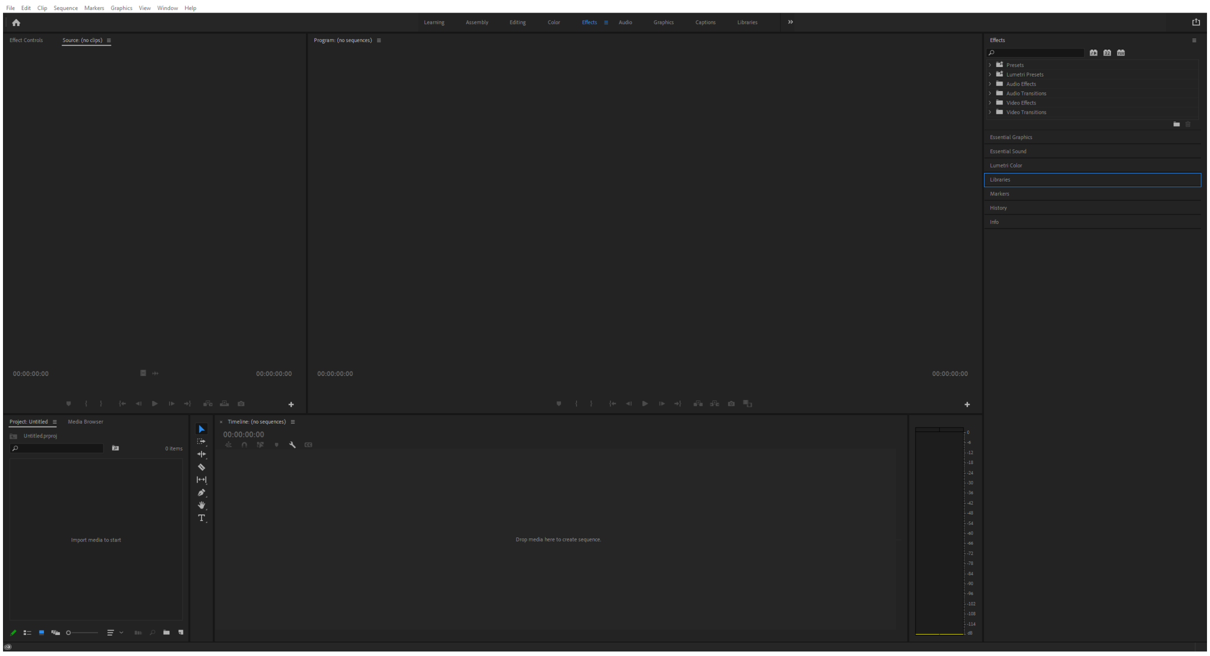
Video clip editing protocol

In this protocol the application used for video editing is Adobe Premiere Pro 2021 using Windows 10 as the operating system. Therefore, all keyboard shortcuts will be using a Windows 10 compatible keyboard. This protocol will also assume that you have already chosen the stock footage for your personal project and are ready to insert the footage into Premiere Pro for editing.

Along with video editing, another application to keep track of video editing is to use spreadsheet software. In this protocol, the spreadsheet application used is Microsoft Excel. First of all ensure you Excel file has suitable headings for your project. The default ones to use would be: Original File; Adobe File; Observation; Detailed description of observation; Time in footage; Time Range; Duration; Quality.

At this time, it is recommended to watch the stock footage in a video player and identify the original file name and where it is saved. This is important as Adobe Premiere Pro uses the original file location to read the file. I would also recommend identifying the observations, creating the descriptions and the time the observation takes place in the footage in the following format: Hours:Minutes:Seconds:Milliseconds. If the video application does not use milliseconds, the nearest second will do at this point.

Now you are ready to use Adobe Premiere Pro. Once you open Adobe Premiere Pro 2021, create a new project, name it and press ok.

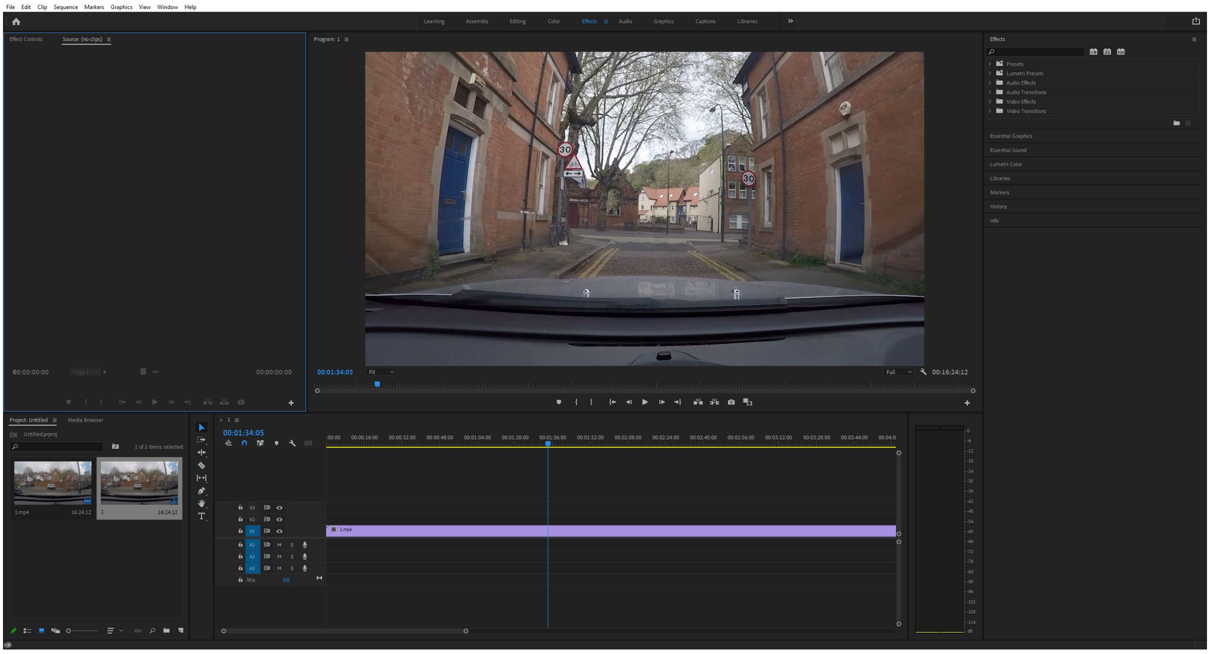


Each of the panels will be explained: The top left panel is primarily used to control effects. This panel will be used very frequently throughout the video editing process. The top middle panel will show the footage once the footage has been dragged into the timeline panel. The long panel on the right is the effect library. This is where you use the search bar to look up the affects you need for the footage. The bottom left panel is the import panel. This is where you import your stock footage as well as add adjustment layers or black videos for black lines (discussed later) the bottom middle panel is the timeline panel where you can add effects, and scrub through the footage

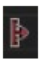
Importing

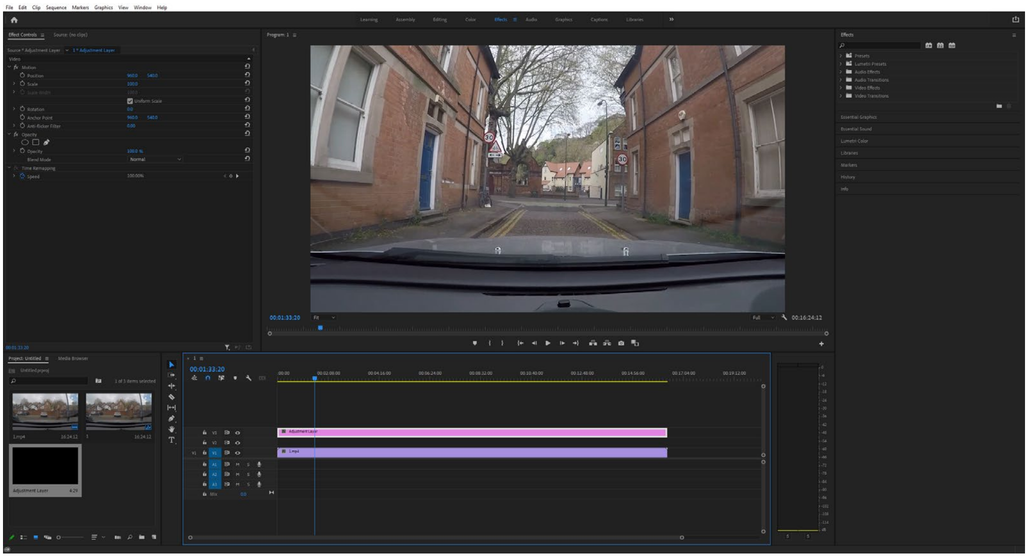
At this stage you can a) import all the clips you are working with in the bottom left panel or b) import one file at a time, edit that single file and then once complete, import the next file. Whichever way you chose the recommended import method is to Drag and Drop your file into the import panel.

Once the file has been imported, drag the footage onto the timeline panel. For front view only footage, the recommended track to insert the footage is track one. At this point, if the video has any audio, you can delete this audio.

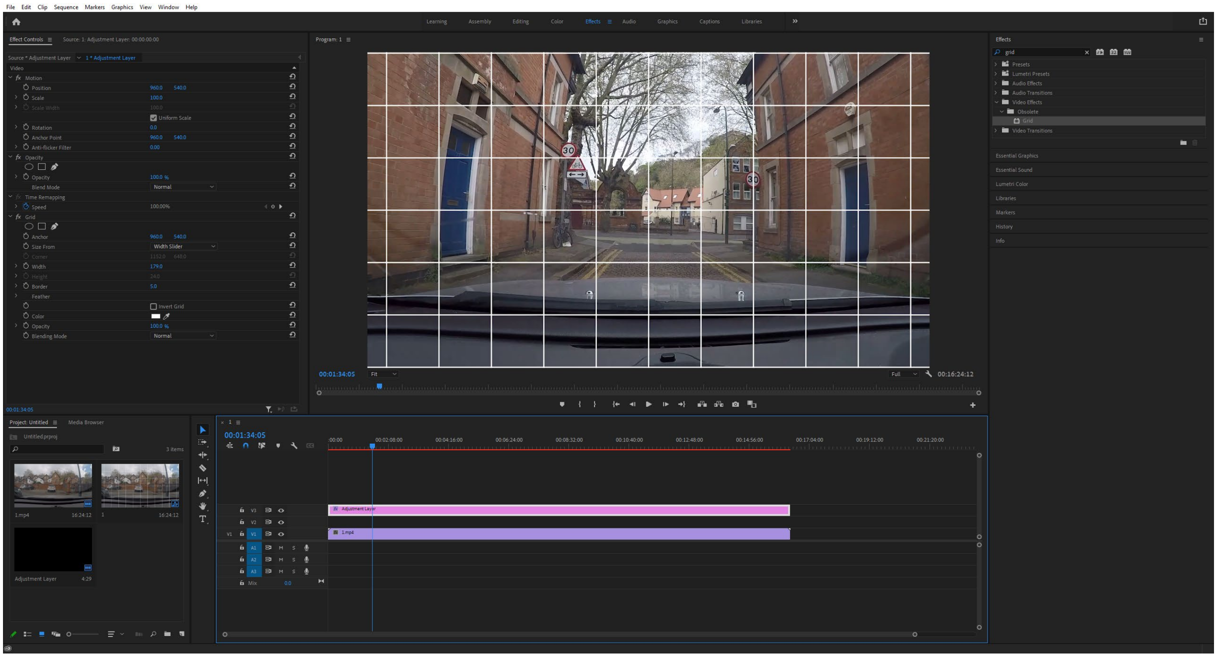


Preparing for editing

Before editing, the first thing to do is to create an adjustment layer with the grid effect to ensure the footage has the correct position, horizon, rotation and scale. This may differ between different footage and needs to be adjusted accordingly. To create an adjustment layer, you need to left click the sticker icon  at the bottom right of the import panel and choose the adjustment layer option and press ok to the next option box. The adjustment layer will then be shown in the import panel. Drag it into the timeline panel using any of the remaining tracks. At this point you will need to lengthen the adjustment layer. To do this move the mouse close to the right-hand side if the adjustment layer until the following symbol replaces the mouse cursor  and pull across to the right to lengthen the adjustment layer to the length of the clip. Next you need to select the adjustment layer and in the top left-hand side choose 'effect controls' (if it is not already selected). This will show the current effects on the adjustment layer.



At this point you need to add the effect 'Grid' onto the adjustment layer. To do this, search for the 'grid' in the effects library which should be under Video Effects > Obsolete > Grid. Drag the effect onto the adjustment layer in the timeline. In the effect controls section, you should see the Grid effect active. In the effect controls, find 'blending mode' (NOT blend mode) and select Normal using the drop-down menu. A personal preference at this point is to change the size of the grid to make it easier to know where the centre point is. The centre point is used to ensure the horizon of the video is in the centre of the view as required. To change the grid view, in the effect controls find 'Size From' and change the option to 'Width Slider'. Then use the 'Width' option and increase the value for your personal preference. A recommendation for this would be '179'.



Front View

Editing the footage

For this section, ensure you have elected the video footage and not the adjustment layer in the timeline and ensure the effect controls are displayed.

Rotation

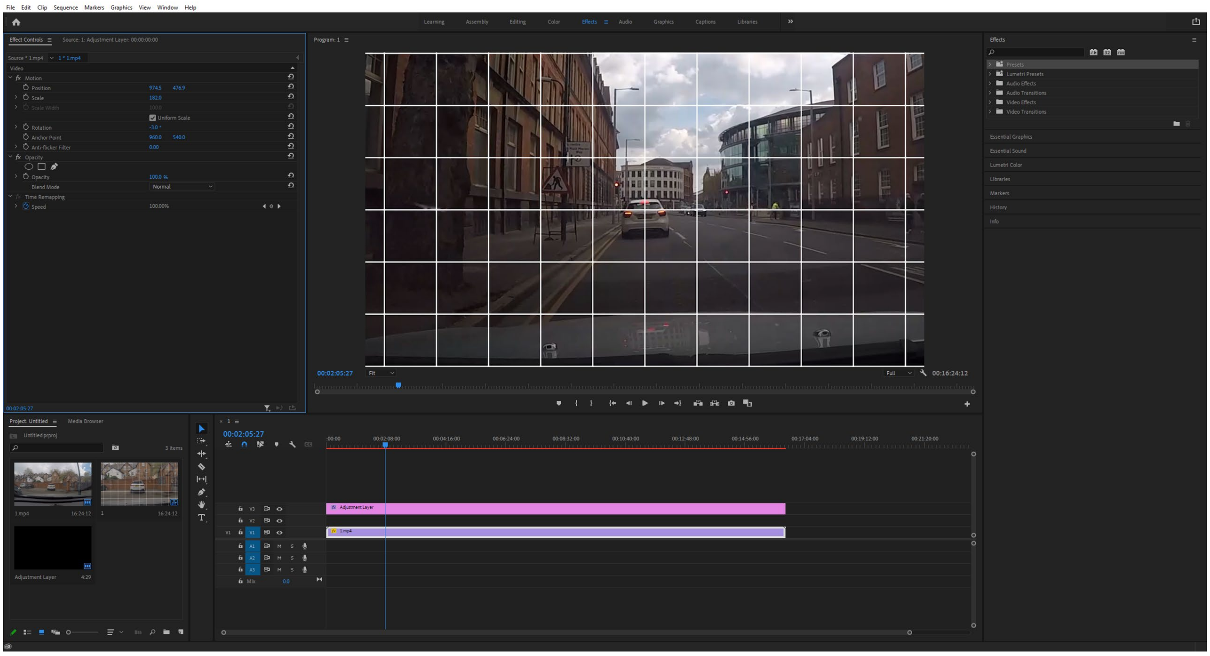
Rotation is important to ensure that the video is believable. Select the rotation effect in the effect controls. If necessary, adjust the rotation, so buildings and streetlights are as vertical as possible. A typical rotation requires +/- 3 degrees of rotation dependent on the footage. Use the virtual lines of the grid to help with the rotation.

Scale

The scale of the video needs to be edited to ensure that the internals of the car are not shown. To do this, use the ‘Scale’ effect which is in the effect controls and zoom in until the internals are hidden. You can use the up and down arrow keys to be more precise. This is dependent on the footage but for this example the scale is approximately ‘159’. This is now the new default scale for this video but will be subject to change after future effects changes such as rotation and position.

Position

Now the footage needs to be moved to ensure the horizon is at the centre of the screen to do this select the 'position' effect in the controls. Use the centre of the grid to ensure the horizon is centre. There are two ways to move the footage. 1. Use the mouse to move the footage (ignore the blue circle in the middle, drag from the footage); 2. Use the X and Y numbers to adjust the position of the footage. It is recommended to use the mouse method first as it is easier to get the rough horizon then use the numbers to be more precise. Once you have changed the position of the footage adjust the scale to ensure the image is correct. This may need to be repeated until you are happy with the scale and position. For this example the final position is 974.5 x 476.9. The scale is 182 and the rotation is -3 degrees



Brightness, contrast and sharpening

Some footage may need a change in Brightness, Contrast and Sharpening to have the optimum quality. These are under two effects in the effects library. The first effect is 'Brightness & Contrast', with a recommendation of 20 for brightness and 16 for contrast. For the sharpening the recommend unit is 10. Please note, the type of monitor is critical for brightness and contrast changes. The recommendations shown here are for high brightness, 1440p monitors therefore, the brightness and contrast units may be higher for different monitors.

Saving a preset

At this point it is best to save the edits you have done as a 'Preset'. This allows you to use the same position, scale and rotation on all other footage without manually editing each one from scratch. It should be noted that the preset will be a general rule of thumb and that slight edits will still be required. To make a preset right-click the 'Motion' effect in the effect control and choose 'save preset'. You will be asked to name the preset. A recommendation for the name is 'Frontview'. Add a description of the position, scale and rotation before saving the preset. The preset is saved in the effects library under Presets > Frontview. You can drag this preset on any future 'frontview' footage as you would any other effect from the effects library.

Cutting

Once the video edits have been completed, the video needs cutting to make adequate clips. The minimum clip length is recommended to be 30 seconds, and the longest clip length is recommended to be 1 minute 15 seconds. Furthermore, there should be roughly 20 seconds before the observation and a minimum of 5 seconds after the observation. All of these recommendations can be adjusted for the particular project. Ensure to reference the beginning cut point and the end cut point in the excel spreadsheet under 'Time Range'. To cut the video make sure you have selected the timeline panel and then use the shortcut 'C' to activate the cut tool and cut the footage on the timeline at the beginning and end of the of the potential clip.

Once the clip has been established, press 'V' to change the tool back to the mouse tool. Once this is done, highlight the clip and use the shortcut SHIFT + U to create subsequence which is added to the import panel. This makes clips easier to export without breaking up the original footage timeline. Double click the subsequence in the import panel to add it to its own timeline.

Exporting

Use the shortcut CTRL + M to open the export panel. When exporting ensure you change the file name and location to a new folder to keep the original files and the clips separate. This is done by selecting the hyperlink next to output name. Once you have done this, use the export preset and change the preset to 'High Quality 1080p HD'. Finally untick the 'Export Audio' option. This will change the preset to custom, but this is normal. An additional option is to tick the option 'Use Maximum Render Quality'. Once all the export settings have been finalised, press the export button.

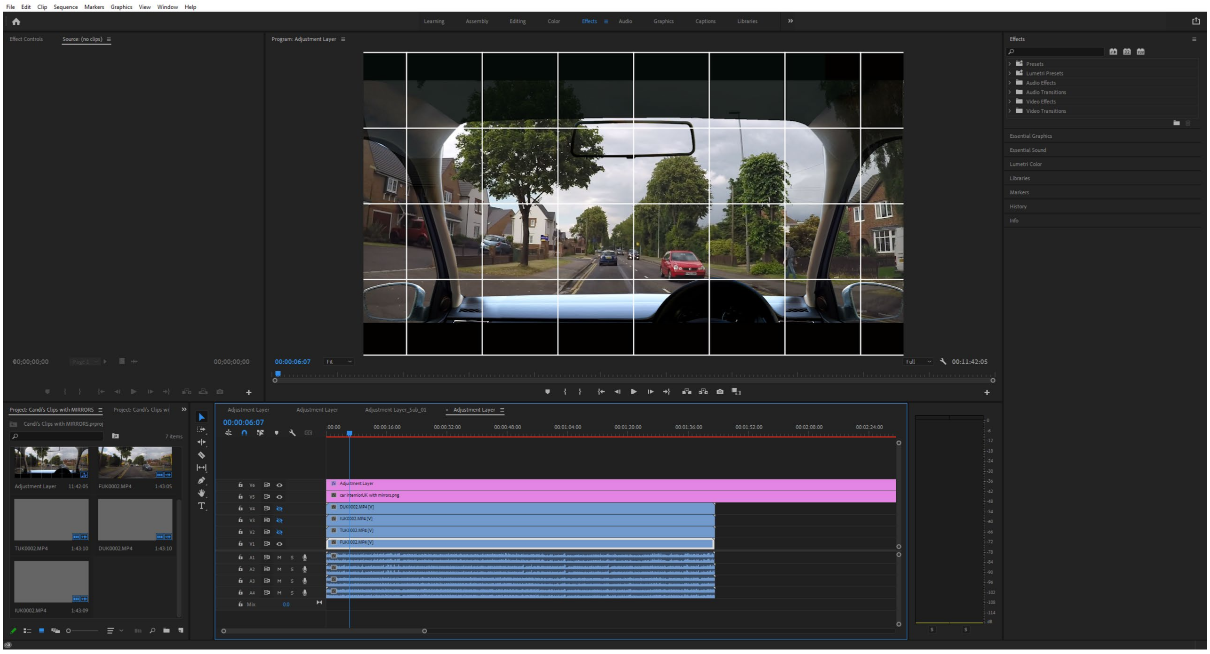
Footage with rear and side mirrors

When working with footage which have rear and side mirrors as well as a front view there are more steps to consider. The following section will help set up and edit this type of footage.

Importing

Use the same method of importing the original files as before. This time import all the footage from the front, rear, left and right footage. Additionally, you need to import a template which has blank rear and side mirrors so the footage can fit within their specific areas. Again, the recommended import method is to Drag and Drop your file into the import panel.

Once the file has been imported, drag the footage onto the timeline panel but in a specific order: Track 1 = Front View footage; Track 2 = Rear view footage; Track 3 = Left Mirror footage; Track 4 Right Mirror footage; Track 5 = Vehicle Template; Track 6 = Adjustment Layer with Grid Effect (See Preparing for editing). Do not delete the audio files yet.

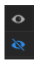


Syncing the footage

At this point it is crucial to sync up all the camera views to ensure a seamless viewing experience once exported. The best way to do this is to sync up the audio of each clip with one another. You can do this by ‘zooming’ into the audio files using the lower slide bar  and bringing one circle towards the other. The time intervals on top of the timeline will become smaller once you do this. Once all the audio and video files are lined up you are ready to edit the footage to fit the template

Editing the footage

For this section, ensure that the footage within the timeline is highlighted and the effect controls are displayed.

Before editing the footage make sure you work with one footage at a time and the vehicle template. To do this you need to ‘hide’ all the other footage. This is done by using the eye icon next to each track in thew timeline panel . An open eye means you can see the footage whereas an eye with a cross means the footage is hidden. Hide all other footage other than the one being worked on.

Front view

See above (page 4) – you may also use the existing Front view preset (see 'Saving a preset' (page 5)

Rotation

Rotation is important to ensure that the video is believable. Select the rotation effect in the effect controls. Adjust the rotation, so buildings and streetlights are as vertical as possible. A typical rotation requires +/- 3 degrees of rotation dependent on the footage. Use the virtual lines of the grid to help with the rotation.

Scale

The scale of the video needs to be edited to ensure that the internals of the car are not shown. to do this, use the 'Scale' effect which is in the effect controls and zoom in until the internals are hidden. This is dependent on the footage but for this example the scale is approximately '159'. This is now the new default scale for this video but will be subject to change after future effects changes such as rotation and position.

Position

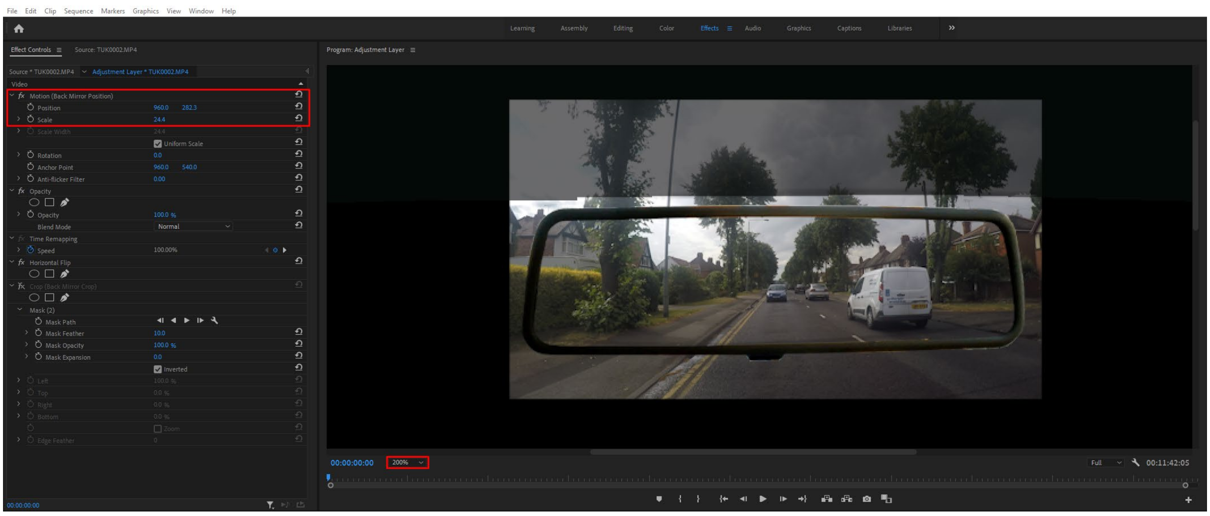
Now the footage needs to be moved to ensure the horizon is at the centre of the screen to do this select the position effect in the controls. Use the centre of the grid to ensure the horizon is centre. There are two ways to move the footage. 1. Use the mouse to move the footage; 2. Use the X and Y numbers to adjust the position of the footage. It is recommended to use the mouse method first as it is easier to get the rough horizon then use the numbers to be more precise. Once you have changed the position of the footage adjust the scale to ensure the image is correct.

Rear-Mirror

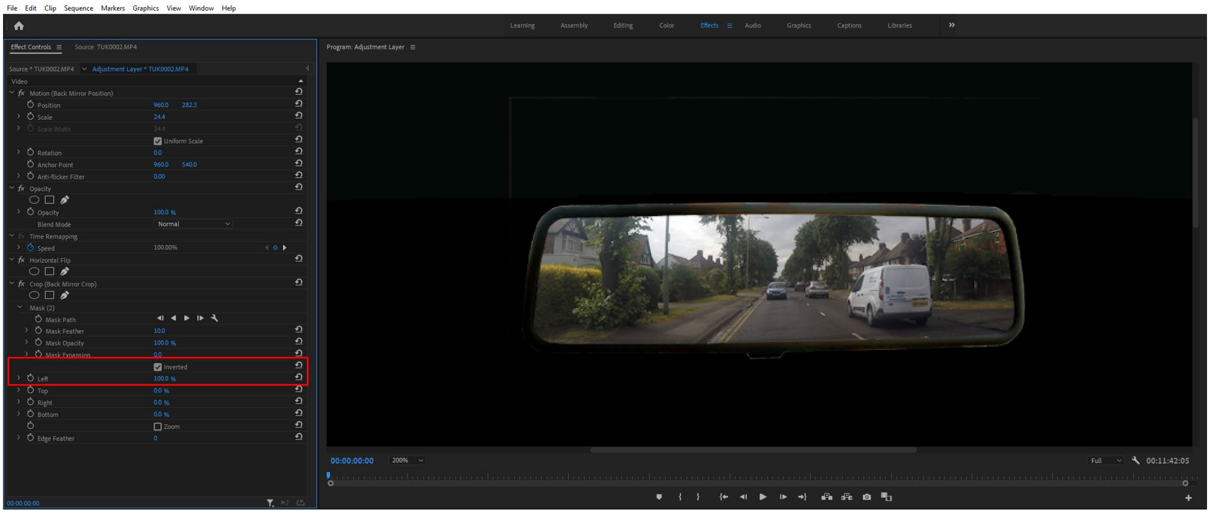
For the rear mirror there are two new effects which need to be used from the effects library.

The first effect is Horizonal Flip. This can be found under Video Effects > Transform > Horizontal Flip. Drag Horizonal Flip onto the rear-view mirror footage. Horizontal Flip is needed because the camera within the car shows the traffic moving the wrong way because the driver normally uses a mirror image to determine what's behind them. Therefore, the horizonal flip mimics the mirror effect needed to simulate the rear-view mirror.

Before the next effect, the scale of the footage will need to be smaller to ensure it fits the mirror template. In this example, the rear-view mirror position scale is 24.4. Next, the rear mirror footage needs to be moved into the position of where the rear-view mirror is on the vehicle template. There are two ways to move the footage. 1. Use the mouse to move the footage; 2. Use the X and Y numbers to adjust the position of the footage. It is recommended to use the mouse method first as it is easier to get the rough horizon then use the numbers to be more precise. A recommendation is to zoom in by 200% in the top middle panel. The rear view mirror footage needs to have the horizon at the centre of the mirror.



The final effect from the effects library is the crop effect. This effect is located in Video Effects > Transform > Crop. Drag Crop onto the rear-view mirror footage. Once crop has been added you need to use the pen tool in the crop effect control to cut out the area needed for the rear-view mirror. This will create a 'Mask' underneath the crop effect in the effects control. Start making points around the mirror line. Once they have all joined up, invert the crop effect by checking the 'inverted' tick box. Finally, with any of the direction crop effects below the mask effects, ensure one of the directions is set to 100% to ensure any footage outside the rear-view template is removed. In this example, left was the directional crop chosen.



Saving rear view presets

Again, it is best to have a preset for the rear-view mirror for future footage. Two presets have to be created, one for the position and one for the crop. To make the position present right-click the 'Motion' effect in the effect control and choose 'save preset'. You will be asked to name the preset. A recommendation for the name is 'Rear view position'. Add a description of the position and scale before saving the preset. The preset is saved in the effects library under Presets > Rear view position. You can drag this preset on any future 'rear view' footage as you would any other effect from the effects library.

The next preset to create is the rear-view crop preset. To make the crop present right-click the 'Crop' effect in the effect control and choose 'save preset'. You will be asked to name the preset. A recommendation for the name is 'Rear view crop'. It is not necessary to add a description to this preset. The preset is saved in the effects library under Presets > Rear view crop. You can drag this preset on any future 'rear view' footage as you would any other effect from the effects library.

Left Mirror

For the left mirror both horizonal flip and crop will be used again from the effects library. Drag Horizonal Flip onto the left view mirror footage. Horizontal Flip is needed because the camera within the car shows a right mirror view instead of the left mirror view, therefore the footage needs to be flipped to show the correct footage at the correct view. Before the crop effect, the left mirror footage needs to be moved into the position of where the left view mirror is on the vehicle template. The scale of the footage will need to be smaller to ensure it fits the mirror template. In this example, the left view mirror scale is 11.5. Next, the left mirror footage needs to be moved into the position of where the rear-view mirror is on the vehicle template. There are two ways to move the footage. 1. Use the mouse to move the footage; 2. Use the X and Y numbers to adjust the position of the footage. It is recommended to use the mouse method first as it is easier to get the rough horizon then use the numbers to be more precise. A recommendation is to zoom in by 200% in the top middle panel. The left view mirror footage needs to have the horizon slightly above the centre of the mirror template. There also need to be some outside door to simulate a real left mirror

Next, Drag Crop onto the left view mirror footage. Once crop has been added you need to use the pen tool in the crop effect control to cut out the area needed for the left view mirror. This will create a ‘Mask’ underneath the crop effect in the effects control. Start making points around the mirror line. Once they have all joined up, invert the crop effect by checking the ‘inverted box’. Finally, with any of the direction crop effects below the mask effects, ensure one of the directions is set to 100% to ensure any footage outside the left view template is removed. In this example, left was the directional crop chosen.

Saving left view presets - See Saving rear view presets

Right Mirror - See above (left mirror)

The final result

Once all the edits have been done, the audio files can be deleted and the observation cutting can commence.

Cutting

Once the video edits have been completed, the video needs cutting to make adequate clips. The minimum clip length is recommended to be 30 seconds, and the longest clip length is recommended to be 1 minute 15 seconds. Furthermore, there should be roughly 20 seconds before the observation and a minimum of 5 seconds after the observation. All of these recommendations can be adjusted for the particular project. Ensure to reference the beginning cut point and the end cut point in the excel spreadsheet under 'Time Range'. To cut the video use the shortcut 'C' to activate the cut tool and <u>cut all the footage and the template</u> on the timeline at the beginning and end of the of the potential clip.

Once the clip has been established, press 'V' to change the tool back to the mouse tool. Next, highlight the clips and the template using SHIFT + left click and use the shortcut SHIFT + U to create subsequence which is added to the import panel. This makes clips easier to export without breaking up the original footage timeline. Double click the subsequence to add it to it's own timeline. Use the shortcut CTRL + M to open the export panel.

Exporting

When exporting ensure you change the file name and location to a new folder to keep the original files and the clips separate. Once you have done this, use the export preset and change the preset to 'High Quality 1080p HD'. Finally untick the 'Export Audio' option. This will change the preset to custom, but this is normal. An additional option is to tick the option 'Use Maximum Render Quality'. Once all the export settings have been finalised, press the export button.

Appendix C

Biopac synchronisation and cleaning protocol

Synchronisation

- SMI uses mouse clicks for the participants to verify when the hazard is. This is compared to their eye movement data (fixations and saccades)
- For the video clips: Experimenter using a keyboard on the SMI machine at the beginning of the clip and F2 on the Biopac. This allows for some level of synchronisation.
- If using pupillometry: Need geometric shapes for the beginning of the video clips for a baseline per clips. This will allow to measure changes in pupils during the clips

1. Start the Biopac before the SMI, this makes the SMI event signals the true signals after the 'delay' function
2. Import SMI data into Biopac
3. Look at the manual biopac markers and compare to the SMI event markers. (Use the measuring baseline for this if possible)
    a. Make sure you are looking for the correct event markers (.avi) as this is when the video is playing.
4. Calculate the difference between the manual marker and event marker (CTRL marker to marker) (make a note of the delta T) **HERE** – <u>Example 66.466</u>
5. Reload the Biopac data and cut the Delta T from the beginning of the biopac data. Change the time scale to the Delta T value – **Use the zoom, i-beam tool and the 'Home' Shortcut to make it easier.**
6. Resync the SMI data
7. The data should be synchronised with manual and SMI markers in the same point. Due to Human error, use the SMI Markers only for analysis.

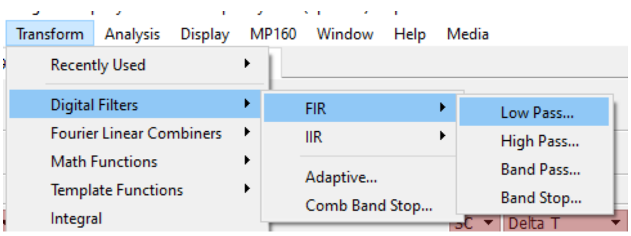
8. You can now clean the data

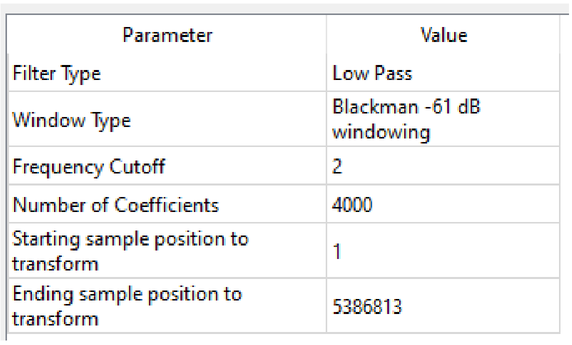
9. **<u>NOTE: If there is no delay and the SMI is faster than the biopac</u>** - cut SMI data to be in front (creates a ‘delayed’ waveform) then merge to see differences in markers, work out delta T then cut biopac data and merge again to sync. May have to merge and sync to get it perfect (cut biopac again)

Cleaning the EDA signal:

For the EDA data there are a number of steps to ensure cleaning is done correctly. Make sure you are working with the ‘delayed’ waveform.

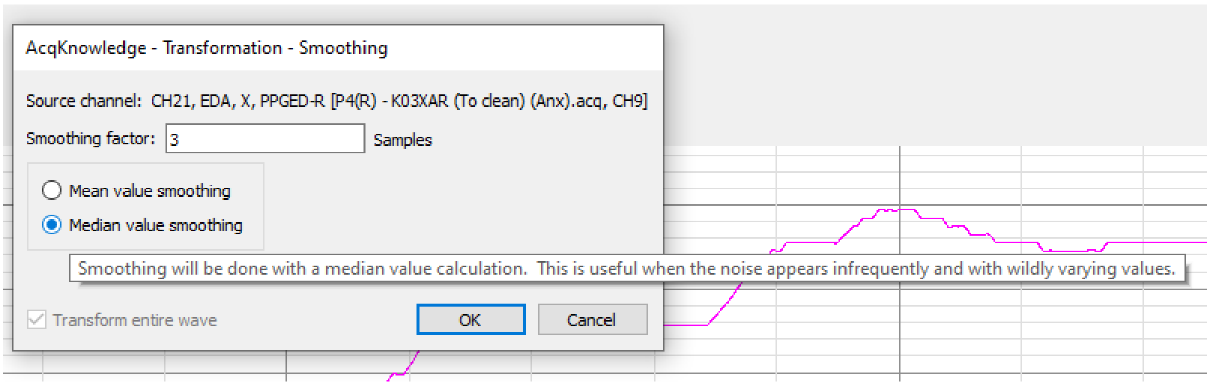
1. Perform a ‘low pass’ filter on the EDA data –



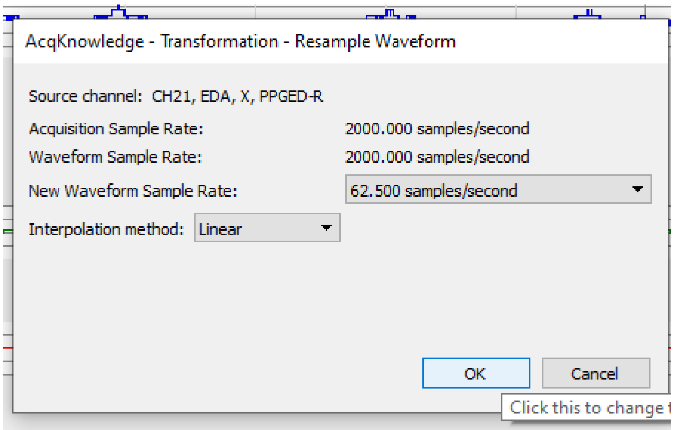


Parameter	Value
Filter Type	Low Pass
Window Type	Blackman -61 dB windowing
Frequency Cutoff	2
Number of Coefficients	4000
Starting sample position to transform	1
Ending sample position to transform	5386813

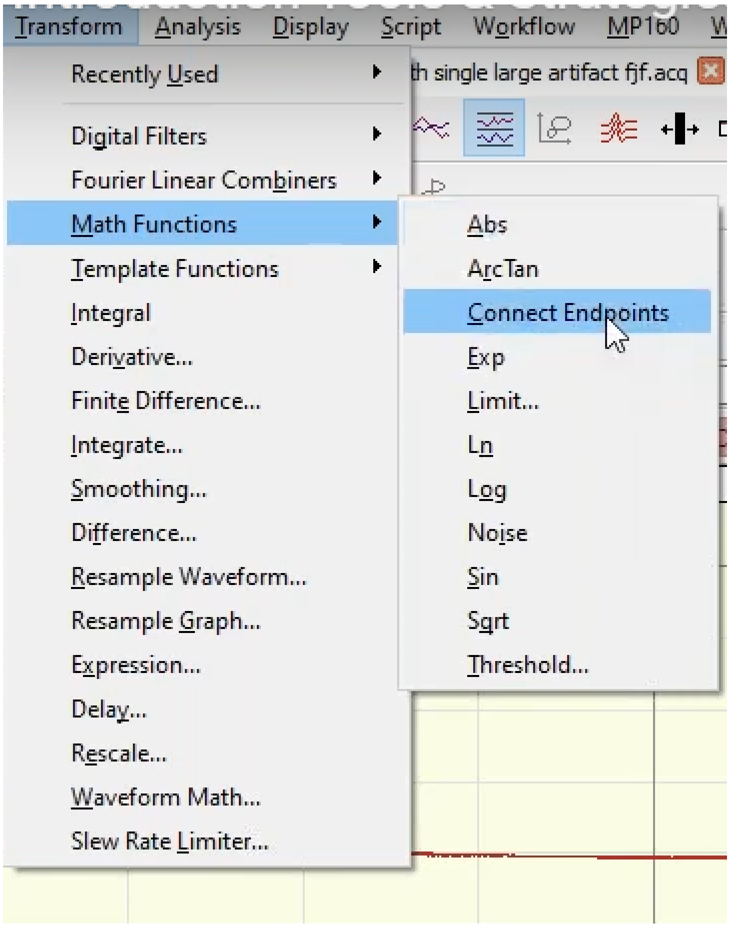
2. Once the low pass filter has been applied, perform a median smoothing



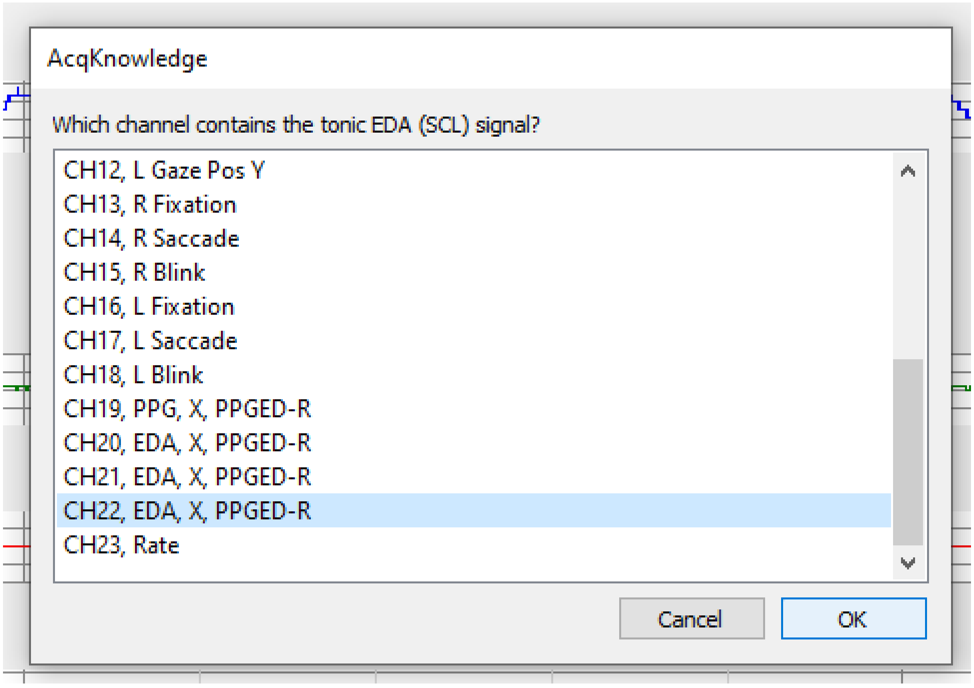
3. Down-sample the waveform from 2000s/sec to 62.5s/sec



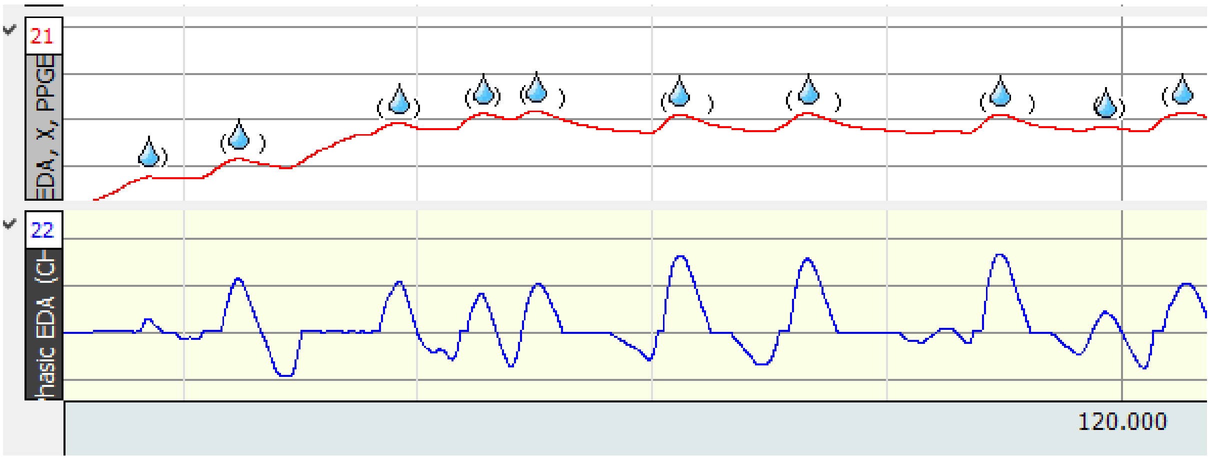
4. If there are any rapid transients (sharp movements) Use Transform > Math Functions > Connect Endpoints to remove the data



5. Derive phasic from tonic on most recent EDA – in this case CH22



6. You want to ensure the SCRs are on the tonic waveform not the phasic



Appendix D

COVID-19 protocol for face-to-face research

NOTTINGHAM TRENT UNIVERSITY

<table>
<tr><td>Risk Assessor’s Name:</td><td>Petya Ventsislavova Petrova and Adam Asmal (PhD Candidate)</td><td>Accountable Managers Name:</td><td>Phil Banyard</td><td>Planned Review Date</td><td>Weekly from May 11th 2021</td></tr>
<tr><td colspan="3">Task or Activity Description</td><td>Location:</td><td colspan="2"></td></tr>
<tr><td colspan="3">This risk assessment template should be used when small numbers of employees and students are accessing the campus prior to the start of 2020/21. Please speak to your Safety Advisor as to the specific nature of your work and they will be able to help identify any additional measures that may need to be in place.</td><td>TAY009
TAY009b</td><td colspan="2">PI: Petya Ventsislavova (Adam Asmal PhD Candidate)

Project name: Driving Anxiety’s impact on Driving Performance and Skills: A mixed method exploration – Study three: The impact of driving anxiety on the ability to perceive hazards</td></tr>
</table>

Fully describe the activity you wish to carry out. You should include dates and the numbers of employees and students that will be on site. *The Return to Work Checklist should be issued to staff who return to site.* *Please ensure that any cleaning requirements are highlighted on this risk assessment.* *There are currently no catering facilities on campus, and this should be reflected in your risk assessment.* *Your current health and safety controls for this activity must still be in place, this includes PPE, operating equipment and lone working etc*		**Project ID**: **Finance Project Code**: PhD **Previous ethics codes**: 2021/98 **Proposed laboratory**: Taylor (B09B) **Dates of access**: From 1st October (or when approved) until December 20th 2021. In August the researcher will create the study using the SMI Eye Tracking Equipment and BIOPAC. Testing is expected to begin in October. **Research Team**: Adam Asmal and Petya Ventsislavova Petrova, **Target participants**: staff, students and general public; *N* = 90.

You may add to any of the control measures below but do not change them.		**Nature of research:** Testing participants on experiments involving eye tracking data recording **Duration**: 2 hours per person (including time for safety protocol requirements e.g. greetings). We intend to conduct an eye tracking experiment, measuring galvanic skin response with approximately 90 participants that have reported driving anxiety. We would like to use the SMI Eye tracking equipment and BIOPAC system between 8th of September and 1st of January. The development of the experiment using the SMI equipment and BIOPAC will ideally start in August and will take place until the end of September (only the PhD student and supervisor). Testing is expected to begin in early October. We expect that each day approximately 4 participants will be tested. The

		experiment would last approximately one hour and 30 minutes however we will assign two hours for each participant to ensure that all safety protocols are followed (e.g. greetings, cleaning and time to leave without overlap). Each participant will receive most of the instructions in advance however some of these will need to be explained F2F (mostly related to eye calibration and electrode placement). We will ensure that all safety protocols are followed. We will follow strictly the eye tracking protocol and we have created a new BIOPAC protocol to be followed in order to minimise risk. Prior to the experiment, electrodes will be placed on participants' finger palms. In order to minimise risk, we will follow all the cleaning and safety procedures recommended in the BIOPAC protocol. During the experiment, participants will only be required to use the mouse and keyboards. No chin rest will be used for the eye tracking. The researcher will need to remain in the testing room with the participant, therefore the eye tracking equipment will be

		moved to B09B allowing for two people to be inside with one metre distance. Bipack equipment will be moved to the same room (BIOPAC is small and easily portable). The SMI equipment, keyboards and mouse, and chair (hard plastic) will be cleaned after each participant to minimise risk. The electrodes are disposable and will be changed for each participant. Cables will be cleaned. We will request the standard cleaning equipment for the laboratory (spray, cloths etc.). The researcher will use Nitrile Gloves at all times. Maximum two researchers will be on site during testing. The PhD candidate will greet and test the participants and the supervisor will engaged in desk-based work and will not meet with the participant unless there is a security issue.

	Persons at Risk - Affected Groups:	
	A -	B –
	C –	D -
	E –	F -

Potential Hazard	Existing Controls	Risk level with controls	Additional Controls or Required Action & Date
Prevention of catching COVID-19	• Employees are not to attend site and are to follow current UK NHS guidance where they are exhibiting any symptoms of the virus; where	**Low**	*Adam Asmal will report symptoms to the team leader* (*Petya Ventsislavova Petrova) and will not attend the workplace.*

Potential Hazard	Existing Controls	Risk level with controls	Additional Controls or Required Action & Date
	they live with anyone who has symptoms of the virus or have been told to isolate for 12 weeks. • Employees in any of the extremely vulnerable at-risk categories, are not to undertake activities on site as noted in this Government guidance • Employees to observe social distancing at all times (maintain 2m away from other people) including in toilets and kitchens.		*Our research will follow the following safety protocols (see attached):* • **Protocol for Recruiting Participants** • **Protocol for Greeting Participants** • **Protocol for Moving Participants around the Building** • **Track and Trace Protocol** • **Cleaning and hygiene protocol** • **Security protocol** • **Generic Eye Tracking protocol**

Potential Hazard	Existing Controls	Risk level with controls	Additional Controls or Required Action & Date
	• Employees to observe good hand hygiene techniques at all times. Hands should be washed frequently. All employees to use hand sanitiser that is available from contactless dispensers, upon arrival to site and before leaving. • Activity time to be kept to an absolute minimum. • Do not leave any rubbish in the waste bins, take all rubbish and personal belongings home with you.		• **BIOPAC Protocol** Following these protocols will mitigate the risk to participants from COVID transmission and will ensure the safety of staff in regard to COVID transmission and potential security concerns.

Potential Hazard	Existing Controls	Risk level with controls	Additional Controls or Required Action & Date
	• Current UK Government guidance (11/05/20) on the use of PPE to be followed including, "*When managing the risk of COVID-19, additional PPE beyond what you usually wear is not beneficial. This is because COVID-19 is a different type of risk to the risks you normally face in a workplace, and needs to be managed through social distancing, hygiene and fixed teams or partnering, not through the use of PPE*." (Gov, 2020).		

Potential Hazard	**Existing Controls**	**Risk level with controls**	**Additional Controls or Required Action & Date**
	• Face coverings are a personal choice in the workplace and are not the same as PPE, if you choose to wear them please ensure you follow the face covering guidance • Face coverings must be worn on public transport from 15 June 2020		*Estates will be alerted to our use of the TAYLOR Eye Tracking LABS. An initial clean would be useful, as would subsequent periodic cleans, though experimenters will disinfect all surfaces* (*laboratory, toilet door, flush and seat if used, etc.*).

Potential Hazard	Existing Controls	Risk level with controls	Additional Controls or Required Action & Date
	• You must practice social distancing and wash your hands frequently, even if you wear a face covering • Prior to undertaking any work, employees are required stay alert to the situation to identify any obvious issues or changes that could increase the risk of coming contact with the COVID-19 Virus. Employees are to report any issues identified to their line manager prior to commencing work.		

Potential Hazard	Existing Controls	Risk level with controls	Additional Controls or Required Action & Date
EQUIPMENT/MACHINERY	• Only equipment listed is permitted to be used – no other equipment should be used without prior permission • All equipment pre use checks should be completed prior to use and any statutory checks should be complete – any equipment that has not been checked should be removed from use. • Any equipment used must be cleaned after use following manufacturers guidelines.		*SMI RED 500 Eyetracking system and BIOPAC MP-160* *Please see attached Generic Eye Tracking Protocol and Generic BIOPAC Protocol document for how we will ensure this equipment is used safely.*

Potential Hazard	**Existing Controls**	**Risk level with controls**	**Additional Controls or Required Action & Date**
	• Use of food preparation equipment e.g. toasters is prohibited.		
TRAVEL	• Use of public transport should be minimised where possible. • Employees should follow Government and transport company guidance if travelling by public transport • Face coverings must be worn on public transport from 15 June 2020. • Park as close to the building as possible		*Staff will drive to TAYLOR. We request permission for staff to park either in the DICE carpark to the rear of TAYLOR.* *We will recommend that participants drive to TAYLOR. We request permission for them to park in TAYLOR carpark (currently used by NTIC).*

Potential Hazard	Existing Controls	Risk level with controls	Additional Controls or Required Action & Date
			If participants choose to travel by public transport we will ensure that they are reminded of the requirement to wear a face mask.

This risk level has been reduced as low as is reasonably practicable			
Assessor's Signature:	Adam Asmal	**Date:**	23/09/2021
Manager's Signature	Petya Ventsislavova Petrova	**Date:**	**23/09/2021**

	1st Review	2nd Review	3rd Review	4th Review	5Th Review
Assessors Name:					
Managers Name:					
Date of Review:					

Appendix E

A protocol for safely undertaking laboratory-based galvanic skin response research under current COVID-19 restrictions

PI: Petya Ventsislavova Petrova and Adam Asmal

Project name: Driving Anxiety's impact on Driving Performance and Skills: A mixed method exploration – Study three: The impact of driving anxiety on the ability to perceive hazards

Project ID:

Finance Project Code:

Previous ethics codes: 2021/98

Proposed laboratory: TAYLOR B09B

Dates of access: From 1st October (or when approved) until December 20th 2021. In August the researcher will create the study using the SMI Eye Tracking Equipment and BIOPAC. Testing is expected to begin in October.

Research Team: Adam Asmal and Petya Ventsislavova Petrova

Maximum of two members of the team will be onsite at any one time. The second member of staff will work in a nearby cubicle

Target participants: staff, students and general public; $N = 90$.

Nature of research: Testing participants on experiments involving eye tracking data recording and galvanic skin response.

Duration: 2 hours per person (including time for safety protocol requirements e.g. greetings).

Background

Provide information about the project to which this piece of data collection involves, and why it is essential that this work is carried out at this time.

The project involves testing participants who have reported to experience driving anxiety. Such sample cannot be tested online for several reasons.

First, we intend to measure participants' eye movements in order to be able to find out how they explore different hazardous and non-hazardous situations. We predict that anxious drivers will focus their attention on specific areas of the traffic scene related to what causes them anxiety and ignore, other, more important sources of danger. For this end, we will need access to the SMI Eye Tracking equipment. The online platform Gorilla does offer online eye tracking but unfortunately it has failed to provide reliable data. This study is essential for this PhD project as it will provide answers to one of the main questions of this project, namely whether anxious drivers focus their attention on what is causing them driving anxiety while ignoring the real source of danger. If the PhD students is not able to initiate F2F testing, this can considerably hinder his research as the following studies will be based on the results of the present study.

Second, we intend to record galvanic skin response which is a common measure for anxiety. Thus, we will be able to find out whether participants with driving anxiety report higher levels of electrodermal activity while watching specific hazardous driving situations. Such data recording cannot be conducted online.

Third, participants who have reported to experience driving anxiety cannot be tested online due to the possibility of finding the hazardous traffic situations distressing. Each participant will be asked to watch and responded to a series of clips that contain a variety of hazardous situations. Some of these situations may be a source of anxiety for the participants. Therefore, we need to ensure that they are aware at all times about this possibility and that they understand the purpose of the research. Participants also need to be provided with the adequate support in case they feel distressed, and they need to exit the study. This might not be possible online as many times the information at the beginning of the study could be ignored (e.g. participants skipping through the information sheet and not providing informed consent) and if the participant should exit the study, there is no possibility to return to the information sheet or see the debrief. F2F testing will ensure that participants are aware of the sensitive nature of the research, adequately supported in case they feel distressed and invited to exit the study if the researcher notices that they feel uncomfortable.

1. As much of the testing procedure as possible will be conducted in advance such as general information about the study and instructions, however participants will be instructed again upon arrival.
2. The experimenter will need to remain in the testing room with the participant, therefore the eye tracking equipment will be moved to B09B allowing one metre distance.

Project Protocol:

1. Staff will travel to work via private transport. We request parking permission for the DICE car park.
2. Participants will be recruited and instructed following the **Recruitment Protocol.** They will be advised to use private transport. We request permission to use the TAYLOR car park, or the DICE car park for participants.
3. The Eye tracking Labs will be prepped following the **Cleaning and Hygiene Protocol,** the **Generic Eye tracking Protocol and the Generic BIOPAC Protocol.**
4. Equipment will be prepped following the **Generic Eye tracking Protocol and the Generic BIOPAC Protocol**.
5. Participants will be greeted and prepared following the **Greeting Protocol.**
6. Participants will have contact details collected following our **Track and Trace Protocol.**

7. Participants will be moved to the TAYLOR Eye tracking labs following the **Movement Protocol.**
8. Participants will be directed towards the disabled toilet in the ground floor the foyer if required.
9. Once participants have completed the research they will be reminded of their obligations under our **Track and Trace Protocol** and will be allowed to leave as per our **Movement Protocol**.
10. Following our **Security Protocol**, whenever possible, a second researcher may be present in the Taylor building. This researcher will be engaged in desk-based work, and will not meet with the participant unless there is a security issue (though the two researchers may test alternate participants providing all protocols are followed).

Required items

In addition to standard cleaning equipment for the laboratory (spray, cloths etc.) we will need the following:

Nitrile Gloves (100 pairs), circa £18.49. These are required to be worn by the experimenter when testing participants.

Provide Amazon link - https://smile.amazon.co.uk/TouchGuard-Nitrile-Disposable-Gloves-Powder-Free/dp/B07QDXWSSH/ref=sr_1_5?dchild=1&keywords=Nitrile+Gloves&qid=1620556708&sr=8-5

Alcohol wipes (80 individual wipes with 75% alcohol), circa £3.69. We will need the entire 80-piece pack of wipes.

Provide Amazon link - https://smile.amazon.co.uk/Gone-Travelling-Protect-Alcohol-Surface/dp/B08CL1HFDN/ref=sr_1_6?crid=1WMNRNJVMHS1G&dchild=1&keywords=alcohol+wipes&qid=1620556784&sprefix=Alcohol+Wipe%2Caps%2C169&sr=8-6

Disposable, individually-packed face masks (30 per pack), circa £16 per pack. These individually wrapped masks will be provided to participants. We will need 2 packs (£32)

Total cost for specialist Eye tracking cleaning equipment for this project = **£54.18**

Appendix F

Study one driving anxiety interview schedule

1. Would you consider yourself an anxious individual?
    a. Why?
2. Do you feel anxious about driving?
    a. (If Yes) What do you think caused your driving anxiety?
    b. Do you think anxiety in general impacts your driving ability?
        i. Positive way/negative way?
3. Can you take me through the experience which made you anxious about driving?
    a. How did you feel at that moment?
    b. What did you do at that moment?
4. Has that driving experience that caused anxiety impacted your daily life in general?
    a. In what ways?
5. Do you think that specific experience leads to driving anxiety or were there multiple factors/situations?
6. Do you continue to drive currently?

    a. Why/why not?
        i. What are your thoughts/feelings when you drive?

7. Do you feel that the anxiety makes you attend/focus on the wrong things when you drive?
    a. What do you focus on?
    b. Why do you focus on this?
    c. How do you try to overcome this?
    d. Do you feel your anxiety distracts you?
8. Are you worried about making mistakes when/if you drive?
9. Does the anxiety impact you if/when you are a passenger in a car?
10. Does this anxiety impact any other modes of transport?
11. Did the experience/your anxiety impact your confidence in driving?
    e. In other aspects of your life?
12. Are you worried that the anxiety has put your life on hold?
13. What do you think would help reduce your anxiety?