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An exploratory study of the role played by sustained attention along a rural Irish route using a video-playback system

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ABSTRACT

Inattention and distractibility are major causes of driver accidents. Using a video playback system with a video sequence taken from a rural Irish road, we compared the speed of those considered as having either high or low levels of sustained attention along the route, as well as, at targeted sections of the road. In addition, we manipulated the video sequence by adding a speed limit sign (augmented sequence) or by removal of the middle white line (redacted sequence) to determine how each group would react. Results revealed that those with high sustained attention showed generally lower speeds compared to those with low sustained attention with a significant difference between the groups at bends. Further, although no difference in reaction was found for any particular manipulated sequence, the high sustained attention group was found to be significantly slower at these locations. In addition, some gender differences were observed, females showed significantly lower speeds on straight stretches of road and at a school compared to male drivers. These results would suggest that both attentional capacity and gender should be considered as separate entities in future driving research and theoretical models.

1. Introduction

Road deaths in Ireland have decreased dramatically over the last number of years, from a fatality rate of 232 per million registered vehicles in 2001 to 77 per million registered vehicles in 2011. Despite this, 186 people were killed and 7235 people were injured in 2011 (Road Safety Authority of Ireland (RSA), 2011). The majority (65%) of the car drivers killed were male and 30% of deaths were aged under 24. Collision reports from An Garda Síochána (Irish Police Force) have indicated that driver error accounted for 84% of all contributory factors identified in fatal collisions and injuries in 2011, with the most frequently cited contributory action was 'went to the wrong side of the road' (33%) followed by 'drove through stop/yield sign' (15.9%) and 'exceeded safe speed limit' (6.4%; Road Safety Authority of Ireland (RSA), 2011). While not specifically mentioned, inattention and distractibility may be important factors in causing driver error.

Inattention is also one of the major factors that contributes to road traffic accidents internationally. According to the United States Department of Transportation 2010 statistics, nearly 6000 people died in crashes involving a distracted or inattentive driver (Pradhan et al., 2011). Data from Australia (McEvoy, Stevenson, & Woodward, 2007) suggest that driver

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distraction may account for between 14% and 33% of all serious crashes, with lack of concentration, passengers and outside factors all being cited as major causes of driver distraction. This study compares favourably with research from Norway, which also cites passengers, in-vehicle factors (e.g. mobile use) and outside factors (e.g. searching for signs or street names) as the main causes of driver distractibility and inattention (Sagberg, 2001). In a more recent study, where 100 cars were fitted with video-recording equipment and monitored for a year to determine causes of accidents, it was found that 22% of crashes and near-crashes were due to secondary task distraction (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006), including in-vehicle passengers (9%), dialling a hand-held device (3.6%), talking on a hand-held device (3.6%), and reading (2.9%; Dingus et al., 2006).

Inattention is also thought to be the leading cause of accidents among various at risk groups. For example, Lestina and Miller (1994) analysed 1396 police reports detailing traffic accidents in California and identified inattention as being a major cause of accidents among young novice drivers. A failure to adequately assess the road (39% of accidents) and a failure to observe the rules of the road (18%) were the most frequently cited causes of accidents among drivers under the age of 20. Similarly, Lee, Olsen, and Simons-Morton (2006) found that novice drivers spent significantly more time looking away from the roadway while performing in-vehicle tasks compared to experienced drivers. Gender differences have also been reported in accident statistics, with the fatality rate for males in the United States being three times higher than females (Kelley-Baker & Romano, 2010). Male drivers are thought to engage more in riskier behaviour compared to females (Harré, Brandt, & Dawe, 2000). More specifically, Al-Balbissi (2003) identified that males were worse than females at violating stop signs, using incorrect lanes, violating yield signs, disregarding obligatory signs, and wrong overtaking. The author explains these behaviours in terms of reduced attention and less cautious driving behaviour amongst male drivers.

Attention is defined as the ability to allocate processing resources to particular stimuli (Robertson I. H., in press). Attention, however, is not a unitary process with Posner and Petersen (1990) advocating 3 separate attentional processes: selective attention, attention switching, and sustained attention. While driving requires the ability to pay attention to certain features on the road while ignoring others (selective attention) and the ability to switch your attention should an unforeseen event arise (switching attention), it is the ability to maintain the focus of cognitive activity on the driving task at hand (sustained attention) that is thought to be a critically important (Staub, Doignon-Camus, Després, & Bonnefond, 2013). For example, many drivers show fatigue and loss of sustained attention during long monotonous drives, particularly at night, which can lead to very serious accidents (Campagne, Pebayle, & Muzet, 2004). Such failures in sustained attention are currently explained in terms of two theoretical frameworks: the resource depletion model and the mindlessness model. The resource depletion model (Davies & Parasuraman, 1982) advocates that vigilance loss is due to a decline in attentional resources with time, while the mindlessness model (Manly, Robertson, Galloway, & Hawkins, 1999) suggests that the repetitive nature of the task leads participants to perform the task in a mindless fashion and are therefore easily distracted.

Interestingly, recent research in the driving domain has attempted to account for differences in driver behaviour in terms of attentional differences, particularly attentional capacity (Pradhan et al., 2011). This idea fits with various driving models, as well as the various sustained attention models. For example, the task-capability interference (TCI) model (Fuller, 2000, 2005), emphasise that when the demands of the driving task exceeds the capabilities of the driver, there is a loss of control which, in turn, may lead to collisions and accidents. Although not explicitly stated in this model, attention may play a role in the range of human factors that can influence driver capability. Therefore you might predict that someone with a high attentional capacity, particularly sustained attention, would have greater 'spare capacity' (see Rubio, Diaz, Martin, & Puente 2004) and would be in a better position to deal with unexpected events that may arise while driving. On the other side of the TCI model, driving task demand can also affect levels of arousal and subsequent driver capability (Fuller, 2005). Indeed, many researchers have found a high correlation between feelings of risk, task difficulty and effort (Fuller, McHugh, & Pender, 2008; Lewis-Evans, de Waard, Jolij, & Brookhuis, 2012; Lewis-Evans & Rothengatter, 2009). Accordingly, as the demands of the environment increase, more effort (mental and/or physical) is required to match such demands (Lewis-Evans & Rothengatter, 2009). Therefore, the more effort that is employed by an individual the more their capacity decreases-as a result the driver's ability to match environmental demands also decreases (Fuller, 2000, 2005; Lewis-Evans & Rothengatter, 2009). Again, we would suggest that an individual with higher attentional capacity would be in a better position to deal with increased demands of the task.

Attentional capacity is not static and is liable to change throughout the lifespan. As brain regions devoted to executive functioning, including attention, develop mainly during late adolescence and early 20s (Blakemore & Choudhury, 2006), it is possible that developmental factors may have an impact on attentional capacity and the greater distractibility observed in younger drivers. These developmental factors are often very difficult to measure. To complicate matters, late adolescence and early 20s is also the age when people first learn to drive, therefore more experienced drivers, due to practice, may also have a greater attentional capacity and thus are able to devote more resources to 'other' aspects of driving, e.g. scanning, watching for hazards etc (Pradhan et al., 2011). Although attentional capacity itself is difficult to measure, tasks (e.g. Continuous Performance Task, Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956; Digit Detection task, Nuechterlein, Parasuraman, & Jiang, 1983; Sustained Attention to Response Task, Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) that measure a person's ability to maintain vigilance, avoid distraction and prevent lapses in attention may serve as a useful proxy for measuring capacity. Using these tasks it may be possible to examine the idea of whether those with higher attentional capacity react better to road situations that require particular attention (e.g. multiple bends, hazards) compared to those with less attentional capacity. In addition, do those with a higher attentional capacity have more 'spare capacity' allowing them to scan and notice their environment more than those with a lower attentional capacity? Therefore, using