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Aging and driving in a complex world: Exploring age differences in attentional demand while driving

Arne Stinchcombe, Sylvain Gagnon *

School of Psychology, University of Ottawa, Ottawa, Ontario, Canada

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ABSTRACT

We investigated the relationship between attention and road complexity in a convenience sample of older drivers. The study sought to examine the impact of age-associated changes in attention in response to situations with an elevated risk of crash. Scenarios were manipulated in terms of handling and information processing complexity. Twenty-six older drivers and 30 mid-aged drivers completed a series of 20 simulated driving scenarios incorporating either rear-end or crossing path situations. For each scenario, the complexity of the driving environment was systematically manipulated in terms of vehicle handling and information processing elements. The attentional demands of half of the scenarios were assessed by means of a peripheral detection task (PDT) as well as through a subjective measure of overall difficulty. The results indicated that when information processing demands were increased, through the addition of traffic, and buildings, all participants exhibited greater workload regardless of age. While no main effects of age were observed, older drivers did exhibit significantly longer PDT responses in the low vehicle handling condition of the crossing path scenario. The results confirm the impact of environmental complexity on attention but suggest that the PDT may not be the most appropriate means of assessing attentional demands among older drivers, particularly when the driving complexity is elevated.

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1. Introduction

Driving an automobile has become associated with more than simply a method of transportation. Instead, it is now perceived as a contributing factor to self-esteem, independence and quality of life, especially in developed countries, where driving is a primary means of mobility (Liddle, Turpin, Carlson, & McKenna, 2008; Mezuk & Rebok, 2008). Despite their convenience and widespread use, motor vehicles present undeniable safety concerns. Transport Canada's annual report revealed that in 2007 there were over 138,470 road collisions, with approximately 2750 of them resulting in fatalities (Transport Canada, 2008). In Britain, there were 230,902 road casualties reported in 2008, and of those 2538 were fatal Great Britain Department of Transportation (2009). Research indicates that most of these motor vehicle collisions (MVCs) occur at similar situations. Specifically, after analyzing the circumstances surrounding all police-reported collisions, the US Department of Transportation concluded that the two most frequent types of collisions were rear-end crashes (i.e., the front of a following vehicle strikes the rear of a lead vehicle), and crossing-path crashes (i.e., one moving vehicle cuts across the path of another) (Najm, Sen, Smith, & Campbell, 2003). Many authors contend that the highly complex nature of road situations increases cognitive workload which, in turn, leads to MVCs (e.g., Horberry, Anderson, Regan, Triggs, & Brown, 2006; Patten, Kircher, Östlund, Nilsson, & Svenson, 2006).

* Corresponding author.
E-mail address: sgagnon@uottawa.ca (S. Gagnon).

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These statistics regarding the number of crashes and fatalities are striking and point to the inherent risks associated with driving a motor vehicle as well as the related public safety concerns. In an attempt to better understand the role of complexity and cognitive workload in the occurrence of MVCs, the authors of the present manuscript developed a series of simulated scenarios resembling those most frequently cited in the crash literature (Stinchcombe & Gagnon, 2010). In one such study, we developed five 1 km simulated scenarios that incorporated crossing-path and rear-end components (i.e., three crossing-path and two rear-end); each scenario was manipulated according to Fastenmeier (1995) taxonomy in which driving situations are characterized in terms of vehicle handling (i.e., high or low) and information processing (i.e., high or low). To explore the effect of complexity on cognitive workload, a sample of inexperienced young drivers (mean age was 18.62 years) completed a measure of subjective cognitive workload (i.e., NASA TLX) after each scenario, while a subset of participants were presented with a peripheral detection task (PDT) as a measure of objective workload at a critical point during the scenario. The results of our study demonstrated the effect of information processing and vehicle handling complexity on cognitive workload as evidenced by a greater latency to respond to the PDT and higher subjective workload scores in response to complex situations. Moreover, the results pointed to the relevance of the PDT as a measure of objective cognitive load to assess differences in environmental complexity in a sample of young adults as demonstrated by nonsignificant differences between individuals who completed the PDT and those who did not.

The abovementioned framework proved to be both valid and worthwhile for examining the effect of complexity in common crash situations. As Stinchcombe and Gagnon (2010) was the first study to employ this particular experimental paradigm, we utilized a convenience sample of inexperienced drivers. However, not all drivers are at equal risk of being implicated in MVCs. When considering mileage-based crash rates, older adults (i.e., adults over the age of 65 years) are implicated in more MVCs than younger adults (Lyman, Ferguson, Braver, & Williams, 2002; Stamatiadis, 1996; Stamatiadis & Deacon, 1995). Older drivers are more likely to be involved in MVCs that occur in good weather, during daylight hours, at intersections, and when making turns (Langford & Koppela, 2006; McGwin & Brown, 1999). Moreover, older drivers are usually involved in multi-vehicle crashes, especially at intersections, characterized by errors related to failure to yield right of way, difficulties merging into traffic, changing lanes, leaving a parking position, and reversing (Hakamies-Blomqvist, 1993). What is more, due to greater frailty and reduced tolerance to injury, older drivers are more likely to experience casualties in the form injury or death (Augenstein, 2001). Many authors contend that the mileage-based overrepresentation of older adults in MVCs is due to functional changes associated with age-related health conditions (e.g., Raitanen, Törmäkangas, Mollenkopf, & Marcellini, 2003; Ross et al., 2009).

Given that older adults experience an increased risk of MVCs, a significant body of research has been dedicated to understand both the specific cognitive processes involved as well as their interaction with the driving environment. The research has consistently shown that the cognitive process of attention significantly contributes to on-road performance and the risk of MVCs among older adults (e.g., Horberry et al., 2006; Patten, Kircher, Ostlund, & Nilsson, 2004). Problems with driver attention can be defined as failure by the driver to pay attention to the correct stimuli, or conversely, failure of the driver to ignore irrelevant stimuli (Trick, Enns, & Vavrik, 2004). For example, a measure of visual attention, entitled the Useful Field of View task (UFOV), has been shown to have a high correlation to crash involvement among older adults (Ball, Beard, Roenker, Miller, & Griggs, 1988; Goode et al., 1998). Moreover, studies have shown that older drivers are implicated in MVCs in highly complex scenarios, such as at left-turns (or at right turns in countries that drive on the left), where attention is a critical process necessary for crash avoidance (Mayhew, Simpson, & Ferguson, 2006; Robertson & Vanlaar, 2008; Staplin & Fisk, 1991; Summala & Mikkola, 1994). A recent study by Cantin, Lavallière, Simoneau, and Teasdale (2009) examined age-related difference in cognitive load in response to environmental complexity. In their study 10 younger and 10 older drivers completed a continuous scenario encompassing both urban and rural settings. To measure cognitive load, latency to respond orally to a visual stimulus was recorded. The visual stimulus was presented during three types of situations of increasing complexity: when driving on straight roads at a constant speed, when approaching intersections where the driver was required to come to a stop, and when overtaking a slower vehicle. Their analysis revealed a significant age by complexity interaction where both younger and older drivers exhibited greater cognitive workload with increasing complexity and, in comparison to younger drivers, older drivers showed increased cognitive workload during the overtaking maneuvers.

The literature regarding older adults and driving indicates that (1) older drivers are at an increased risk for MVCs, (2) their increased risk is partly attributed to a decrease in cognitive function, notably in attention, and (3) older drivers are most often implicated in crashes at highly complex situations, such as intersections. Given that our previous experimental paradigm proved to be sensitive to changes in cognitive workload of young drivers in response to environmental demands, we sought to utilize this protocol to explore the driving challenges of older drivers. Precisely, the purpose of the present study was to examine the impact of age-associated changes in attention in response to scenarios of varying handling and information processing complexity on cognitive workload. Since previous literature has found changes in attention in response to handling and perceptual complexity in a young sample, we hypothesized that these differences would be even more pronounced within an older population. Moreover, given that older adults are known to experience age-related deficits in attention, it seems plausible that the PDT might interact with their reduced attention. Thus, a secondary goal was to explore the appropriateness of a visual secondary task as a measure of attentional demand for this population.

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