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Route familiarity breeds inattention: A driving simulator study

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ABSTRACT

Inattention is a major cause of traffic accidents. Here, we show that, contrary to common-sense expectation, familiarity with a route is itself a source of driving impairment. This effect may be attributed to increased mind-wandering along familiar routes. In the present work, participants followed a vehicle along a route with which they were either familiar or unfamiliar. During the experimental session, the lead-vehicle braked at random locations, forcing participants to brake to avoid a collision. Participants were also required to respond with a button press when they noticed pedestrians heading toward the road from a sidewalk. In Experiment 1 we found that familiar drivers follow the lead vehicle more closely and are slower to notice approaching pedestrians. In Experiment 2, with following distance held constant, reaction times to central and peripheral events were longer for familiar drivers. Consistent with the mind-wandering hypothesis, all these effects were eliminated in Experiment 3 when drivers were made to focus on the driving task.

1. Introduction

Repeatedly engaging in a task, often results in a gradual transition from initially needing to consciously control one's actions, to a state where our actions are governed by more automatic processes (Schneider and Shiffrin, 1977). This transition from controlled to automatic processing is thought to be accompanied by a reduced demand on attentional resources. Neuroanatomical evidence consistent with this position is found in a study showing reduced brain activation patterns in participants practiced in completing a word generation task versus unpracticed participants (Raichle et al., 1994).

Posner and Snyder (1975) characterized the difference between *controlled* and *automatic processes* as follows. Controlled processes are those that are under top-down control (i.e., are volitional), can be modified based on task demands, and require attentional resources in order to be carried out. Automatic processes, on the other hand, occur without conscious awareness, are ballistic, and do not interfere with separate processes that require attentional resources.

One task that most of us engage in daily that illustrates this practice effect is the task of driving a car. When we first started driving, we had to devote a lot of attention to checking our mirrors, having our hands in the 10 and 2 positions, watching the speedometer, etc. (this is even more evident if the car has a manual transmission). Over time, however, the task of driving that car becomes easier. In addition to learning the general aspects associated with driving a vehicle, similar learning also occurs with respect to learning the route between two locations. Initially we have to pay a lot of attention to road signs, etc., but as we become familiar with the route, these aspects, as well as more subtle things like the curves in the road and intersection locations, no longer have to be sought out, but rather are provided to us through our memories. That is, we shift from a more controlled, effortful, processing of the route, to a more automatic one. This shift to more automatic processing of the route should free up resources (Posner and Snyder, 1975) that could be allocated to some other task, like hazard detection. As a result, one might predict that familiar drivers should be more efficient at executing an appropriate response to a hazardous event than unfamiliar drivers. Although it makes intuitive sense that the development of efficient route processing should aid driving performance, this possibility has not been previously explored.

On the other hand, the idea that route-familiarity might promote a *delay* in hazard response is indirectly supported by evidence in the driving literature. For example, compared to novice drivers, drivers with extensive experience are less likely to check their mirrors and to follow a lead vehicle at an adequate distance (Duncan et al., 1991). These findings could be an indication that experienced drivers are less likely to successfully monitor the environment for hazards, thereby limiting the ability to respond promptly when needed. In addition, it has been shown that as one becomes familiar with a route, there is a decrease in the amount of time spent looking at peripheral items, and drivers are less likely to notice changes in the environment (Charlton and Starkey, 2011; Martens and Fox, 2007). In fact, Martens and Fox (2007) demonstrated that route

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familiarity can promote a state of *inattentional blindness*, where drivers are less likely to notice a critical stimulus in the environment even when the driver fixates on that stimulus.

One possible explanation as to why route familiarity promotes a form of inattentional blindness comes from the literature on *mind wandering*. The reasoning goes something like this. Mind wandering is a state where the thought processes that occupy the mind are on topics that are unrelated to the task(s) at hand (Smallwood and Schooler, 2006). The incidence of mind wandering has been shown to increase as a task becomes more practiced (Cunningham et al., 2000; Mason et al., 2007; Teasdale et al., 1995). An important consideration for the present work is that mind wandering can occur spontaneously and is thought to utilize the same resources as goal directed thought (Christoff et al., 2004; Smith et al., 2006; Teasdale et al., 1995). Thus any other task that requires these resources, like the encoding of sensory information from the external environment, would be impaired (Smallwood and Schooler, 2006). This conjecture is supported by the common phenomenological experience that, having driven along a familiar route, a driver can hardly remember any of the specifics associated with the drive. These 'time gaps' (Chapman et al., 1999) that are often experienced by drivers provide a clear indication that, during those periods, the vehicle operator was driving without full awareness of the environment. To the extent that executive attention is necessary to respond appropriately to a hazard, familiar drivers should perform worse than unfamiliar drivers when encountering a hazard.

The results obtained by Martens and Fox (2007) may be explained by the mind wandering hypothesis as follows. As familiarity with the route is increased, drivers may have been more likely to let their minds wander, thereby making it less likely for them to successfully process incoming sensory information – inattentional blindness – because the system is otherwise preoccupied. This possibility is supported by anecdotal evidence provided by Charlton and Starkey (2011) who noted that many participants found themselves starting to 'daydream' as they excessively practiced a route. Based on these findings, it is reasonable to expect that when driving along a familiar route, drivers might take longer to notice an emergency event, and hence would be expected to take longer to respond than if they were driving along an unfamiliar route.

There are two opposite theoretical predictions concerning the effect that route familiarity has on hazard avoidance. Familiarity might lead to the route being processed automatically and thus freeing up resources that could be used to process other stimuli in the environment, like potential hazards. From this it follows that reaction time (RT) to avoid a hazardous stimulus should be faster in familiar than in unfamiliar route conditions. On the other hand, given the previous evidence linking automaticity and route familiarity to a reduced likelihood of successfully monitoring the environment (Charlton and Starkey, 2011; Martens and Fox, 2007), one might predict the opposite pattern of results. For example, it could be that as the route becomes familiar, the incidence of inattentional blindness might increase, and thus the driver would be less able to deal with the hazardous stimulus. In this case, it follows that RT to the hazardous stimulus should be *slower* in familiar than in unfamiliar routes. The present experiments were designed to test these two competing theories.

2. Experiment 1

The objective of Experiment 1 was to investigate whether familiarity with the route will affect driving performance, such as responding to emergencies, in a positive or a negative way. If familiarity with the route leads to the route being processed more automatically, the extra attentional resources made available should improve driving performance. In contrast, if route-familiarity promotes a form of inattentional blindness (Martens and Fox, 2007) then driving performance should be impaired relative to when unfamiliar with the route. This issue was explored in the present experiment using a simple car-following paradigm (see Strayer et al., 2003), where participants followed a pace car through a route that they had either previously been made familiar with or not. Responses to a series of unexpected events were assessed, along with other measures of driving performance.

2.1. Methods

2.1.1. Participants

Fifteen female and five male undergraduate students (mean age = 20.9 years, SD = 1.66) from Simon Fraser University participated either for class credit or for payment. All had self-reported normal or corrected to normal vision. All had a valid British Columbia driver's license (class 5) and reported driving on average 5.6 times per week. Before starting the experiment, participants filled out a modified 'Simulator Sickness Questionnaire' with questions such as "are you taking any medications" or "are suffering from any ailments that might make you prone to motion sickness." In order to minimize the incidence of simulator sickness we excluded any participants who answered yes to any such questions (see Kennedy et al., 1993; for an overview).

2.1.2. Materials

A DriveSafety high-fidelity driving simulator (model DS-600c) was used. Examining driving performance with a driving simulator grants several advantages over real-world on-road tests. Driving simulators not only provide a safer environment, but also allows for complete control over the driving conditions. In addition, driving simulators allow consistent and reliable data to be collected over a broad range of variables.

Participants were seated in a modified Ford Focus cab equipped with a windshield, driver and passenger seats, dash board, instrument panels, and a central console, as well as all the devices needed to operate a car (accelerator and brake pedal, turn signal switch, a steering wheel etc.). The simulated environment was generated using HyperDrive Authoring Suite and was displayed using DriveSafety's Vection Simulation software (Version 1.9.35: http://www.drivesafety.com). The simulator is also equipped with an automatic gearbox.

2.1.3. Driving routes

Five freeway driving routes were developed for this experiment (routes 1–5). Each route was approximately 12 km in length and included a series of overpasses (where the roadway passes over another), underpasses (where the roadway passes under another) and cloverleaf intersections (on and off ramps: where the roadway gradually corners to merge with a new roadway). Each route was designed to have the same number of cloverleaf intersections and each route had the same number of left and right turns. The five routes were programmed to look very similar to one another, consisting mainly of long stretches of rural freeway. However, the exact location for each cloverleaf intersection was different for each route. Consequently, the specific sequence of exits that participants were required to take to get to the end was different for each route. These routes were driven in daytime conditions with good visibility. There were three lanes of traffic going in each direction (separated by a cement median). For all routes, a pace car and the participant's vehicle were the only two cars on the road. The participants were instructed to follow the pace car, and the pace car was programmed to maintain its position in the right lane.