ROUTE FAMILIARITY BREEDS INATTENTION AND CELL-PHONE ADDS TO IT

by

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ABSTRACT

Many traffic accidents occur because of inattention. We hypothesized that familiarity with a route may lead the driver to pay less attention to details in the environment. To examine this hypothesis, we tested two groups of participants in a high-fidelity driving simulator. In an initial training session, one group was familiarized with Route A, the other with Route B. In the test session, both groups drove through Route A, thereby making one group familiar and the other unfamiliar with the route. Sudden events (car pulling out, people running onto the road) were presented during the test session, and reaction times (RTs) to activate the brakes in response to those events were recorded. RTs were significantly slower in the Familiar group, consistent with the hypothesis that familiarity leads to inattention. Further, we investigated how the familiarity-based inattention interacts with divided attention due to cell-phone use.

Keywords: Driving simulator, cell-phone use, familiarity

DEDICATION

I dedicate this thesis to my parents for giving me all the help I needed to complete my degree. I also dedicate this thesis to Jennifer Harvey because if not for her encouragement, I would not have pursued a Master’s degree.

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1: INTRODUCTION

1.1 What is attention?

As a passenger in your car, if I were to tell you to “pay attention to the road”, you would probably understand my request immediately and would ‘attend’ to the appropriate part of the environment without difficulty. This is because everyone has a general understanding of what attention is, and the broad concept of *attention* has been thought about by academics for centuries. In addition, attention can be directed at different aspects of the environment. For example, people can voluntarily shift their attentional focus onto some visual aspect of the environment even without moving their eyes, or they can focus their attention on the voice of one individual while ignoring the voices of others in the background. The intentional manipulation of attention comes easily to people, and as a result we tend to take it for granted that attention is an easily definable term. William James (1890) was one of the first to define attention and said that:

> Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others…

This definition is certainly in line with the general public’s notion of what attention is, but for many psychologists the concept is complicated and difficult to define. In fact, many might take the opposite extreme as William James and say that “nobody knows what attention is” (Styles, 2006, p.1).

The difficulty in appropriately defining attention stems from the fact that there are so many different ways that attention can be conceptualized. For example, one might make the distinction between focused and divided attention but still must be able to account for the top-down (active and goal-driven) versus bottom-up (passive and stimulus-driven) control of attention. Perhaps attention should not be thought of as a single unitary ability, but instead as a blanket term for all of the different ways that we process information (Lund, 2001; Styles, 2006).

While many psychologists will disagree in regards to an accurate definition of attention, there is a general consensus that attention deals with the processing of internal or sensory information, and that is serves to bring the information into conscious awareness. One has the capacity to shift from processing one thing to another in either a voluntary or an involuntary fashion.

1.2 Early models of selective attention

Although some earlier work had been done on studying attention (e.g. Wundt), the large scale study of attention began following the “cognitive revolution” of the 1950’s. Many early experiments on attention focused on selective attention, which is the focusing of attention to one stimulus, or set of stimuli, while ignoring others (Broadbent, 1958). Specifically, auditory *dichotic listening* experiments were utilized to examine how people can attend to relevant information while ignoring irrelevant information. In a dichotic listening paradigm, participants are presented with two different auditory messages, one message presented to each ear. Participants are required to attend to one message (usually by shadowing the message) while ignoring the other. These experiments demonstrated that people are able to successfully repeat the ‘to be attended’ message out loud while ignoring the ‘to be ignored’ message (Cherry, 1953). It was also established that the correct message can be selected based on low level physical characteristics, like the tone of the speakers voice (Broadbent, 1952; Cherry, 1953;

Poulton, 1953). In fact, Cherry (1953) demonstrated that people were unable to recollect any of the topic themes presented to the ignored ear, but were able to recall information about the voice of the speaker (whether it was a female or a male voice for example).

Based on these findings, Broadbent (1958) postulated a filter, or ‘bottleneck’, theory of attention. According to Broadbent’s filter theory, people are able to successfully attend to one message over another because the messages are filtered early on based on low level physical characteristics of the message. The incoming sensory information that matches the filter settings are passed on to higher order processing centers in the brain, whereas the incoming sensory information that does not match the filter settings is discarded and is no longer processed. This theory can easily account for the finding that people can remember the voice characteristics from the unattended message, because that information is part of the low level characteristics that were processed before being discarded. This theory is known as an *early selection* model of attention because selection of the appropriate signal takes place in an early stage of processing before elaborate processing of the signals takes place. An important aspect of Broadbent’s theory is that before the filtering stage, all incoming information is processed in a parallel manner, meaning that all of the information is processed simultaneously. Once filtered, the selected information proceeds through the attention system in a serial manner, meaning that simultaneous processing of different incoming information is not possible. In essence, there is a ‘bottleneck’ of information processing at the filter location. When performing two tasks at the same time, processing of both sets of relevant information does not happen in a parallel fashion. Instead, there is a rapid switch in processing the two tasks (Styles, 2006).

There is an inherent supposition made by Broadbent in this model. That is, within this theory, it is assumed that the physical characteristics that are used to channel the selection process represents the maximum level at which the irrelevant information is processed. This might not be the case. An alternative possibility is that all of the incoming information, relevant and irrelevant, is processed quite deeply, and selection takes place at a much later stage right before conscious awareness (Deutsch & Deutsch, 1963). This is known as a *late selection* model of attention. The central aspects of this model are identical to that of early selection. There is an information filter and information is processed in a parallel manner until reaching the filter (that is, there is a bottleneck). The only difference is that in the late selection model, the filter is positioned at a much later stage in processing, right before conscious awareness. Treisman (1964) provides some evidence for the late selection model. She found that, during a dichotic listening study, people began to repeat the message in the unattended ear when the experimenter switched the messages presented to each ear half way through the experiment. If selection takes place early on, then the participants should have continued to repeat the message in the attended ear because the physical characteristics of the message were unchanged.

Treisman (1964) postulated a model of selective attention that is a middle ground between the two extremes views of the early and late selection models. Her *attenuation* theory is an early selection model, which can explain the findings that support the late selection view. Her theory holds that incoming information is subject to a selective filter that sorts out irrelevant information based on the low level physical characteristics of the stimulus. Importantly, the filter acts like an attenuator which lowers the strength of the incoming irrelevant information. The information then passes through a ‘dictionary’ and if the intensity of the signal exceeds a certain threshold, then it will pass on to conscious awareness. This model predicts that sensory input that is supposed to be ignored can still activate the dictionary above threshold in some instances. Indeed, it had been shown previously that some auditory semantic information, like one’s own name, can proceed to conscious awareness even when the information is presented to an ear that is ignored (Moray, 1959). One’s name may have a low threshold in the dictionary because it holds personal significance. In the case where an unattended massage contains the participant’s name, attention might be inadvertently drawn towards the unattended message.

Early visual attention experimental results suggest that the selective processing of visual information occurs in a similar way to that of auditory information. Sperling (1960) was the first to demonstrate that a physical cue can prove to be effective in selectively attending to a set of visual stimuli. He noted that when people are briefly (50ms) presented with an array of twelve letters, they are only able to report three or four of the letters once the display disappears. However, when there is a physical cue that represents a certain row in the stimulus array (a high, medium or low auditory tone) people are very accurate at identifying all of the items within the corresponding row. As the time lag between the offset of the visual array and the onset of the physical cue (the inter stimulus interval; ISI) is increased, this ‘partial report’ advantage disappears. It was also found that colour, size and shape are useful cues for selective visual attention (Dick, 1969; Turvey & Kravetz, 1970). However, Sperling found that when category cues (as opposed to physical cues) are used to classify items to be attended to, the partial report advantage disappears. This suggests that, like auditory filtering, visual information is processed in a parallel manner during early processing and physical cues in the environment can aid in selective attention. This is because low level location information (physical location, colour or size) all show the partial report advantage, since they are processed in parallel. Higher level categorical information is extracted by higher order processes that have access only to information left over after the bottleneck. Thus, one would expect a lack of the partial report advantage for categorical information. This evidence was also taken as suggesting that selection was at a low (early) stage of visual processing, at some point before categorical representation are processed. This is because if categorical representations were processed before selection, then category should be a useful cue for selective attention (like the physical location cues).

Is the filter positioned early or late in the processing chain? This seemed to be a critical question at the time. However, later models of attention started to take task demands into consideration (Johnston & Heinz, 1979). Johnston and Heinz proposed that the filter position is plastic, meaning that selection can move from an early to late stage depending on task demands. Psychologists were starting to think of attention as having a limited capacity and that higher task demands drain the available attentional ‘resources’ to selectively attend to information (Styles, 2006).

2: ATTENTIONAL RESOURCES

2.1 What is a resource?

Many are inclined to describe the allocation of attention in terms of the distribution of *attentional resources*. But what is an attentional resource? The term was generally described by Kahneman (1973) but regrettably, this remains a relatively vague term. Thus, a metaphor to explain attentional resources is often used. The ‘hydraulic metaphor’ is one of the most commonly used to describe attentional resources (described by Wickens, 1984). Using the hydraulic metaphor, an attentional resource is expressed in terms of a reservoir, or a tank of fluid. This fluid is an energy that can be distributed throughout the brain and can be consumed by mental processes in order to perform tasks. Simply speaking, if there is enough fluid in the tank to go around, all of the mental processes that the tank is fuelling can continue unimpeded. However, if the mental demands exceed the amount of fluid available, performance on one or more of the tasks will suffer. The theory that attention is a ‘pool’ of resources (in whatever form) that can be accessed to perform mental tasks, makes predictions that can be tested empirically.

2.2 Single resource models

Attentional resources can be described using several traditional models. One such model represents attention as having one large ‘pool’ of attentional resources that can be accessed to perform tasks (Kahneman, 1973). This resource has a limited capacity but, as stated earlier, it is not restricted to supplying only one mental operation at a time. Several operations can tap the resource at the same time. The capability of the system to perform all of the concurrent tasks optimally depends on whether or not the allocated resources exceed the capacity of the system. If the cognitive tasks demand more resources than the system can supply, there is an overload and performance will degrade for one or more of the tasks.

Schneider and Shiffrin (1977) provide a more elaborate model of resource allocation and distinguish between *controlled* and *automatic* processes. Controlled processes are those that are under top-down, conscious control. These processes can efficiently react to changes in task demands but they take up a large amount of resources. Automatic processes are those that are not under conscious control. These processes are fast and take up little attentional resources. However, automatic processes are only efficient when the task itself remains stable and expected. The moment the task changes, the processes become inefficient because the system must switch to doing the task in a controlled manner. The system will initially try to perform the task in an automatic way, but the response will prove to be inappropriate in the present context, and will therefore cause a performance decrement compared to if the system was performing the task with controlled processes form the beginning.

This model suggests that the cognitive system will be able to perform a relatively complex task that requires a large proportion of the attentional resources, while at the same time performing a generally automatic task with little compromise on the performance of either task. This is because the automatic task does not consume resources, and so those resources are available for the other task. Hole (2007) gives a driving example to illustrate the predictions made by the Schneider and Shiffrin (1977) model. If a driver is a beginner, driving requires a large amount of conscious processing. The driver must learn to pay attention to a large amount of incoming information simultaneously, and this puts a large demand on cognitive resources. This leaves little capacity available for important tasks like avoiding dangers, and also prevents efficient performance on secondary tasks like tuning the radio or talking on a cell-phone. However, with practice, the driving task starts to utilize automatic processes that allow the driver to control the vehicle with relative ease, leaving plenty of resources to utilize on hazard avoidance, and secondary tasks.

These models assume that there is one main pool of resources that can be distributed between mental operations. However, there is evidence that it is possible to perform two unrelated tasks at the same time with a high level of proficiency even when the difficulty of one of the tasks is increased (McLeod, 1977; Shaffer, 1975). For example, Schaffer (1975) demonstrated that professional typists could copy written material onto a typewriter while at the same time shadowing an auditory message. This observation is not predicted by the single resource theory. A *multiple resource theory* seems more appropriate (Wickens, 1984)..

2.3 Multiple resource models

Whereas a ‘single resource’ model of attention assumes that there is a single primary resource pool of attention, the ‘multiple resource theory’ assumes that there are discrete resource pools that exist along four dimensions (Wickens, 1984; Wickens & Liu, 1988; Wickens & McCarthy, 2007; illustrated in Figure 1 below).

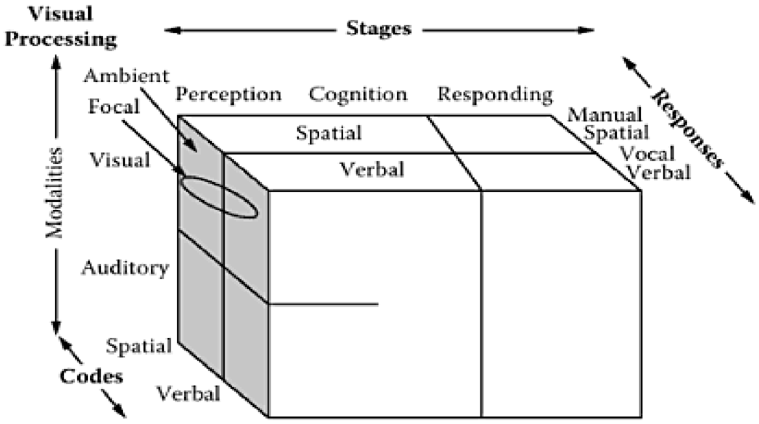

Figure 1: An illustration of Wickens multiple attentional resource theory obtained from Wickens and McCarthy (2007).

The first dimension is the type of sensory modality utilized for information acquisition. For example, the theory predicts that there are separate resource pools for visual and auditory processing. The second dimension involves processing stages. Specifically, resources required to respond to stimuli are separate from those used to process stimuli. The third dimension involves response execution. Responding verbally utilizes different resources than responses that require manual behaviours. Finally, verbal information processing exploits different resources than spatial information processing. The theory states that interference will not occur if the tasks in question avoid using overlapping resources (e.g., a visual stimulus that requires a manual response will not interfere with an auditory stimulus that requires a vocal response). However, if the tasks share a common dimension and therefore require the use of overlapping resources, interference will occur (e.g., a visual stimulus that requires a vocal response will interfere with a visual stimulus that requires a manual response).

Regardless of the theory (single or multiple) used to describe attention allocation, there is one consistent aspect of resource models. That is, there is a limited capacity to the resources available, and if the task(s) demands more capacity than is available, performance will suffer. Another important assumption is that the total capacity is relatively fixed. In other words, the total amount of resources available remains fairly stable over time. However, it is generally accepted that factors like age, mood and arousal can have an influence on the overall capacity of the cognitive system. Extreme fluctuations in arousal, for example, are thought to influence performance with both high and low levels of arousal having a negative impact on performance. With an increase in arousal, there is an increase in attentional resources up to a certain point. At that point, as arousal increases, the resource capacity begins to diminish. This is best illustrated by the classic Yerkes and Dodson (1908) law, whereby performance is shown to follow an inverted ‘U’ shape function dependent on arousal levels.

3: LOW MENTAL WORK LOAD AND PERFORMANCE

As noted earlier, Schneider and Shiffrin (1977) proposed that when a well practiced task changes, one is less able to cope with the change because the system will initially try to perform the task in an inappropriate, automatic fashion. Controlled processes must take over to cope with the change and these processes are slower and less efficient than automatic processes. There is growing evidence that suggests that low mental work load (MWL) can have a similar effect on performance (Desmond, Hancock & Monette, 1998; Nilsson, 1995; Young & Stanton, 2001). This finding is counterintuitive. After all, if a task is easier, imposing less MWL, one would expect performance to be superior to when the task imposes a higher level of MWL.

3.1 Malleable attentional resource theory (MART)

Generally, the resource capacity within an individual is thought to be relatively stable, meaning that the overall resources available do not tend to change. As a result, most theories of resource allocation focus on why the performance degrades with increasing task demands (exceeding the limit of the resource pool(s) will cause poorer performance). However, this does not explain why performance can be poor in mental underload situations. The malleable attentional resource theory (MART) is a theory that tries to explain this finding with the assumption that resources can shrink as a result of low task demands.

As noted earlier, it is well known that factors like arousal, mood and age can result in an inverted ‘U’ shape function for performance. The long term variations in arousal, age or mood are thought to lower or raise the resource capacity limit, depending on where the individual’s levels are situated on the inverted ‘U’ shape curve (Young & Stanton, 2002). MART posits that MWL affects the capacity of a task relevant resource pool much in the same way that arousal or mood can. Young and Stanton (2006) demonstrated that spare attentional capacity can significantly decrease within the first 2 min of a low MWL task. The main hypothesis of MART is that during mental underload situations, there is shrinkage of the attentional resource capacity to accommodate the reduction in task demands (Young & Stanton, 2006; Young & Stanton, 2002). As a result, performance on the primary task is not seriously influenced by the decreased attentional capacity, because the resource pool shrinks to a level where there are enough remaining resources to perform at an optimal level. If the task was to suddenly change, like during a critical situation where the operator now has to react appropriately, the smaller resource capacity makes the operator less able to cope with the changes. As a result, performance during the critical situation is poorer than in a higher MWL situation where there is a greater capacity in the resource pool.

4: DRIVING DISTRACTION

In order to drive a car effectively, one must be able to perform a number of tasks concurrently. When driving, one must be able to coordinate the manual manipulation of the steering wheel, the accelerator and the brake pedal. The driver must be aware of the speed that the car is travelling, the curves in the road, the location of pedestrians, parked cars, street signs or a desired street address. Even though experienced drivers are generally able to manage the coordination of all of these tasks in an efficient way, any lapse in attention can have serious consequences for the safety of the driver and the general public.

It is well known that distractions caused by cell-phone use can negatively affect driving performance (McKnight & McKnight, 1993; Strayer, Drews & Johnston, 2003; Strayer & Johnston, 2001). One of the most damaging effects is on reaction time (RT). Specifically, while on a cell-phone, drivers tend to take longer to respond to events in the environment (Burns, Parkes, Burton, Smith & Burch, 2002; Consiglio, Driscoll, Witte & Berg, 2003; Strayer, Drews & Crouch, 2006; Strayer & Johnston, 2001). As a result, drivers on a cell-phone have a higher risk of being in an accident (Strayer et al., 2006). In fact, driving performance tends to remain low even when the drivers demonstrate compensatory behaviours like slowing down (Burns et al., 2002; Haigney, Taylor & Westerman, 2000). It has also been shown that cell-phone drivers can sometimes compensate for the added distraction by showing less lateral deviations from their mean lane position (Törnros & Bolling, 2005). However, this effect is inconsistent in the literature (Burns et al., 2002; Haigney et al., 2000; Strayer et al., 2006) and has been argued to be a lesser measure of driving performance than RT (Horrey & Wickens, 2006). Regardless of any compensatory behaviours, the overall research in the area suggests that the sufficient allocation of attention that is required for driving is compromised in some way when talking on a cell-phone. There may be a conflict in the resource demands needed by the cell-phone conversation and that of driving. Since a cell-phone conversation can demand a lot of attention, the allocation of resources for driving becomes compromised. This idea is supported by the observation that increasing the complexity of the conversation can impair driving much more than less complex conversations (McKnight & McKnight, 1993).

It is quite common to see people driving while talking on a cell-phone despite warnings about its risks. However, studies of the effects of cell-phone use on driving performance have consistently been conducted along routes that were unfamiliar to the driver. This issue is especially relevant because most driving is known to take place along familiar routes, such as to home or office. Understanding the effect that cell-phone use has on drivers that are familiar with the route is critically important to understanding the effect that cell-phone use has in the general population.

Identifying the possibility that familiarity with the route might influence the effect that cell-phones have on driving performance raises another important question. What effect does familiarity alone have on driving performance? Even though the intuitive prediction may be that familiarity with the route will aid driving performance, there is indirect evidence that familiarity with the route might actually hinder performance. Martens and Fox (2007a, 2007b) found that as people became more familiar with a driving route, the amount of time that people spend looking at peripheral items (like signs) decreases. As a result, familiar drivers are less likely to notice a critical change in the environment. Specifically, Martens and Fox (2007b) manipulated drivers’ familiarity with a route and made a critical change to the last sign in the route (The ‘right of way’ sign was changed to a ‘yield’ sign). They found that even though familiar drivers fixated on the ‘yield’ sign, they were much less likely to yield at the intersection than those that were unfamiliar. There is some difficulty in interpreting these results. It could very well be that drivers are less attentive overall when they are familiar with the route, but it is just as likely that familiar drivers are simply less prone to noticing a change in areas of the environment that rarely change. That is, one would rarely expect a road sign, positioned in the same location, to change from one time to another. Familiar drivers might simply have a high expectation for the sign identity that the unfamiliar people do not share. It is also important to note that the ‘yield’ sign used in the critical manipulation in the Martens and Fox study shares many of the same physical characteristics as the expected ‘right of way’ sign (The study was conducted in the Netherlands where both signs consist of orange triangles on a white background). This might have made it even harder for familiar drivers to notice the change. Although the studies conducted by Martens and Fox provide intriguing results, more research is needed to identify any driving impairment caused by familiarity.

The detrimental effect that practice can have on performance has been demonstrated outside of driving as well. For example, pilots are required to go through a checklist before making their approach to land. During this procedure, the co-pilot reads off items on the list while the captain checks to make sure that the item on the checklist is sufficiently attended to. One item on the checklist is to check to make sure that the landing gear is down. Barshi and Healy (1993) identified an incident where two pilots failed to notice a critical mistake in their landing procedure. In 1983, a flight to Wyoming crash landed because the pilot did not properly check that the landing gear indicator light was on. The important thing to note is that the checklist was fully completed, meaning that every item of the checklist was properly noted. The captain stated that the landing gear lights were on, when in fact they were not. The idea here is that the pilot had gone through the checklist countless times before, and the repetitive behaviours involved in going through the checklist caused a critical failure for the pilot to notice the change in the routine (that the landing gear lights were off).

Practice has also been noted to have a negative effect in the medical community. Toft and Mascie-Taylor (2005) explain that nurses all over the world use checklists prior to patients entering surgery or critical care. The checklist is frequently used and is gone through in order to ensure that the patient is about to undergo the correct procedures, and that a mistake in treatment decisions has not been made. Toft and Mascie-Taylor note that nurses tend to make errors when performing the checklist (an average of 3 per 1000 patients). These mistakes can have serious consequences for patient safety. Perhaps those that are well practiced with a task are likely to have low arousal levels or a reduced resource capacity which might negatively impact performance (Yerkes & Dodson, 1908; Young & Stanton, 2006). Another possible explanation may be that well practiced people are more likely to daydream, which might pose a demand on attentional resources, thereby compromising task performance.

5: THE CURRENT STUDY

Can practice with a driving route cause inattention, and in turn poor driving performance? That is, while driving down a familiar route, are people less likely to respond to a critical event in the environment, much like the pilots described above? If so, what effect, if any, does this have on the distraction effect caused by cell-phone use? In the present work, participants were placed in a high fidelity driving simulator and in the experimental phase, drove down a route that they were either familiar or unfamiliar with. Also, to observe any interaction with the cell-phone induced driver distraction, half of the participants drove the route while conversing on a cell-phone. It is hypothesized that drivers that are familiar with the driving route will show increased RTs to emergency events in the environment (e.g., a dog running on to the road) than those that are unfamiliar with the route. It is also hypothesized that those conversing on a cell-phone will show increased RTs to the emergency events. Considering that there have been no previous studies looking at the effect that familiarity has on the cell-phone induced driving impairment, it is uncertain how the two variables will interact.

5.1 Methods

5.1.1 Participants

Forty eight undergraduate students from Simon Fraser University aged 18-31 (mean 21.5) participated in the experiment (36 males). All had a valid British Columbia driver’s license (class 5).

5.1.2 Materials

A DriveSafety high-fidelity driving simulator (model DS-600c) was used. The 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.).

Participants filled out a ‘Simulator Sickness Questionnaire’ to screen out participants who might become nauseous while driving in the simulator (see Kennedy, Lane, Berbaum, & Lilienthal, 1993, for an overview). The experiment was programmed with the HyperDrive software provided by DriveSafety. Two driving routes, Routes A and B, were developed for this experiment. Each route was approximately 12 km in length and included a series of rural intersections and a 10-km portion of rural highway. The two routes were programmed to look different from one another, with different road curves and different rural backgrounds. However, each route was designed to be the same length and have the same number (and type) of intersections. Specifically, there were eight intersections in each route. These routes were driven in daytime conditions with good visibility. There were two lanes of traffic (one for each direction) and had a modest level of ambient traffic. A RadioShack Full-Duplex Conference Speaker-phone (model 43-2006) was also used in this experiment.

5.1.3 Procedure

The experiment comprised three sessions: Acclimatization, Training, and Testing. In the Acclimatization session, participants who passed the Simulator Sickness Questionnaire took part in a ten-minute session to get used to the equipment and to adapt themselves to the physical sensations involved in driving the simulator. The Acclimatization session consisted of three short driving scenarios. In the first, participants performed a couple of starts and stops. In the second, participants pulled out into sparse traffic, reacted to a vehicle entering their lane, and performed a 90-degree turn to the right. In the third, participants performed two 90-degree turns (one to the left and one to the right), responded to pedestrians and cyclists, and interacted with a moderate amount of ambient traffic. The Training session followed directly after the Acclimatization session.

In the Training session, participants drove through one of the two driving routes (A or B) a total of 4 times to become familiar with the route. Participants were randomly assigned to learn either Route A or Route B, and started from a full stop at an intersection. They were instructed to drive through the route while abiding by all speed limits. At selected intersections, there were signs that indicated either a left turn or a right turn. Participants were instructed to follow the signs until they reached the end of the route (the absence of a sign at an intersection was an indication to proceed straight through the intersection). Each participant made a total of six 90-degree turns (four right and two left) and drove straight through two intersections. Both routes had the same number of left and right turns and contained a 10-km stretch of winding highway with gradual curves. Once ended, the simulation was restarted from the beginning. The Testing session followed directly after the Training session.

During the Testing session, all participants drove through Route A. This means that in the Testing session, half the participants drove along a familiar route, and the other half drove along an unfamiliar route. During this session, seven sudden emergency events were programmed to occur, as detailed below. To avoid a collision during these events, the driver was required to respond by stepping on the brake pedal. RTs to activate the brakes were recorded. The degree of brake depression was sampled at a rate of 30Hz.

Half the participants from each group were randomly chosen to drive through the Testing session while having a speakerphone conversation with a confederate located in another room. The confederate was placed in a separate room in order to fully simulate a hands-free cell-phone conversation. The speaker-phone was placed on the passenger seat. The participants and the confederate were instructed to have a conversation about any topics of interest to them. For example, it was common to hear conversations about the weather, or favourite movie genres. The participant and the confederate were instructed to try to each talk about 50% of the time. This ensured that the participants were adequately engaged in the conversation. The phone call was started before the participant began to drive.

5.1.4 The Emergency Events

1) Tractor event – shortly after the beginning of the Testing session, a slow-moving tractor was programmed to be moving in front of the participant's vehicle between two intersections. The tractor was traveling at 30 km/hr which was well below the 50 km/hr speed limit. When the participant's vehicle passed a specific location (a *location trigger*) the tractor's speed suddenly changed to 15 km/hr and the brake lights came on. To avoid a collision, the participant had to press the brake pedal.
2) Dog event – The next event consisted of a dog suddenly running onto the road. This event took place on a stretch of highway with a speed limit of 95 km/hr. The dog was

programmed to run onto the road when the participant's vehicle was 3 seconds away from the dog (a *time trigger*).

3) Pullout event – the next event consisted of a car pulling out onto the road from a parked position without warning. This event took place on a stretch of highway with a speed limit of 95 km/hr. The car was programmed to pull out onto the road when the participant's vehicle was 4 seconds away from the rear end of the pullout vehicle.
4) Child event – the next event consisted of a child suddenly running onto the road from behind a parked car. The mother of the child also ran onto the road in pursuit. This event took place on a stretch of highway with a speed limit of 95 km/hr. The child was programmed to run onto the road when the participant's vehicle was 4 seconds away from the child.
5) Head-on collision event – The next event consisted of a head-on collision that had to be avoided. This event took place on a stretch of highway with a speed limit of 95 km/hr. For this event, an oncoming car was programmed to pass another car and to be in the participant's lane. Namely, the programmed vehicle was in the wrong lane, heading in the wrong direction (a possible head-on collision). The car was programmed to begin to change lanes when the participant’s car was 4 seconds away from the location of the impending collision.
6) Red light event – The next event consisted of a car running a red light. When the participant's vehicle was 4 seconds away from the intersection, with the traffic light being green for the participant, a pickup truck was programmed to drive into the intersection from the right side. Namely, the pickup truck ran through the red light.

7) Driveway event – The final event consisted of a car suddenly pulling out onto the road from a parked position in a driveway. The event took place on a road with a speed limit of 50 km/hr, just prior to an intersection. The car was programmed to pull out onto the road when the participant's vehicle was 4 seconds away from the driveway.

With the exception of the head-on collision event, in which the RT was defined as the interval of time between the activation of the time trigger and when the brake pedal was half-way down, all RTs were defined as the interval of time between the activation of the time trigger and the beginning of the depression of the brakes.

6: RESULTS AND DISCUSSION

The results (see Figure 2 below) were analyzed in a 2 (route familiarity) x 2 (cell-phone use) between-subjects analysis of variance (for descriptive statistics, see Table 1). Cell-phone use led to slower responses to the braking events, *F*(1,44) = 5.49, *p* = .024. Familiarity with the route also led to slower RTs, *F*(1,44) = 4.44, *p* = .041. The interaction was far from significant, F(1,44) = 0.38, *p* = .541.

	Familiar		**Unfamiliar**	
	No cell-phone	**Cell-phone**	**No cell-phone**	**Cell-phone**
RT in seconds	1.73 (0.252)	1.90 (0.248)	1.64 (0.132)	1.74 (0.126)

Table 1: Reaction time measures as a function of familiarity and cell-phone use

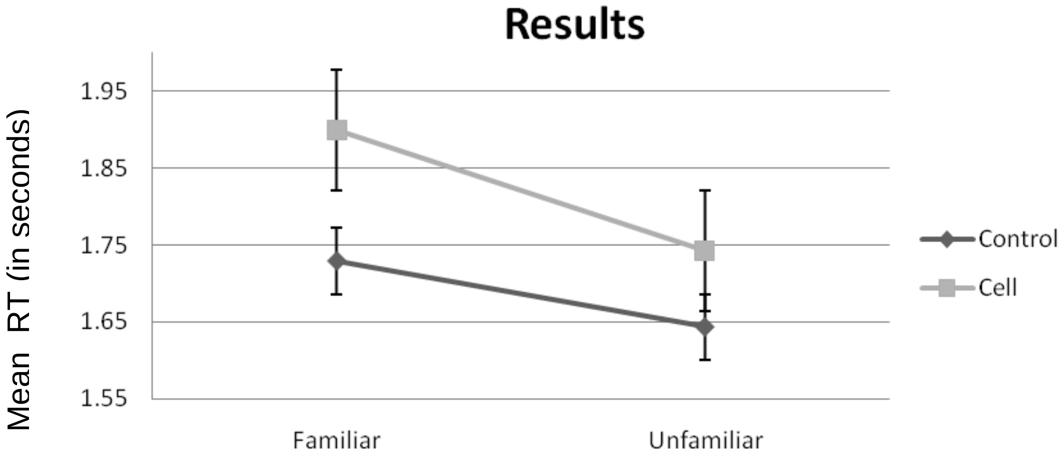

Figure 2. Reaction times in response to emergency events as a function of route familiarity and cell-phone use

In line with the results obtained from previous studies (Burns et al., 2002; Consiglio et al., 2003; Strayer et al., 2006; Strayer & Johnston, 2001), drivers conversing on a cell-phone responded more slowly to the emergency events than those that were not conversing on a cell-phone. As expected, familiarity with a route also slowed down the driver's response to an emergency braking event.

6.1 Possible Explanations for the Familiarity Effect

Why does familiarity negatively affect driving performance? One possibility is that those that are familiar with a route are less anxious or aroused than those that are unfamiliar with a route. Recall the Yerkes and Dodson (1908) law which states that extreme fluctuations in arousal causes performance to suffer. If that is the case, perhaps familiar people show a decline in performance because of their low arousal levels. Even though on the surface this seems like a reasonable explanation, it is unlikely to be the explanation for the data observed here. The Yerkes Dodson law refers to extreme levels of arousal. It is unlikely in that the familiar group was showing an extremely low level of arousal compared to the unfamiliar group in this case. All of the participants were driving in a simulator, which was a relatively novel, and interesting event for most of the participants. In addition, all of the participants were aware that they were taking part in an experiment that may require them to respond to events at any time. As a result, it is unlikely that the familiar group was demonstrating a considerably low level of arousal compared to the unfamiliar group. Furthermore, the participants that were on the cell-phone consistently showed poorer driving performance compared to those not on a cell-phone. It is a reasonable assumption that the cell-phone manipulation should raise arousal. If familiar drivers have a low level of arousal, and talking on a cell-phone raises arousal, then one would expect better performance for the cell-phone group. This was not the case. I would like to acknowledge that since I did not have a direct measure of arousal in the current study, it is not possible to completely rule out the role that arousal plays in this effect. Perhaps a future research project that utilizes the Galvanic Skin Response (GSR) to measure arousal levels can provide evidence that is more conclusive.

Another possibility is that the MWL involved in driving diminished with the increase in familiarity. As a result, the resource pool utilized by the driving task may have reduced in size. Recall that MART posits that with a decrease in MWL, the relevant resource pool will shrink to accommodate the lower task demands. As a result, the spare capacity needed to attend to a change in the environment will be compromised, making one less able to cope with the increase in task difficulty. However, MART theorizes that performance levels follow the inverted “U” shape as a function of MWL, much like the Yerkes and Dodson law does for arousal levels (Hole, 2007). Thus, it is unlikely that MART can explain these findings for the same reasons provided in response to the affect of arousal on performance. That is, the MWL while on a cell-phone should have increased relative to the condition where there was no conversation. With an increase in MWL, one would expect performance to increase as well because there would have been an increase in the size of the relevant resource pool. Performance was poorer in this condition, which is contrary to that predicted by MART. On the other hand, it is possible that the system underestimated the resource requirements for the cell-phone task, and as a result, the conversation utilized more resources then were available, leaving the system with even fewer resources for driving compared to the non cell-phone group. However, it would be difficult to explain why a system designed to fluctuate resources to accommodate task demands would do so in such an inefficient manner. The current study was not a test of MART and one must take caution before dismissing it as an explanation. I am simply stating that although theoretically possible, MART is unlikely to be a good explanation for these findings.

Perhaps a simpler explanation is in order. Familiarity with a route might induce a false sense of security with corresponding wandering of attention away from the driving task. One might say that familiarity induces a state akin to daydreaming. This is consistent with the common phenomenological experience that, having driven along a familiar route, a driver can hardly remember any of the specifics associated with the drive. When there is an event in the environment that requires immediate action, drivers are less able to handle the situation because their attention is occupied.

Interestingly, these results also address the long-standing issue of whether attention is to be regarded as a unitary resource or as an aggregate of multiple resources that are, at least to some extent, independent of one another (Wickens & McCarley, 2007). The parallelity of the functions in Figure 2 – confirmed by the absence of a statistical interaction effect – strongly suggest that the mental processes enabled by route familiarity and those involved in cell-phone conversation tap separate pools of attentional resources. This assumption is based on additive-factors logic (Sternberg, 1969), which states that if the effect of two different variables on a dependent variable are additive, then the underlying processes associated with the two variables have separate underlying mechanisms. The multiple resource model (Wickens, 1984; Wickens & Liu, 1988; Wickens & McCarthy, 2007) can provide a possible explanation. Processing a cell-phone conversation is likely to be utilizing the resources associated with auditory processing.

Familiarity induced “day dreaming” may use the spatial processing resources (largely or exclusively). Driving is likely to require both of these resources and since the resource pools are disconnected, as theorized by the model, they will have separate and additive effects on driving performance.

If it is the case that familiarity induces a day dreaming state, then it is difficult to understand why the cell-phone conversation did not eliminate that effect. In other words, it seems counterintuitive that people could daydream and talk on the cell-phone at the same time. Nevertheless, if the processes for both tasks tap different resources, it is a possibility that performance on both tasks can remain unchanged.

I would like to propose a future study might provide more evidence for the daydreaming hypothesis. It is suggested here that daydreaming taps resources associated with spatial processing, whereas the cell-phone task does not. If the cell-phone conversation is manipulated in a way that requires the participant to utilize spatial processes, then an interaction with familiarity and cell-phone use should be evident. For example, if the cell-phone task requires that participants describe the layout of their home or the lecture hall that they were last in, we would see an interaction if the hypothesis is correct.

Finally, from a practical standpoint, perhaps the most important conclusion stemming from the present research is that, far from being of help, route familiarity actually makes driving more hazardous. Prior to the present work, one might have made an intuitive prediction that the impairment caused by cell-phone use will be muted when driving along a familiar route. In fact, as seen in Figure 2, the amount of impairment associated with cell-phone use is invariant with route familiarity. What is increased is the total level of impairment: the hazard is at its worst when using a cell-phone while driving along a familiar route.

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