Safety Science 72 (2015) 302–309

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Emotion matters: Implications for distracted driving

Michelle Chan [a,*], Anthony Singhal [a,b]

[a] Department of Psychology, University of Alberta, Edmonton, Alberta T6G 2E9, Canada
[b] Neuroscience and Mental Health Institute, University of Alberta, Edmonton, Alberta T6G 2E1, Canada

ARTICLE INFO

Article history:
Received 1 May 2014
Received in revised form 7 August 2014
Accepted 1 October 2014
Available online 24 October 2014

Keywords:
Driving
Emotion
Attention
Audition
Dual-task
Event-related potentials

ABSTRACT

Driver distraction is estimated to be one of the leading causes of motor vehicle accidents. Roadside billboards containing negative and positive emotional content have been shown to influence driving behaviour by modulating attention; however, the impact of emotion-related auditory distraction on driving is relatively unknown. In the present study, we explored the behavioural and event-related potential (ERP) effects elicited by auditorily presented words of different emotional valence during driving (dual-task) and non-driving (single-task) conditions. The results demonstrate that emotion-related auditory distraction can differentially affect driving performance depending on the valence of the emotional content. Negative distractions reduced lateral control and slowed driving speeds compared to positive and neutral distractions. On the other hand, the results revealed an arousal effect on memory and decision-making during driving as performance improved with both negative and positive distractions. Finally, ERPs elicited by the auditory distractions were reduced in amplitude during driving compared to non-driving, revealing a division of cognitive resources under dual-task demands. These findings have important implications for road safety and bring to light the detrimental effects of negative emotional auditory content on driving performance. Furthermore, these findings show that emotional valence and arousal can differentially influence behaviour.

1. Introduction

Driver distraction is estimated to be one of the leading causes of motor vehicle accidents. In 2011, it accounted for 10% of all fatal crashes and 17% of injury crashes (NHTSA, 2013). In a recent review by Young and Salmon (2012), secondary task distraction is suggested to be a contributing factor in at least 23% of all accidents.

To distinguish between inattention and distraction, driver distraction has been defined as "a specific type of inattention that occurs when drivers divert their attention from the driv ing task to focus on some other activity instead" (NHTSA, 2013). Thus, distraction involves a triggering event or activity as opposed to inattention due to a cognitive state (e.g., fatigue). Common sources of distraction include cell-phone use, use of in-vehicle information systems, and interactions with passengers. Distraction can also occur when highly salient objects (e.g., a roadside billboard with emotional content) inadvertently draw the attention of drivers (Chan and Singhal, 2013; Megías et al., 2011).

One theoretical account for the cause of distraction is that insufficient attention is devoted to the driving and non-driving related task at the same time. This can occur when the combined demands of driving and the competing activity exceeds the driver's capacity to respond to critical events on the road (Lee et al., 2008). Thus, when drivers are highly engaged with another task, their attention may not be optimal for safe driving due to reallocation of attention to the secondary task.

1.1. Emotional distraction

Emotional stimuli have been widely reported to capture attention more readily than neutral stimuli (Compton, 2003; Vuilleumier, 2005). However, compared to the extensive body of research on secondary task distraction such as cell-phone use, emotion-related distraction is a relatively recent topic in the driver distraction literature. This has important implications as enhanced processing of emotional stimuli may come at the expense of driving performance compared to neutral stimuli.

In Chan and Singhal (2013), roadside billboards containing words of different emotional valence were shown to have differential effects on driving behaviours. The presence of negative words decreased driving speeds and slowed response times compared to positive words. A similar study found that the number of eye fixations and total fixation time elicited by emotional images on billboards were larger than for neutral billboards. In addition, gaze

* Corresponding author. Tel.: +1 780 492 5262.
E-mail address: mc3@ualberta.ca (M. Chan).

http://dx.doi.org/10.1016/j.ssci.2014.10.002
0925-7535/

disengagement was later for negative billboards compared to positive and neutral ones (Megías et al., 2011). In an interesting study by Trick et al. (2012), negative images were associated with poorer steering control than positive images. Together, these findings demonstrate that visual stimuli with emotional, particularly negative, content can modulate attention to influence driving performance. It has been suggested that negative stimuli may trigger more attentive, but time-consuming, evaluation than positive stimuli (Pratto and John, 1991); therefore, negative content may lead to worse driving performance.

However, the impact of emotional distraction in other modalities, such as audition, is relatively unknown. This is important as research has shown that in-car listening while driving can be an auditory distracter (Brodsky, 2002; Brodsky and Slor, 2013). Only a few studies have examined the effects of emotional auditory content while driving. In Pêcher et al. (2009), happy music reduced driving speeds and impaired lateral control more than sad and neutral music. In Di Stasi et al. (2010), emotional sounds (e.g., a scream or laugh) decreased alertness in drivers compared to a neutral beep. All these results demonstrate that emotional music and sounds can influence driving performance. However, the impact of emotion-related auditory distraction while driving has yet to be investigated with an electrophysiological approach.

1.2. Event-related potentials

It is widely considered that the human attention system has a limited capacity, and studies show that when two tasks are performed at the same time, there is competition for attentional resources (Bunge et al., 2000; Szameitat et al., 2002). Event-related potentials (ERPs) are well-suited for studying attention-related phenomenon because of their excellent temporal resolution. Extracted from electroencephalography (EEG), ERPs are averaged brain responses that are time-locked to the onset of a stimulus. It is generally considered that the morphology, timing, and topography of ERP components reflect various ongoing cognitive processes, including those related to attention and working memory (Luck, 2005).

In Strayer and Drews (2007), the amplitude of the P300, an ERP known to reflect attention allocation, was reduced in response to the onset of participants' brake response to a pace car's brake lights when conversing on a cell-phone (dual-task) compared to driving alone (single-task). Memory performance on objects in the driving scene was also worse in dual-task conditions, suggesting a diversion of attention from driving to the cell-phone conversation. In a similar study using functional magnetic resonance imaging (fMRI), concurrent performance of a sentence listening task on driving was shown to decrease brain activation associated with the driving task, namely in parietal areas, which has been implicated in the allocation of visual spatial attention (Just et al., 2008). At the same time, driving performance was impaired compared to driving alone. These findings provide evidence of driver distraction caused by dual-task interference, in which a secondary task hinders driving behaviour by competing for attentional resources. In Wester et al. (2008), ERPs related to an auditory oddball task were reduced in amplitude during driving compared to non-driving conditions, indicating that attention was allocated to maintain focus on the driving task at the cost of processing the secondary stimuli. Taken together, these results demonstrate that multi-tasking during driving can increase cognitive workload and lead to competition for limited neural resources.

1.3. Research objectives

In the present study, we sought to examine the nature of distraction due to emotion by measuring the behavioural and electrophysiological effects elicited by auditorily presented words of different emotional valence (neutral, negative, and positive). The words were presented alone (single-task) and while participants operated a driving simulator (dual-task).

There were seven conditions in total: one control condition, where participants drove with no auditory distraction; three single-task conditions, where they listened to: (1) neutral, (2) negative, and (3) positive words; and three dual-task conditions, where they drove and simultaneously listened to: (1) neutral, (2) negative, and (3) positive words. At the same time, decision-making was assessed by having participants respond to target words (animal names) presented in the context of the three types of words. At the end of the study, participants were given a surprise free recall test in which they were asked to recall as many as words as possible from all conditions.

Word stimuli were used in order to more directly compare the findings in this study with those in Chan and Singhal (2013). Our main objective was to determine whether emotion-related auditory distraction would produce similar driving behaviours as has been shown with visual distraction, where driving performance and response times were shown to be differentially affected by the emotional valence of words on roadside billboards (Chan and Singhal, 2013). Our secondary objective was to use ERPs elicited by the auditory distraction to assess the allocation of neural resources under single (non-driving) and dual-task (driving) conditions. To that end, we collected behavioural and ERP data while participants drove a simulator and concurrently listened to words of different emotional valence. We hypothesize that emotion-related auditory distraction will have differential effects on driving behaviours and memory depending on the emotional valence of the words; specifically we predict that (1) negative words will have a higher influence on driving performance than positive and neutral words due to greater recruitment of attentional resources, and (2) more negative words will be recalled than positive and neutral words. We also hypothesize that ERPs elicited by the auditory words will be reduced in amplitude under dual-task compared to single-task conditions, presumably due to a division of neural resources between the driving task and processing of the distracting stimuli.

2. Methods

2.1. Participants

25 participants (13 males; $M = 21.1$, $SD = 3.35$, range 18–30 yrs) from the University of Alberta were recruited via advertisements placed on campus. All were in the age range of 18 to 30 years old and had normal to corrected-to-normal vision. Each received $20 as an honorarium.

2.2. Stimuli and apparatus

120 words were selected from the Affective Norms for English Words database (Bradley and Lang, 1999). As detailed by Bradley and Lang (1999), each word has an assigned valence value on a scale from 1 (“very negative”) to 9 (“very positive”), and an arousal value from 1 (“not arousing”) to 9 (“highly arousing”). Of these words, 40 were neutral, 40 were negative, and 40 were positive. All words were matched for word frequency. Emotional words were matched for high arousal, with negative words being low in valence and positive words being high in valence. In addition, 30 animal words were selected from the University of Toronto categorized word pool (Murdock, 1976), which acted as target words that participants had to respond to. See Table 1 for details on the word parameters and the Appendix A for a list of the words used.