

The effects of taboo-related distraction on driving performance

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Driver distraction is an important risk factor in motor vehicle crashes. Roadside billboards containing negative and positive emotional content have been shown to have differential effects on driving, however, little is known about the impact of taboo information. Taboo information more reliably evokes emotional arousal than other emotional information and can lead to greater attentional capture due to its inherent 'shock value.' We examined the potential for driver distraction from four different types of information presented on roadside billboards: highly arousing taboo words, moderately arousing positive and negative words, and non-arousing neutral words. Results showed that taboo words were associated with better lane control and memory recall compared to the other word types. Our findings suggest that taboo words captured the most attention, but also led to a more careful driving style. One possible explanation is that drivers may be narrowing their attention to the driving task when highly aroused.

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 (National Highway Traffic Safety Administration, 2013). One contributing cause of driver distraction is lack of attention (McKnight & McKnight, 1993; Strayer, Drews, & Johnston, 2003). Because attentional resources are limited in nature, when drivers are highly engaged with another task, insufficient attention may be devoted to the primary driving task.

One contributory source of distraction is roadside billboards. The amount of attention that drivers give to billboards and other irrelevant objects varies from 30% to 50% (Hughes & Green, 1986). Studies have found that distraction by foreign objects (including signs) is a significant cause of crashes (Stutts, Reinfurt, Staplin, & Rodgman, 2001) and that drivers do look and process billboards (Hughes & Green, 1986). However, little is known about the influences of emotional content on billboards. This is important as evidence suggests that attention is highly biased by emotional factors (e.g., Mather & Sutherland, 2011). As a result, emotion-based distraction may reorient attention away from the driving task.

Recently it has been shown that roadside billboards containing negative and positive emotional content have differential effects on driving performance (Chan & Singhal, 2013). Drivers drove slower in the presence of negative information, while positive information led to faster speeds. Moreover, drivers recalled the content of negative billboards better than positive billboards. These findings demonstrate that emotionally valenced information can be a significant factor in driving performance, and suggests that emotional distraction can modulate attention.

While these results shed some light on the influence of emotional distraction on driving, the impact of taboo information on driving has not been investigated. Taboo (e.g., sexual-related) information have been shown to more reliably evoke emotional arousal than other types of emotional information. Previous studies have found that taboo stimuli can lead to greater attentional capture, presumably due to the

inherent 'shock value' associated with these stimuli (Arnell, Killman, & Fijavz, 2007; Bertels, Kolinsky, & Morais, 2010; Mathewson, Arnell, & Mansfield, 2008). For example, Aquino and Arnell (2007) found that sexually explicit words presented between two digits increased reaction times on a digit-parity task, compared to emotionally neutral and negative words. Additionally, more sexual words were later encoded into memory for recall compared to the other word types.



Figure 1. Example of a real-world billboard depicting taboo content. (Image obtained from <http://teachmix.com/litartred/?q=node/10>.)

The effect of taboo distraction on driving has ecological relevance as many North American roadways are lined with billboard advertisements and messages that have highly arousing and sexual content, as illustrated in Figure 1. In the present study we examined the potential for driver distraction from four different types of information presented on roadside billboards: highly arousing taboo words, moderately arousing positive words, moderately arousing negative words, and non-arousing neutral words. We hypothesize that driving

performance will be most impaired by taboo words compared to all the other word types, as attention will be most involuntarily captured by the taboo distraction. As a result, less attention may be devoted to the driving task in the presence of taboo words compared to the other word conditions, which will impair driving performance. Alternatively, there is evidence that arousal can enhance focus (e.g., attentional narrowing, cognitive tunneling) (Dirken, 1983; Easterbrook, 1959). Thus, it is possible that the presence of taboo words may improve driving performance.

METHODS

Participants

39 participants from the University of Alberta participated for course credit. Data were excluded from nine participants because they did not drive to criterion (see Data Analysis section) or because of technical issues, resulting in a final sample of 30 participants (13 males; $M = 19.5$, $SD = 3.3$). All participants had a valid driver's license, normal to corrected-to-normal vision, and were in the age range of 18 to 35 years old. The study was approved by the University of Alberta Ethical Review Board.

Materials

Word lists. Five 16-word lists were used in the study: one list of highly arousing taboo words; one list of moderately arousing, positive words; one list of moderately arousing, negative words; one list of non-arousing, neutral words; and one list of household-related ("target") words that participants were asked to respond to.

All of the words were selected from the Janschewitz (2008) normative word database. In the database, several subjective ratings were used for each word, including: arousal, valence, tabooeness (the extent to which the rater found the word offensive to people in general), offensiveness (the extent to which the rater found the word personally offensive), familiarity (how often the rater encountered the word in any setting), personal use (how often the rater used the word on him or herself), and imageability (conduciveness to mental imagery), as well as number of letters and syllables.

Driving simulator. A STISIM Drive™ fixed-based driving simulator (Systems Technology Inc., Hawthorne, CA, USA), modeled as a small automatic transmission passenger vehicle, was used in the study. The simulator consisted of a steering wheel, gas and brake pedals, and a 22" widescreen computer monitor providing a projected field-of-view of approximately 60° horizontal and 40° vertical. The display included a rear-view mirror and speedometer.

Design

The simulated driving environment was 4.4 km in length and consisted of a two-lane (one in each direction) rural road that was mostly straight, with a few winding turns. Road events included pedestrians crossing the road, stop signs, and traffic lights. Pedestrians were programmed to cross the road

when the participant's vehicle was within 200 m of the pedestrian. Traffic lights were programmed to turn red when the participant's vehicle was within 200 m of the traffic light. Buildings and trees were included in the simulation and other vehicles occasionally approached in the opposite lane.

A repeated-measures design was employed in which five driving conditions were performed in 1 hr: (1) In *Control*, participants drove without billboard distraction. (2) In *Taboo*, participants drove with 16 taboo words and four target words on billboards. (3) In *Positive*, participants drove with 16 positive words and four target words on billboards. (4) In *Negative*, participants drove with 16 negative words and four target words on billboards. (5) In *Neutral*, participants drove with 16 neutral words and four target words on billboards. The order of conditions was counterbalanced across participants using a Latin-square. See Figure 2 for a screenshot from the taboo condition.

Using the same design used by Chan and Singhal (2013), billboards were placed on the right-hand side of the road every 200 m and the words were readable to the driver when the vehicle was approximately 60 m in front of the sign. The order of the words for each condition was randomized for each participant.



Figure 2. Screenshot of the driving scenario with a taboo word billboard.

Procedure

Participants were first familiarized with the driving simulator by completing a practice drive that was 6.4 km in length and similar to the control scenario. Using the same criterion used by Chan and Singhal (2013), participants were instructed to drive their vehicle in the center of their lane, maintain a speed of 40-80 km/h, and pay attention to pedestrians, stop signs, and traffic lights.

Following the practice, each participant completed all five driving conditions (control, taboo, positive, negative, neutral). They were instructed to press a button on the steering wheel with their left hand as quickly as possible when a target (household-related) word came into view. Prior to the start of the experiment, participants were given a definition of household related words, along with a list of examples (different from the words used in the actual experiment). Target words were placed to ensure participants were attending to all the words in the driving scenario. Upon completion of all

conditions, participants were given a surprise free recall test, in which they were given 5 min to recall and type all of the words they could remember from the study, in any order.

Measures

To measure driving performance, three measures were collected from the simulator: mean driving speed, lane maintenance (assessed as the root-mean-square error [RMSE] of the driver’s lateral lane position with respect to the roadway dividing line), and steering wheel rate (assessed as the RMSE of how fast the driver is turning the steering wheel while doing steering maneuvers) (Rosenthal, 1999). Proportion of words recalled was defined as the mean number of correct words recalled of each word type, divided by the total number of words presented of each type.

Data Analysis

All effects were considered statistically significant based on the alpha level of 0.05. Greenhouse-Geisser corrections were applied to account for violations of sphericity.

The driving performance data were analysed with a one-way repeated-measures ANOVA with five levels (driving condition: control, taboo, positive, negative, neutral). The driving measures were aggregated over the entire driving scenario for each condition. The recall data were analysed with a one-way repeated measures ANOVA with five levels (word type: target, taboo, positive, negative, neutral).

RESULTS

Driving performance

The ANOVA on mean driving speed revealed a significant main effect of condition, $F(4, 116) = 2.80, p < .05, \eta_p^2 = .09$. Planned contrasts showed that driving speed was faster in the positive condition compared to the taboo ($p < .05$), negative ($p < .05$), and neutral ($p < .001$) conditions, as illustrated in Figure 3A. No other comparisons were significant (all p 's $> .05$).

There was also a significant main effect of condition on RMSE lane position, $F(4, 116) = 3.57, p < .05, \eta_p^2 = .11$. As shown in Figure 3B, planned contrasts indicated that RMSE lane position was lower in the taboo condition compared to the control ($p < 0.01$), positive ($p < .05$), and neutral ($p < .05$) conditions. The other word types did not differ significantly (all p 's $> .05$), however a trend was observed for which RMSE lane position was lower in the taboo condition compared to the negative condition ($p = .084$).

The main effect of condition on RMSE steering wheel rates was not significant, $F(4, 116) = 1.87, p = .151, \eta_p^2 = .06$.

Memory recall

The ANOVA on proportion of words recalled revealed a significant main effect of word type, $F(4, 116) = 40.19, p < .001, \eta_p^2 = .58$. As shown in Figure 4, planned contrasts revealed that taboo words were recalled more so than any

other word type (all p 's $< .001$). Target words were recalled more than positive, negative, and neutral words (all p 's $< .001$). The proportion of words recalled for positive, negative, and neutral words did not differ significantly (all p 's $> .05$).

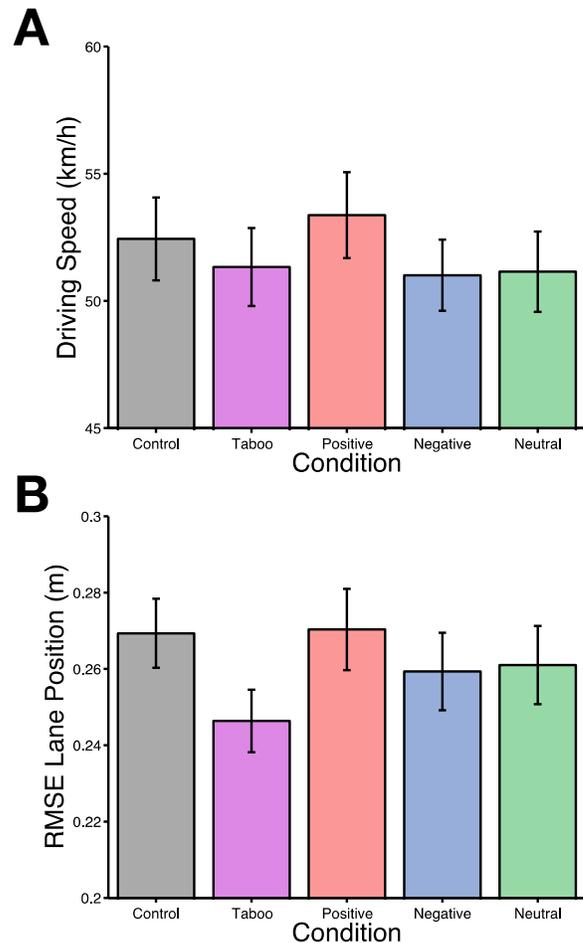


Figure 3. Driving performance measures for each condition. (a) Driving speed. (b) RMSE lane position.

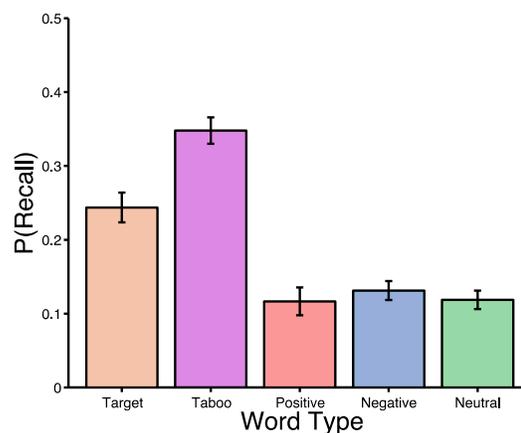


Figure 4. Proportion of each word type recalled in the free recall task.

DISCUSSION

In the present study we examined the potential for driver distraction from four different types of information presented on roadside billboards: highly arousing taboo words, moderately arousing positive words, moderately arousing negative words, and non-arousing neutral words. The results showed that positive words led to faster driving speeds compared to all the other word types. However, taboo words were associated with better lane control and memory recall compared to the other words. These findings suggest that driving performance and attention are differentially affected by the arousal level of the distracting content.

It is well-established that emotional stimuli can modulate the allocation of attention (Easterbrook, 1959). Additionally, studies have found that sexual or taboo information receives more preferential processing than other emotional information (Arnell et al., 2007; Bertels et al., 2010; Mathewson et al., 2008). Our findings showed that taboo words captured more attention than all the other word types, leading to superior memory for these words in the surprise recall task (see also Buchanan, Etzel, Adolphs, & Tranel, 2006; Madan, Caplan, Lau, & Fujiwara, 2012). This attentional capture is likely due to the high arousal associated with taboo stimuli, and is consistent with arousal theories of attention, suggesting that arousal modulates the amount of attention that is given to information (e.g., Gronau, Cohen, & Ben-Shakhar, 2003; Lang, Greenwald, Bradley, & Hamm, 1993; Mather & Sutherland, 2011).

The driving performance results showed that positive words were associated with faster driving speeds compared to all the other word types. This is consistent with previous results showing that positive emotions can potentiate a "readiness for action," as demonstrated by faster reaction times toward positive stimuli relative to negative or neutral stimuli in recognition and categorization tasks (Feyereisen, Malet, & Martin, 1986; Leppänen, Tenhunen, & Hietanen, 2003; Stenberg, Wiking, & Dahl, 1998). This type of facilitation also converges with research showing that positive emotions can lead to enhanced physical performance, such as running faster, compared to negative and neutral emotions (McCarthy, 2011; Ruiz, 2008). It is possible that this same type of faster behavior may also be present in driving, and may be due to similar mechanisms connecting positive arousal to human performance.

Our results also showed that drivers had better lane control in the presence of taboo words. One possible explanation for this is that drivers may be experiencing cognitive tunneling when in a highly arousing situation. Cognitive tunneling occurs when observers focus their attention on one aspect of the environment to the exclusion of information outside this highly attended area (Dirken, 1983; Thomas & Wickens, 2001). It is possible that the taboo distractions were sufficiently high in arousal to cause the drivers to employ selective attentional strategies to drive effectively (Dirken & Hancock, 1985). As evidence suggests that arousal can enhance attentional focus (Dirken, 1983; Easterbrook, 1959), drivers may have been narrowing their attention to the task of driving. This would have a positive

effect on driving as it would limit the processing of other sensory information in the driving environment, and allow drivers to allocate their remaining resources to only the driving task. Accordingly, drivers would have an improved ability to maintain lane control. Converging with this idea, Briggs, Hole, and Land (2011) found that drivers who were highly anxious reduced their range of visual fixations in the driving scene to better focus on the road ahead compared to less anxious drivers.

However, it is likely that cognitive tunneling is not the only mechanism that may have contributed to the enhanced lane control when driving in the presence of taboo words. For instance, our effects may have been mediated by linguistic properties that may not generalize to non-verbal pictorial taboo stimuli, such as the billboard shown in Figure 1. Future research will be necessary to determine whether driving performance will differ with pictorial billboards compared to word billboards. Taboo words also have greater visual salience compared to other word types. The effects of visually salient billboards that are non-taboo should also be investigated in future studies.

In contrast to taboo stimuli, positive emotions have been shown to broaden the scope of attention (Fredrickson, 1998). Several studies have found that positive emotions can lead to greater global perceptual processing in global-local focus tests, whereas negative affect leads to greater local processing (Basso, Scheff, Ris, & Dember, 1996; Fredrickson & Branigan, 2005; Gasper & Clore, 2002). The impact of positive emotion on visual attention has also been measured using eye tracking in response to emotional pictures (Wadlinger & Isaacowitz, 2006). Using a mood induction task, it was found that participants who experienced positive emotions had a broader visual attention area. While driving, positive arousal may enhance central and peripheral focus due to a broadening of attention to global aspects of the driving environment, which may reduce the ability of drivers to maintain lane control compared to the presence of taboo distractions.

Together with the recall results, it appears that taboo words captured the most attention, but also led to a more careful driving style. One possible explanation is that drivers may be narrowing their attention to the driving task when in a highly arousing situation. Additionally, as 'shock value' is an intrinsic attribute specific to taboo words (separate from arousal and valence alone; Madan et al., 2012), it is possible that this additional property may be contributing to the differential effects on driving performance. Our findings showed that drivers had better control of their vehicle in the presence of taboo words, suggesting that taboo distractions may improve driving performance, rather than impair it.

CONCLUSION

Distracted and inattentive driving is a major cause of motor vehicle accidents. Our findings have important implications for drivers' safety by demonstrating that attention and arousal are linked, and have a significant impact on driving performance. These results add to the growing

literature on distracted driving and provide new insights into the influences of emotional distractions on driving.

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