Compare Different Sensory Outputs of the Driving Overtake Alarm System

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Abstract. Most of the car accidents were cause by improper driving behavior, according to investigates shown that changing lanes improperly would be the one of the main cause. It directed to drivers need an assisting alarm system to help them avoid the dangerous of overtaking. And, we found the existing alarm system and researches try to use different sensory outputs as the alarm signals. However, there were no studies to compare how the different sensory alarm signals affect to the drivers. Therefore, in this study we setup three kinds of alarm signals (visual, sound, haptic alarm signals) to see which one is more proper form the high speed context. More, the sensitivity of the alarm system may be the other key factor affect drivers’ behavior. So, we manipulate two levels of the frequency that the alarm signals constantly appear or only when the driver was threaten would be appear. The result of this study point out the sound and haptic signals are better than visual outputs when drivers in a high visual loading situation. This result could be the guideline for the designers who want to design a driving alarm system.

Keywords: Overtake, Alarm System, Haptic signal.

1 Introduction

With economic development we have more roads and convenient traffic, but traffic accidents are also increase. According to the data of Taiwan’s Ministry of the Interior that from 2010 January to October the main reason of the car accidents is car driver negligence (96.07%). The first three factors of car driver negligence are drunk driver (20.1%), did not pay attention to the state (19.5%), and drive the car without follow the rule (13.8%). Furthermore, by the report of Taiwan area Freeway Bureau we can know that the first cause of the accident was improper driving, including changing lanes improperly and not pay attention to front the state, (18.8%) in 2009. From the information we understand that car accidents usually happened when driver want to overtake someone. The reason of the happen factor must be refer to drivers could not realize the situation of the lane that they would transfer to (sometimes they can not see the following car from the side mirror or review mirror). If there were a system to provide driver alarm signals, it might help to prevent accident. But, what exactly this alarm should contains, and how to present the alarm signals when the driver were in a high speed and limited attention condition? Therefore, in this study we would like
summarize the present researches to realize how to observe and evaluate the participants’ driving behaviors and problem. Review the existed alarm system, and then, we try to design a new alarm system to decrease the accident by provide the warnings appropriately.

2 Driver’s attention and alarm system

2.1 Driver’s attention allocation

Human attention could be seem as a multi-resources [15], it means that people could arrange their attention to did things parallel. But, it may constraint by the physical world. Such as the deployment of central control system, if the switch or button doesn’t arrange by their operational step or function, it would add driver’s loading.

Furthermore, driving is special activities that both need dividing and focusing attention. The impact factors of attention harmonious could be inference from some basic study. For instance, Patrick and Elias [12] made a dual-task performance as it relates to driving, such as tuning a radio or manipulating a cellular phone, drive on the right side of the road: perceptual asymmetries for judgments of automobile proximity. It forces drivers to divide their attention between the traffic demands and the in-car task. The current study examined how mental navigation (spatial distraction) affected accuracy and response time for depth judgments on vehicular stimuli in each visual field. These were compared to a control condition in which no distraction was present, as well as when a semantic (non-spatial) distraction was present two centered tabs, and so on.

2.2 Relative issues of alarm system

There were some alarm systems be made and research. Some studies suggest some principles for alarm system design. For example, Nass et al., [11] analysis the advantages and disadvantages of existing systems and propose to focus on signal characteristics, frequency, amplitude, older, compatibility. Some research had point out that the modalities of input signals would also interference driver’s performance. For instance, some studies find out that compared to visual warning signals, auditory and tactile signals are more effective and have less reaction time at drawing cross modal attention for particular positions, such as rear-end collision situation [7] [14]. Furthermore, some papers indicate that tactile signals were better than auditory and visual [8]. Even if driver talking on the cell phone when driving, tactile still have shorter reaction time [10].

Some studies more in depth to discuss the location of tactile system. For example, tactile warnings delivered by gas pedal [4] or in the driver’s safety restraint or seat [5] [6] [16] is also effective to alert the driver. Atsuo Murata et al. [1] both point out that the driver will response faster when the tactile signals is show by the foot vibrator than the steering wheel.
When it talking about the direction of tactile warning. Cristy Ho et al. [2] indicate that the response was significantly faster with no spatial prediction of vibrating alert. De Vries et al. [3] also showed that the correct rate is not consistent with directional alarm.

From the related work we can know that most of the car accidents is cause by driver negligence. And, the faults of the negligence were usuaally happened when the drivers try to change their driving side. However, this kind of accident was correalted to the visual attention limitation. Based on the present studies, we can understand that there were many way of alarm systems such as tactile, visual, and auditory. From the exist paper we can arrange them to the following paragraph. 

About the haptic standard, Van Erp [16] has mentioned that they use 250 Hz vibration in their experiment. In the other hand, Ho and Spence [6] use red and blue LED light for visual warning in their alarm system. Also there are many paper discuss about the auditory warning system [6] [9] [13]. Most of their auditory warning is 75-88dB. And all of them also take environment noise into consideration (about 60 dB).

2.3 Brief summary

In this study we would like summarize the review the existing alarm systems, and we try to design a new tactile alarm system to afford drivers different perceptual signals and manipulate the context that when the alarm signals appear. There were two main issues should discuss. Was the first thing of the driver’s attentional limitation be restricted by the loading of perceptual pathway? We use either visual or tactile signals to see what kinds of perceptual signal would take less effort, and afford driver a useful alarm. The other issue would be the salience effect of the alarm signals. Actually, some of the existing alarm systems present alarm signals when drivers want to change their original own way. But, there still have some systems present alarm signals when the drivers want to change their route “and there have other cars in that route”. Therefore, compare this two kinds situation may let us realize is the salience effect of alarm signal interference our vigilance or not.

3 Method

3.1 Participants

There were 3 male and 3 female graduate school students, age ranging from 25 to 31 (mean=27), served as participants in this experiment. Two strict eligibility requirements to increase the likelihood of all participants having the adequate driving safety knowledge: (a) Have valid driver’s license. (b) At least 1 years driving experience within the city.
3.2 Apparatus

For the purpose to compare three kinds of sensory outputs as overtake alarm system. We have to build up a safety experimental environment for all participants. Therefore, we use 3DsMAX 2009 software to build up the whole driving environment and render different animations as different treatment levels. There were four segments of the animations and all the films would be taken by the first person view which concluded the front, left and right side of the car. We also use a piece of street sound (60 dB) as the background noise in all animations.

![A sample scene from the driving environment with visual alarm signal](image)

The visual alarm signal was draw by the Photoshop CS3 that was a red triangle with the size of 24x24 points. The sound alarm signal was a 1000 Hz pure tone voice that the volume would be control as 80 dB. And, the haptic alarm signal was made by a motor vibrator that setup on the participants’ hands. The location of the haptic signal was decided by our pilot study that the driving wheel was the best location. And, the haptic signal presented was control by Arduino, Arduino was an open-source physical computing platform based on a simple microcontroller board. We can write programming script to make the connection with the motor vibrator, and receiving the different trigger as different conditions that send from the E-Prime software.

Experiment environment were administered on a projector running at 1280x720 film resolution. Participants control the brake which was made by a keyboard and a pedal by right foot on floor.

3.3 Experimental design and procedure

There were two independent variables we would like to manipulate. First, the alarm signal characteristics (perceptual pathway) either the visual, sound or haptic signals. Second, the frequency (salience effect) of alarm signals: once the other cars would threaten or alarm signals constantly appear. Such as figure shown, the left one indicated that only when the driver would be threaten while they were overtaking someone. However, the right figure shown no matter there were a threat or not, the alarm signals would appear anyway.
A two factors repeated measures of within-participant design was applied as experimental design. Two independent variables were: three kinds of alarm signals (visual, sound, haptic alarm signals); two levels of the frequency that the alarm signals constantly appear or only when the driver was threaten would be appear. Therefore, the whole experiment contains 96 trials, and it was separated into 6 blocks which contains three kinds of sensory inputs and two kinds of signal frequency. The participants would take different sequence of the have to accomplish the task by following the former car on those situations, and it may have to stop the vehicle after each trials. The braking response would be the dependent variable which was the reaction time between the onset of the alarm signal and the braking time.

4 Result

As the dependent variable was the reaction time between the onset of the alarm signal and the braking time. We can see the description statistic result as table 1. In the different sensory outputs, the haptic alarm signals induce the shortest reaction time, and the visual output signals got the fastest reaction time. In the different levels of the frequency that the alarm signals appear, when the alarm signals constantly appear the participants showed the faster reaction time.

Moreover, a two factors repeated measures ANOVA was executed. The result shown on the table 2 and figure 5 that the different alarm signal outputs have main effect \( p=0.047<0.05 \). But, the different frequencies of the alarm signals don’t have significant difference. However, the non-significant difference comes from the huge difference of the visual outputs.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Conditions</th>
<th>Reaction Time (MS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory outputs</td>
<td>Visual</td>
<td>848.79</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
<td>540.34</td>
</tr>
<tr>
<td></td>
<td>Haptic</td>
<td>428.54</td>
</tr>
<tr>
<td>Frequency</td>
<td>Constantly</td>
<td>617.06</td>
</tr>
<tr>
<td></td>
<td>Threaten</td>
<td>617.07</td>
</tr>
</tbody>
</table>
Table 2. Statistic results of repeat measure ANOVA

<table>
<thead>
<tr>
<th>Variables</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory outputs</td>
<td>591995.10</td>
<td>2</td>
<td>295997.55</td>
<td>5.29</td>
<td>.047*</td>
</tr>
<tr>
<td>Output frequency</td>
<td>5969.58</td>
<td>1</td>
<td>5969.58</td>
<td>.28</td>
<td>.632</td>
</tr>
<tr>
<td>Sensory outputs*</td>
<td>31676.65</td>
<td>2</td>
<td>15838.33</td>
<td>.95</td>
<td>.438</td>
</tr>
</tbody>
</table>

Fig. 3. Reaction time in different conditions

5 Discussion

In this study, we used different kinds of the alarm signals which were collected from the existing alarm system and pervious researches. Then, we used three kinds of sensory outputs to compare which one was the most suitable for the overtaking behavior. Therefore, we build up a virtual driving environment and render different animations as our experimental conditions. All participants have to do were focus on the driving situations and step on the brake when they receive the alarm signals. As the result shown, we can find out when participants face a high visual loading task. The additional visual alarm signals would interfere with their reaction time. Instead, the participants respond more quickly on sound and haptic alarm signals. This result could be corresponding to the Wicken’s attentional theory that the human attention
was regarded as a multi-resources system [15]. Therefore, when the visual attention was exhausted, we should use other sensory signals as our alarm signal.

However, there still have other extend issues for the other sensory outputs, for example the sound and haptic alarm signals didn’t afford the orientation cues for the participants. And, the strength of the sensory outputs may interfere by the different driving environment.

The second issue we would like to test was the different frequency (salience effect) of alarm signals. It was presented the sensitivity of the alarm system that alarm signals would constantly appear or only shown when the driver was threatened. But, in our result we didn’t find the salience effect. It may cause by the lower difficulty of the task. Contrast to the real driving situation, in this experiment the participants only have to step on the brake as soon as possible. They don’t have to control the gas pedal and control the moving direction. And, the experiment was executed trial by trial, participants may keep the arousal level of alarm signals. Base on those differences of task difficulty and awareness of alarm may immerse the salience effect.

6 Conclusion

In this modern age, the density of personal vehicles was getting higher and higher, but it follows the more traffic accidents. According to the investigations, improperly change lanes and not paying attention to the front state while driving may be the main cause of car accident. The reason of the happen factor must be refer to drivers could not realize the situation of the lane that they would transfer to (sometimes they could not see the following car from the side mirror or review mirror). Therefore, there were some new technologies to help drivers to avoid the accidents. However, the engineers who innovate the overtake alarm system don’t realize how the different signal outputs interfere to the drivers. So, in this study we try to compare the different outputs of the alarm system. According to the experiment result, when driver face to the high visual loading task the sound and haptic were more suitable than the visual alarm signals. Although the virtual driving environment and the task difficulty could not externalize completely to the real situation, but this study still provide some guideline for the driving overtake alarm system.

References

1. Atsuo, M., Kohki, T., Makoto, M.; Fifth International Workshop on Computational Intelligence & Applications (2009)


