Driver Attention during Cell-Phone Calls

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ABSTRACT
We looked at returning drivers' attention to road obstacles while carrying on a conversation via cell phone. To determine how drivers' attention could be returned from a distracting conversation to the driving situation, we looked at two methods: having the non-driving conversant pause the conversation at key times, and playing an auditory alert before a dangerous driving event. The auditory alert alone proved most effective, while pausing the conversation alone showed a slight improvement over the baseline. Surprisingly, playing the auditory alert with a pause in conversation led to performance that was worse than the baseline.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. – Auditory (non-speech) feedback.

General terms: Experimentation, Human Factors

Keywords: Driving, cellular phones, auditory alerts

INTRODUCTION

Redelmeir and Tibshirani [4] demonstrated that cellular phone use while driving increased the likelihood of a collision. As the collision rate is similar for drivers using handsets and those using hands-free devices, the increase in collisions seems to be caused by the cognitive load of the conversation and not by the physical aspects of phone conversations.

Manalavan et al [3] showed that driving performance increased when the conversation was paused during tricky driving situations. Their experiments showed that if the non-driving conversant stopped talking when the driver drove through a difficult section of a course, the accident rate was reduced. We wondered if drivers paid more attention to the course because the pause *alerted* them to a dangerous situation, or because the pause *removed the distraction* and let them concentrate more.

Ho and Spence [2] found that auditory signals were effective in drawing drivers' attention to driving conditions when the drivers were not talking on a phone. We decided to include an auditory alert as an alternative to a pause in conversation to assess their relative effectiveness.

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RESEARCH QUESTIONS

We felt that the alerting effect of conversational pauses contributed more than the reduced distraction. We also felt that an explicit alert combined with a pause in conversation would be most effective.

H1: Auditory alerts will be more effective than conversational pauses in preventing collisions.

H2: Auditory alerts combined with conversational pauses will be more effective in preventing collisions than either alone.

METHOD

The study was a within-subjects design (n=9). We had two variables (auditory alert and pause in conversation) which each had two possible values (on or off), resulting in four conditions. Conversation was performed with a speakerphone to simulate a hands-free cell phone.

Subjects drove the same course in each condition, and all subjects used the same course. To mitigate learning effects, a Latin square was used to order the conditions for each subject. Obstacles on the course included pedestrians, cross traffic, and traffic lights. The course took most subjects five to six minutes to complete.

We ran the study using STISIM Drive, a well-known research driving simulator. The physical environment consisted of a GamePod driving seat that included a mounted steering wheel and pedals. A ceiling-mounted projector displayed the course on the wall in front of the driver. The experimenter who was involved in the conversation stood in a sound-proof booth and could see the driving display in conditions where he had to pause speaking at appropriate moments.

Subjects were recruited from our classmates, colleagues, and other acquaintances. Before the experiment, they were given a chance to familiarize themselves with the driving simulator. They drove on a short course without participating in a conversation. Subjects were told about the auditory cues, but were not told to expect pauses in the conversation. No set topics were used during the conversations.

RESULTS

The metric we used to measure the performance of the driver was number of collisions during a single course run. Figure 1 shows the total number of collisions across all drivers for each set of conditions, as well as the number of drivers who made those collisions. For example, under the baseline conditions – no auditory alerts and no pauses – two drivers crashed a total of four times.

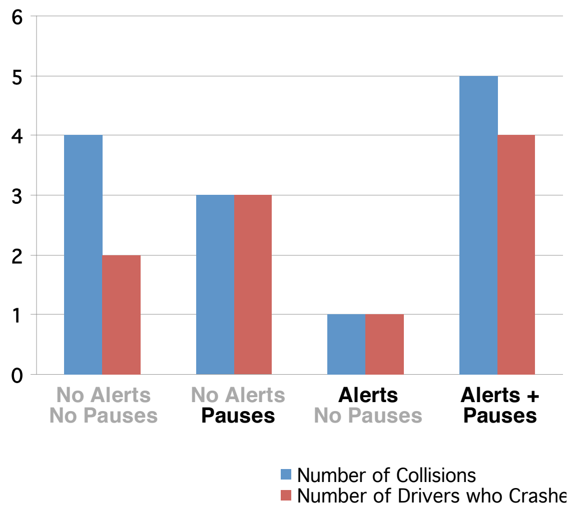

Figure 1: Total Collisions for Each Condition

As shown, adding remote-conversant pauses to the conversation led to a small improvement in driver performance, with the total collisions dropping to three. With auditory alerts, there was only a single collision across all drivers. This was the condition with the best observed driver performance.

Surprisingly, coincident conversational pauses and auditory alerts reduced driver performance significantly. With four drivers making a total of five collisions, this performance is worse even than under the baseline conditions.

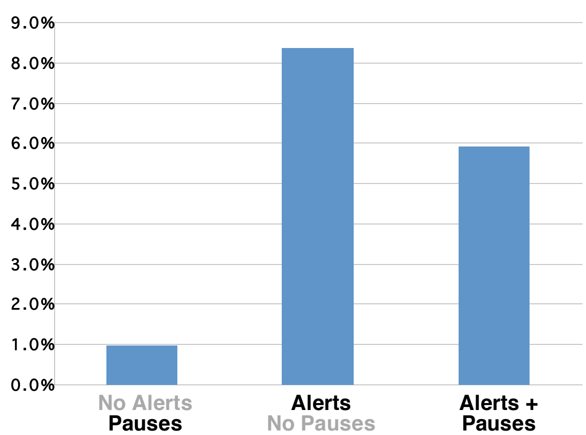

Figure 2: Average Percent Increase in Course Completion Time Relative to Baseline

We also measured the total time each driver took to complete the course under each set of conditions. On average, course completion time increased as alerts and pauses were employed, as shown in Figure 2. The longest average course completion time, 8.4% longer than for the baseline, was for the second set of conditions -- auditory alerts without conversational pauses.

DISCUSSION

Our first hypothesis, that auditory alerts would be more effective than conversational pauses at preventing collisions, was confirmed. Our second hypothesis, that together the two would be more effective than either alone, was incorrect. The degree to which it was incorrect was surprising.

There is an interesting inverse correlation between average course completion time and total number of collisions. Under the conditions with the lowest number of collisions – auditory alerts and no pauses – average course completion time was longest. In general, auditory alerts seemed to slow drivers down.

Although conversational pauses sound simple, in practice they can be complex. For one thing, the remote conversant can't pause the conversation at a critical moment if he isn't the one talking. Even when he can, the timing of the pause can lead to different interpretations by the driver. In some cases, we observed the driver attempting to pick up a stalled conversation or complete the conversant's sentences -- socially appropriate responses that probably don't help the driver pay attention to the driving task. Given this, it's possible that coincident auditory alerts and conversational pauses compete for the drivers attention – the former to pay attention to the road and the latter to attend to the conversation – and this may help explain the observed results.

We did not anticipate the degree to which drivers moderate their conversation when they need to shift attention to the driving task. Frequently, we observed drivers using fillers such as "um" and "uh" as a signal to the remote conversant that the conversation would pause as they assessed a difficult driving situation. As a result, we saw far fewer accidents than expected under the baseline conditions. Auditory alerts often induced the driver to moderate the conversation as well.

FUTURE WORK

We feel that better results would be achieved with longer courses and driving sessions (on the order of 20 or 30 minutes). To avoid keeping a subject in the simulator for a long time, this would probably require a between-subjects design, or multiple visits per subject in a within-subjects experiment.

Ethnographic techniques hold great potential for learning about the causes of cell-phone induced collisions. Esbjörnsson et al [1] argue that ethnographic techniques are much more useful than lab studies, but even in the lab some subjects noticeably altered their speech when reacting to an event. A dedicated observer could learn much about techniques used to mitigate danger (reduced speeds, careful control of attention).

Several subjects reported that they did not know why the auditory alert was sounding. Future studies could examine which types of events need alerts, when they should sound, and how much drivers would trust an unreliable alert.

CONCLUSION

As hypothesized, auditory alerts proved to be a better method for returning drivers' attention to the road than pauses in the conversation initiated by the remote caller. However, we were surprised by the negative impact on driver performance from coincident alerts and pauses. Both this observed effect, and the promise of auditory alerts in general, deserve further investigation.

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