Abstract - ASHA Convention 2009

Abstract Title:

Conversation Effect on Driving: From ERP Lab to On-Road Driving

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Abstract

We investigated cellular phone conversation effect on multitasking performance in a simple but validated “Static Load” driving paradigm. Emotional speech tone and speech complexity were tested. Behavioral results showed speech content and emotional speech have a minor influence on visual event detection during driving. Concurrent ERP recordings is a promising way to shed light on underlying neural mechanisms for higher cognitive processes and attention allocation during multitasking of cell phone conversations and driving.

Summary

Recent behavioral simulator studies suggest that the effects of a cell phone conversation on driver performance as a secondary task may be large, due to cognitive distraction (Strayer and Johnston, 2001; Strayer et al. 2003). Horrey and Wickens (2006) used the meta-analysis technique to analyze 23 on-road and simulator driving studies. They found that conversation caused a delay in reaction time of about 130 ms to visual events with no effects on miss rate, tracking performance, or lane-keeping. Such claims require careful investigation as to what might give rise to such effects in the laboratory, and whether they predictive of real-world driving performance (Young 2001, Young et al., 2005, Young & Schreiner, 2009; Schreiner et al. 2004). Despite these behavioral findings, little is known about how concurrent secondary speech tasks may influence the various neural components of primary driving. Furthermore, what is often lacking is a validation of these simulators using on-road data (only 16 known simulator validation papers). Such validation is especially important given: 1) The cognitive complexity of a real-world driving task with a concurrent cellular conversation and 2) The implications of human performance and attention research. This is the first study we know of to attempt validation of a neuroscience measure (ERPs) from lab to road.

Our previous research (Hsieh et al., 2009; Bowyer et al., 2009) has revealed that small, reliable effects of conversation on driving performance can be observed using simulators, but data concerning the kind of conversation – and the specific effects on driving performance it may have – has been lacking. In this study, we examined the effects of emotional speech and speech complexity during cell phone conversations and driving. Particularly, current study addressed the following research questions: 1. Is there an effect of cellular phone conversation on driving performance? 2. Does the effect of conversation on driving performance depend on the conversation content? 3. Does the
effect of conversation on driving performance depend on emotional speech tone? 4. How are the results in the lab compared to those on the road?

We conducted two experiments: neutral vs. angry conversations, simple vs. complex conversations compared with no conversation baselines. Four different calls were received (each lasting 1 minute) in each 9 minute block. Each participant completed 3 runs (4 cell phone conversations in each run), and a baseline run (without any conversation). A battery of behavioral measures estimated the effects of a simulated cellular phone conversation on driving performance. We collected behavioral and EEG data during simulated driving in the lab and driving on an open highway by using two computers, a battery-powered 64-channel amplifier, and a shielded EEG cap. Participants drove on real open roads in a test vehicle, and responded to simulated road events using light stimuli positioned around the driver’s field of view in the vehicle. In the lab, this was simulated using a steering simulator and light events presented on a computer. In both environments, participants’ reaction times to visual events were assessed, and ERPs were recorded to the visual events. While driving or in the lab, participants answered questions from an experimenter in a hands-free cellular phone conversation. Then we compared data collected in lab with data collected on the road.

Method

Participants

40 participants performed hands-free phone conversations during simulated driving in the lab. 16 participants performed hands-free phone conversation in the car while driving on an open highway. Behavioral and ERP data collected in lab and on the road were analyzed, and then compared across sites.

Task Procedure and Data Analysis

The participant initiated a call by pressing a manual button to begin a cell phone conversation. In the lab, participants’ primary driving task involved watching and responding to a pre-recorded video of a driving scene. The driving scene was recorded from a sedan roof-mounted camera, and contained a mix of highway, city and rural driving. In both in the lab and on the road, participants were told to press the foot pedal whenever they detect a red circle in the visual field during driving. Targeted red circles were displayed in the lower center position, and directly in the lower left position. In addition to visual event detection, the participant was asked to keep track on the driving lane by steering a white arrow leftward and rightward.

Driving performance was conceptualized as the response times and accuracy of pedal press responses to visual events. Reaction times (RTs, in milliseconds), misses, and false alarms were measured during each task. We analyzed the data set with a linear mixed-effect (multilevel) analysis of variance with log RT as the dependent variable and participant as random effect (Pinheiro and Bates, 2000). Factors included duration and content, as well as the interaction between the two factors.
Results

In Experiment 1, neutral conversations are associated with statistically significant longer RTs (about 100 msec) in lab and on road. Angry conversations did not differ in mean RTs with no conversation periods in lab and on road. In Experiment 2, both simple and complex conversations are associated with significantly longer RTs than no conversation periods or baseline runs. Complex and simple conversations had similar RTs. Reaction time patterns for visual detection across lab and on the road were similar for conversation effects; whereas, the accuracy patterns were different between lab and on the road.

In conclusion, hands-free cellular phone conversations caused statistically significant but small reaction time (RT) effects for visual event detection for simulated driving in the lab and on-road. The “Static Load” driving paradigm gives rise to highly correlated red light reaction times between lab and on-road in these experiments. Consistently high accuracy for red light detection was found regardless of emotionality and complexity of speech content during cellular phone conversations in lab and on road. Preliminary EEG data indicate that it is possible to conduct an applied cognitive neuroscience study in an open road driving scenario. Detailed results and discussion will be presented during the presentation.
