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What is This?
Providing conversation partners views of the driving scene mitigates cell phone-related distraction


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Cognitively demanding cell phone conversations impair driving performance. In some situations, conversations with a passenger are less disruptive than cell phone conversations, in theory because of heightened situational awareness. Here, drivers completed challenging freeway drives in a high-fidelity simulator while conversing with a partner. The pairs engaged in naturalistic conversations in three different conditions: remotely on a hands-free phone, as a passenger in the vehicle, and in a videophone condition where the hands-free phone experience was enhanced by a live video the driving scene and the driver’s face. This condition was designed to increase the conversation partner’s awareness of the driving situation to a level similar to that of an in-vehicle passenger, to test our hypothesis that this cognizance leads to less distracted driving. We compared these conversation conditions to a driving-alone condition. Drivers were involved in more collisions with merging vehicles in the phone condition compared to drive-alone, passenger or videophone conditions, and crucially there was no difference in collisions between the passenger and videophone conditions. Providing remote conversation partner information about the driver and driving scene reduces the detrimental effect of cell phone conversations, possibly by increasing shared situational awareness.

INTRODUCTION

Despite mounting research and increasing regulations, drivers continue to use their cell phones. In 2010 in the United States, 18% of all crashes, and over 3,000 fatal crashes, were attributed to distracted driving (NHTSA, 2010). These crashes are likely due to overestimations of multitasking ability, the extent to which one can perform two or more tasks concurrently. In fact, a recent study found a negative correlation between self-reported multitasking ability and actual performance on a complex computer task (Sanbonmatsu et al., 2013). Most alarmingly, participants with the worst multitasking performance also reported multitasking the most in daily life.

Cell phone conversations impair driving performance (Strayer & Drews, 2007), and despite mounting research and increasing regulations, drivers continue to use cell phones. This disruption is primarily cognitive, as hands-free phones cause similar impairment as do hand-held phone (Strayer & Johnston, 2001). Conversing on a hands-free phone while driving increases response times and the likelihood of collisions (Horrey & Wickens, 2006), reduces lateral vehicle control (Drews et al., 2008), and impairs conversation quality (Becic et al., 2010).

This disruption is theorized to result, at least in part, because conversations draw some of the driver’s attention away from the driving scene, resulting in inattentive blindness. Strayer and colleagues (2003) found that drivers conversing on a hands-free phone had poorer recognition memory for visual information in the driving scene, even when they had fixated it. McCarley and colleagues (2004) similarly found poorer change detection in driving scenes when participants conversed on a hands-free phone compared to when they were not conversing. Cell phone conversations also disrupt a driver’s situational awareness of their speed, environment, and goals (Ma & Kaber, 2005).

However, not all conversations are necessarily equally distracting. Some research suggests that conversing with an in-car passenger may be less detrimental than conversing with a partner on a cell phone. Epidemiologically, drivers were 1.49 times more likely to be involved in collision when driving alone compared to driving with an in-car passenger (Reuda-Domingo et al., 2004).

Drews, Pasupathi and Strayer (2008) compared the effects of passenger and cell phone conversations in a simulated freeway environment. They recruited pairs of participants, one of which was assigned as the driver and one as the conversation partner. One set of pairs conversed remotely on a hands-free phone and another set of pairs conversed with their partner as a passenger in the vehicle. Drivers who conversed on the cell phone showed poorer (i.e. more variable) lateral vehicle control compared to when driving alone. Importantly, there was no difference when drivers conversed with a passenger and drove without conversing (see also Charlton, 2009). Drivers who conversed on a cell phone also made more navigational errors than did drivers who conversed with a passenger.

Whether cell phone and passenger conversations have different effects on driving seems to depend, in part, on the driving task. A meta analysis by Horrey and Wickens (2006) found that cell phone and passenger conversations produced similar costs to driving performance. However the driving task in these studies often comprised a basic reaction time test where drivers only had to respond to a lead vehicle braking.

Passenger conversations may be less disruptive than cell phone conversations during complex driving where the passenger can help the driver notice unexpected events, such as when driving on a busy freeway (Drews et al., 2008).

Drews and colleagues (2008) found interesting conversational differences between pairs assigned to the passenger and cell phone conditions. In the passenger condition, the conversation partner moderated the pace of the conversation based on the complexity of the driving scene (e.g. fewer syllables per
minute). Passengers also supported the driver by referencing traffic situations more often than did conversation partners on the cell phone. This provides evidence for heightened shared situational awareness between passengers and drivers, compared to the cell phone condition.

The goal of the present study was to determine whether making cell phone conversations more like passenger conversations could reduce driver distraction. We recruited pairs of participants; one was assigned as the driver and drove along a busy freeway in a high-fidelity driving simulator and the other was designated the conversation partner. The pairs engaged in naturalistic conversations in three different conditions: remotely on a hands-free phone, as a passenger in the vehicle, and a videophone condition where the pair conversed remotely over a phone and the conversation partner could see live video of the driver’s face and the driving scene. We compared these with a condition where the driver drove without conversing. Our primary goal was to test whether the novel video condition would replicate the benefits (i.e. lack of distraction) of passenger conversations compared to remote cell phone conversations.

Charlton (2009) compared driving performance when drivers were speaking on a cell phone, speaking with an in-car passenger, or speaking on a cell phone with a conversation partner who could see the driving scene through a window (“remote passenger”), and found benefits for the in-car but not the remote passenger. A critical difference in the present study was that the remote conversation partner in the videophone condition could see the drivers face and the driving scene from a perspective similar to what they would see as an in-car passenger, and we predicted that this would make it easier for the remote conversation partners to envision themselves as “passengers”.

We hypothesized that providing the conversation partner information via the videophone would increase shared situational awareness compared to the cell phone condition, and that this would allow drivers to respond more effectively to unexpected events compared to when the conversation partner was blind to the driving scene.

**METHOD**

**Participants**

23 young adult pairs (N = 46) were recruited from the Urbana-Champaign community (mean age = 20.4, SD = 1.7) and were paid $8 per hour. All participants had a valid driver’s license and two or more years driving experience, normal or corrected-to-normal visual acuity, and normal color vision.

**Apparatus**

We assessed simulated driving performance in the Beckman Institute Driving Simulator at the University of Illinois (http://isl.beckman.illinois.edu). The simulator consists of a General Motors Saturn Automobile surrounded by eight projection screens, creating a highly immersive driving environment. Traffic environments and experimental scenarios were developed using HyperDrive™ Authoring Suite. Driving simulator data were recorded at 60 Hz.

**Driving Task**

The driving task comprised a 12-mile, 3-lane highway. Participants merged into traffic and took a specified exit to end the drive. Drivers were asked to maintain the posted speed limit, and to pass other vehicles when necessarily. The speed limit changed three times throughout the drive (50, 55, 60 mph), and the order of the posted speeds was randomized for each drive.

Surrounding vehicles assumed varying speeds within a predetermined range for each lane, with faster traffic in the left lane and slower traffic on the right. Vehicles were programmed to change lanes and adjust speed periodically. We manipulated traffic density by continuously changing the number of vehicles surrounding the participant. This produced conditions similar to driving along a busy highway, and demanded that drivers attend to surrounding vehicles and traffic conditions.

**Critical Events.** Several sudden, potentially hazardous events were triggered during each drive. These comprised Lead Vehicle Braking events and Merge events. Lead vehicle braking events were triggered when the vehicle immediately ahead of the driver was within 20m and the difference in speed was less than 5m/s, and consisted of the vehicle immediately ahead of the driver braking suddenly. Merging events were triggered when a vehicle in an adjacent lane was within 20m, and the difference in speed was less than 10m/s and comprised a vehicle in an adjacent lane quickly entering the driver’s lane. Merging events were meant to simulate times when another driver might change lanes without noticing the participant’s vehicle. The program attempted to trigger 6 events (2 lead vehicle braking, 4 merging) during each third of the drive, with the stipulation that no two events could be triggered in the same 10-second period. If the conditions above were not met, the event did not occur. The order of events was randomized for each drive. On average, this resulted in 9 merging events and 4 braking events per drive.

**Conversation Conditions (Figure 1)**

*Drive-Alone.* Participants drove without conversing.

*Passenger.* The conversation partner sat in the passenger seat next to the driver and the pair conversed normally.
The conversation partner sat in a different room and the pair conversed remotely via microphones and speakers. The conversation partner was unable to see the driver or the driving scene.

**Outgoing Videophone.** The conversation partner was again seated in a different room, and conversed with the driver via a microphone and speaker (same as cell phone condition). However, the conversation partner could also see live video of the driver’s face and the front screen of the driving simulator, presented on two 19-inch displays.

**Procedure**

After providing informed consent, participants were randomly assigned as either the driver or conversation partner by flipping a coin, and remained in this role for all four drives. During each drive, one member of the pair initiated the conversation by starting to tell a story about a trip they had taken. The pair was told that their goal was to continue conversing for the duration of the drive, and we found that pairs soon began conversing normally, often deviating from their original stories. All conversations were recorded for further analysis.

Participants completed four drives, one in each of the four conversation conditions. The order of conversation conditions was counterbalanced across participants, and pairs were allowed to rest between drives. Each drive lasted 10-15 minutes, and the entire experiment took approximately 2 hours.

**RESULTS**

**Collisions.** Collisions were identified any time the event vehicle (i.e. the vehicle braking or merging in front of the driver) occupied the same space as the front of the driver’s vehicle. Collision events were excluded if the driver passed the event vehicle after an event was triggered but before it occurred. Collisions were summed separately for lead vehicle braking and merging events, and we used Pearson’s χ² to compare the number of collisions in each condition. Figure 2 shows the number of collisions for each event in each of the four conditions. Overall, drivers were involved in many collisions (over 2 collisions per subject on average), particularly during merging events. This reflects the challenging and unexpected nature of the critical events.

For lead vehicle braking events, there were not significantly more collisions, relative to the drive alone condition, in the phone condition, \( \chi^2(1) = 1.84, p = .18 \), or in the videophone condition, \( \chi^2(1) = .65, p = .42 \). There were marginally more collisions in the drive alone condition than in the passenger condition, \( \chi^2(1) = 3.27, p = .071 \).

For merging events, drivers were involved in significantly more collisions when conversing on the phone compared to when they were driving alone, \( \chi^2(1) = 6.20, p = .013 \). Importantly, when drivers were conversing in the phone condition, they were also involved in significantly more collisions compared to when they were conversing in the passenger condition, \( \chi^2(1) = 4.82, p = .028 \), or in the videophone condition, \( \chi^2(1) = 4.31, p = .038 \). As we predicted, the number of collisions in the passenger condition, \( \chi^2(1) = .09, p = .76 \), and the videophone condition, \( \chi^2(1) = .43, p = .51 \), were not significantly different from the drive-alone condition.
To understand the likelihood of a collision, we computed the percent of events in each condition in which a collision occurred (Figure 3). For example, a value of .05 would mean that a collision occurred with 5% of the events in that condition. These values were submitted to an ANOVA with conversation condition as a within-subjects factor. There was no effect of condition on collisions/event in for lead vehicle braking events, $F(1,22) = .45, p = .715$. There was a significant effect of conversation condition for merging events, $F(1,22) = 5.69, p = .002$. As seen in Figure 2, drivers were approximately twice as likely to be involved in a collision in the phone condition as in the passenger condition, ($p = .002$), or in the videophone condition, ($p = .026$). The passenger and videophone conditions were not significantly different from the drive-alone condition, ($p's > .21$)

$F(1,22) = .92, p = .436$, suggesting that events were equally challenging in each of the four conditions.

**DISCUSSION**

This study examined whether providing conversation partners video information about the driver and driving scene would reduce the detrimental effects of cell phone conversations. We compared driving performance in four conditions: driving alone without conversing, conversing with an in-vehicle passenger, conversing on a cell phone, and conversing over a videophone where the conversation partner could see the driver and driving scene. Drivers collided with merging vehicles significantly more often when they talked with a conversation partner on a hands-free phone compared to when the conversation partner was able to see the driver and the road while they talked, or when they drove with a passenger.

The simulated freeway driving task was very challenging, evidenced by the high number of collisions, especially during unexpected merging events. Though these collision rates are much higher than those seen in real-world driving, our goal was to test driving performance under demanding circumstances, where crashes are most likely to occur in the real world. Specifically, the merging events were meant to represent times when a merging vehicle did not notice the driver’s vehicle and merged when it was unsafe to do so. Compared to the drive-alone condition, drivers were involved in significantly more collisions with merging cars when they were conversing over the phone. This supports a wide body of research which shows deleterious effects of conversing on a (hands-free) phone while driving (Strayer & Drews, 2007).

Most importantly, drivers were involved in significantly fewer collisions when conversing over the video phone or with an in-vehicle passenger compared to when they were conversing over the phone. This collision difference was not due to differences in event difficulty between the conditions. Our results extend those of Drews et al. (2008) by showing that the benefits of passenger conversations can be replicated with a remote conversation partner. Drivers were half as likely to collide with a merging vehicle when talking on the videophone or with a passenger as they were when conversing on the phone.

**Event starting distance.** To rule out the possibility that events triggered during the phone condition were more challenging than events in the other conversation conditions, we computed the average distance from the event vehicle (i.e. the braking or merging vehicle) to the participant’s vehicle when the event began (Figure 4). Shorter distances would allow the driver a smaller margin for error to avoid a collision event. These distances were entered into an ANOVA with conversation condition as a within-subjects factor. There was no effect of conversation condition for either lead vehicle braking events, $F(1,22) = 1.06, n = 371$ or for merging events.
The explanation for the benefit of the videophone over the phone is largely unknown. Drews et al. (2008) showed that passengers modulated their conversations based on the demand of the driving scene. Passengers were also more likely to reference traffic, which supported the conclusion of heightened shared situational awareness in the passenger condition. Though we have yet to examine the recorded conversations from the present experiment, we predict that we will find pairs will have similar conversation patterns in the passenger and videophone conditions. We also expect to find evidence of heightened situational awareness in these conditions relative to the phone condition.

Improving the conversation partner’s situational awareness would allow them to notice unexpected events and to warn the driver. Much like an in-vehicle collision warning system (e.g. Kramer et al., 2007), the conversation partner may have helped the driver localize an event in time to respond. This may have been particularly beneficial during merging events, where the conversation partner could have provided information about the spatial location of the merging vehicle.

Allowing the conversation partner to see the driving scene may also have prompted them to modulate the conversation based on the demand of the drive. If the conversation partner noticed that traffic was becoming dense, they may have slowed their rate of speech. This could have allowed the driver to devote more attention to the driving task, and reduced inattentional blindness associated with cell phone conversations (Strayer & Drews, 2003). Such situational aid could be even more beneficial in the real world, where the conversation partner could just end the conversation if traffic became too demanding.

Charlton (2009) found that allowing a remote conversation partner to see the driving scene through a window did not reduce the cost of conversing on a cell phone. Our results may differ for a number of reasons. First, our freeway task was very complex in that the driver was constantly surrounded by other vehicles and events could occur in several directions. Drivers also had to respond to a variety events with some spatial uncertainty. The videophone may be most beneficial in demanding traffic. Furthermore, our videophone interface also showed the conversation partner a closer approximation of what an in-vehicle passenger would see. This may have allowed the passenger to more easily imagine themselves in the vehicle and driving scene. Also, our design provided a much better view of the road, allowing a better understanding of the current situation and driving pressures.

There is some mismatch between simulations and on-road driving, however, using a high-fidelity driving simulator allowed us to frequently put drivers in dangerous situations where collisions were likely to occur. These instances, while critical, are rare in on-road driving. Future work is needed to validate the efficacy of the videophone interface in on-road driving and in different driving situations. Furthermore, this study had an ideal videophone observer. Conversation partners outside the vehicle had high quality video of both the driver and the road and were unable to engage in other distracting activities. Further research is necessary to examine how much the videophone conversation partner must attend to the driving task to avoid cell phone-related distraction. Further work will also explore other measures of driving performance such as lane keeping and car following, as well as less conventional measures such as recognition memory for items in the driving scene.

Ideally, drivers would not use cell phones. For the foreseeable future, however, drivers will continue to talk and text, and a large portion of accidents will come from driver distraction. Our results present a promising potential means of reducing cell phone-induced driver distraction by making cell phone conversations more like passenger conversations.

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