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# Video Call, or Not, that is the Question

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**Abstract**

New technologies have made video calling in vehicles possible. Results from a driving simulator experiment indicate that video calling reduces visual attention on the road. While in some situations drivers would refrain from engaging in this activity, our results should serve as a warning to interface designers, lawmakers, transportation officials, and drivers that video calling presents a real distraction from driving.

**Author Keywords**

Driving simulator; video calling; driving performance; visual attention.

**ACM Classification Keywords**

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

**General Terms**

Measurement, Design, Performance, Experimentation.

**Introduction**

The number of in-vehicle services such as navigation, music selection, and social networking is increasing rapidly. There is considerable demand for these services, as people spend a significant amount of time in vehicles commuting to work (in the USA over 100 hours a year [1]). The availability of powerful smart phones and high-bandwidth communication networks make it possible to meet this demand.



Figure 1. Driving simulator.

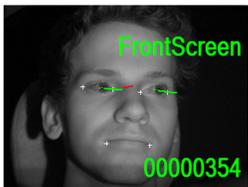


Figure 2. Remote eye-tracker (top). A view of the participant as seen by the eye-tracker (bottom); green vectors indicate gaze direction, in this case towards the simulator's front screen.

Many researchers have investigated the influence of some of the most popular services, such as mobile telephony [2; 3] and navigation [4] on driving. However, new technologies are being introduced every day, thus enabling new services. One prominent example is video calling. With the proliferation of smart phones which integrate advanced multimedia functionality, it is now possible to see remote people during in-vehicle conversations. Even though this capability may be useful in creating a more “connected” experience in ordinary circumstances, the influence it may have on driving should be thoroughly investigated before its introduction into vehicles. To the best of our knowledge, to date no other study has investigated video calling while driving. Given the importance of this topic for driving safety, this paper describes the initial steps in this research area.

We expect that video calling is not appropriate in vehicles. Specifically, our first hypothesis is that video calling will reduce the driver's visual attention on the road ahead. Our second hypothesis is that this reduced visual attention will contribute to the deterioration of driving performance.

## Background

There is a large body of literature exploring interactions with various in-vehicle devices, such as mobile phones [2; 3], personal navigation devices [4], iPods [5], and infotainment systems [6; 7]. The literature points to widespread agreement among researchers that any secondary activity performed in parallel with driving can have a negative impact on driving performance. The magnitude of this impact depends highly on the complexity of the interactions.

In-vehicle video calling, which is the topic of this paper, has similarities with using mobile phones and head-down displays (HDDs) while driving. Both (non-hands free) mobile phones and HDDs draw the drivers' visual attention away from the road ahead [4; 8]. Moreover, the work of Strayer et al. [9] indicates that even using hands-free mobile phones can lead to degradation of driving performance. We believe that similar effects may be observed in the case of video calling. Our expectations are in alignment with the concerns of lawmakers [10] and transportation officials worldwide.

## Experiment

In order to test our hypotheses we conducted a within-subjects, repeated measures experiment in which pairs of participants, the *driver* and the *other conversant*, engaged in a spoken task<sup>1</sup>. In addition to the spoken task, the *driver* also operated a simulated vehicle, while the *other conversant* was seated in a separate room.

### Equipment

The experiment was performed in a high-fidelity driving simulator with a 180° field of view, realistic sounds and vibrations and a full-width car cabin with a motion base which simulates braking and acceleration (figure 1). Participants talked to each other over headphones, thus simulating hands free communication. The conversation was monitored by the experimenter and recorded. Visual attention was recorded by a stereoscopic remote eye-tracker mounted on the dashboard (figure 2).

### Method

We report on the results for 16 participants (8 pairs) between the ages of 18 and 21 ( $M = 19.4$ ). All were

<sup>1</sup> See video at <http://youtu.be/-E26k9Wn-3I>

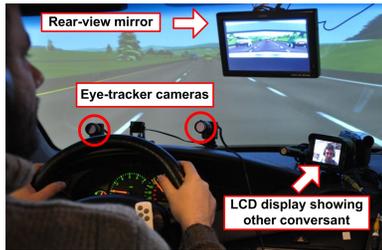


Figure 3. Driver inside the cabin.



Figure 4. Other conversant.

male college students, recruited through email advertisement and received \$20 for their participation. We rejected results for 2 pairs due to technical issues in data collection.

#### Driving task

Drivers drove in the middle lane of a three-lane highway in daylight (figure 3). The highway had both straight and curvy segments. Drivers were instructed to follow a lead vehicle at a comfortable distance. The lead vehicle traveled at 89 km/h (55mph). There were also other vehicles on the road travelling in adjacent lanes; these vehicles travelled faster than the driver and lead vehicle without interfering with them.

#### Spoken task: Taboo

The spoken task was to play a series of Taboo games. In Taboo the other conversant is given a word, and needs to work with the driver to identify it, but cannot say that word or five related words. We chose Taboo over real conversation as it results in a predictable, and fairly constant, cognitive load for the driver. We displayed the words to the other conversant on an LCD monitor, as shown in figure 4. We imposed a 1 minute time limit on each game.

The experimenter signaled the end of each Taboo game with a 0.5 second beep heard by both conversants. The end of a game was reached when the driver correctly guessed the word, when the other conversant used a taboo word, or when the conversants ran out of time.

#### Experimental conditions

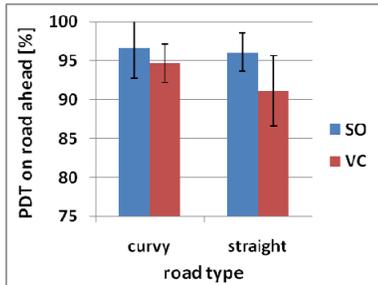
We employed two independent variables: *Interface* and *Road Type*. *Interface* had two levels and determined how the spoken task was performed. In the *speech-*

*only* (SO) condition the conversants could not see each other, and thus could only use speech communication. In contrast, in the *video call* (VC) condition conversants could also see each other on LCD displays. Figure 3 and figure 4 demonstrate the VC condition from the driver's and the other conversant's perspective, respectively. *Road Type* determined the type of road where the spoken task was performed, namely, *straight* (figure 3) or *curvy*. Since this was a within-subjects experiment, all participants experienced all experimental conditions.

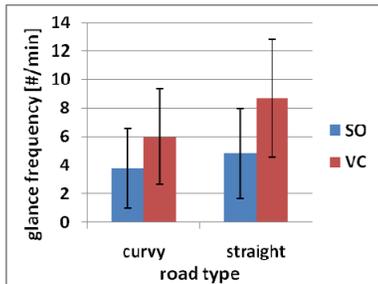
#### Procedure

After completing the consent forms and personal information questionnaires, participants were given an overview of the driving simulator, the Taboo game, and descriptions of the SO and VC conditions. Next, they completed two experiments, one for each interaction condition. We counterbalanced the presentation order of the experiments (that is the interaction conditions) between the 8 participant pairs. Before each experiment, we provided the participants with about 5 minutes of training using the interaction condition for that experiment. For training, participants played Taboo games, with the driver operating the simulated vehicle.

Experiments started with a short drive on a straight road during which the driver could adjust to the driving task. Next, participants completed Taboo games while the driver was presented with two longer road segments: one straight and one curvy. For the first interaction condition drivers drove on the straight segment first, followed by the curvy segment. For the second interaction condition drivers encountered the curvy segment first and the straight second. This order of presentation was the same for all drivers. In each



**Figure 5.** PDT on the road ahead.



**Figure 6.** Glance frequency away from the road ahead.

experiment drivers covered about 15 km of road in about 11 minutes, and played 11 to 16 Taboo games.

After each experiment participants completed a NASA-TLX questionnaire, which is a subjective estimate of cognitive load. Finally, after completing both experiments, participants provided subjective opinions about various aspects of the two interaction types.

#### *Dependent variables*

All dependent variables were obtained for each driver, interaction type and road type, and then averaged across drivers to obtain the overall result. We collected a number of dependent variables and report on the following in this paper:

- visual attention variables obtained from the eye-tracker: percent dwell time (PDT) on the road ahead (i.e., percent of time drivers spent looking at the forward road) and frequency of gazes (number of gazes per minute) directed away from the road. Decreased PDT on the road and an increased frequency of gazes away from the road indicate reduced visual attention.
- variances of driving performance variables obtained from the driving simulator: lane position and steering wheel angle. In both cases, higher variances indicate deterioration of driving performance.
- NASA-TLX scores.
- levels of agreement with preferential statements. They were collected using 5-point Likert scales. Additionally, we solicited written and verbal comments about the experiment from participants.

## **Results**

### *Visual attention*

Figure 5 shows the average percent dwell time on the road ahead. A repeated-measures multivariate analysis of variance (MANOVA) showed significant main effects of both *Interface* ( $F_{1,7}=14.013$ ,  $p=0.007$ ) and *Road Type* ( $F_{1,7}=7.941$ ,  $p=0.026$ ); however, no interaction was observed between *Interface* and *Road Type* ( $F_{1,7}=2.761$ ,  $p=0.141$ ). Exploring interface usage within the individual road types using a univariate ANOVA, a significant difference was observed between SO (96.1%) and VC (91.1%) on straight roads ( $p=0.004$ ), while no difference was observed on curvy roads (SO=96.6%, VC=94.7%,  $p=0.199$ ). Figure 6 shows glance frequency away from the road ahead. Again, significant main effects were observed for both *Interface* ( $F_{1,7}=16.068$ ,  $p=0.005$ ) and *Road Type* ( $F_{1,7}=8.038$ ,  $p=0.025$ ), but no interaction was observed between the two ( $F_{1,7}=5.411$ ,  $p=0.284$ ). Also, glance frequency was different between SO (4.8) and VC (8.7) on straight roads ( $p=0.003$ ), while no difference was observed on curvy roads (SO=3.8, VC=6.0,  $p=0.105$ ).

### *Driving performance*

The variances of steering wheel angle and lane position were not significantly different for the two interfaces (SO and VC). There was a significant main effect of *Road Type* ( $p<0.014$ ) on the variances, confirming that the straight and curvy roads indeed presented different challenges to the drivers.

### *Subjective estimates of cognitive load*

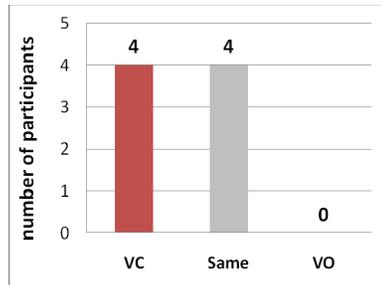
Responses to the NASA-TLX questionnaire indicated no significant differences in the perceived workload between the two interfaces (SO=49.1, VC=52,  $p=0.5$ ).

Quote 1 (Driver 2): "... overall I felt more comfortable driving, when it was voice-only."

Quote 2 (Driver3): "I normally look at people when they talk to me but in this case I decided that keeping my eyes on the road makes more sense."

Quote 3 (Driver 8): "... the video enabled one [VC] seems like it would be more distracting than a regular voice only conversation."

**Figure 7.** Quotes from three drivers on distraction caused by VC.



**Figure 8.** Responses to the question "Which phone conversation distracted you more from driving?"

### Preferential statements

Table 1 shows the percent of drivers who highly agreed (HA) and agreed (A) (white cells) or highly disagreed (HD) and disagreed (D) (shaded cells) with two preferential statements for each tested interface (SO and VC). Note that the percentages do not sum up to 100% because some of the subjects were undecided. For each statement we performed a Wilcoxon Signed Ranks test with respect to *Interface*.

Statement	Agreement	SO [%]	VC [%]	P
I would engage in a [SO/VC] phone conversation in my own car.	HA/A	75	12.5	.017
	HD/D	12.5	75	
The [SO/VC] phone conversation distracted me from driving.	HA/A	12.5	25	.564
	HD/D	62.5	75	

**Table 1.** Level of agreement with preferential statements.

As we can see from table 1, there was a significant difference in drivers' willingness to engage in SO and VC conversations in their own vehicles ( $p=0.017$ ). While 75% of participants indicated they would engage in a SO conversation, the same percentage indicated they would not engage in a VC conversation in their own vehicles. Driver responses also indicate that they did not feel that the two interfaces distracted them from the main task of driving. The responses do not indicate that the perceived distraction was different between SO and VC ( $p=0.564$ ).

In written and verbal comments 5 of the 8 drivers evaluated the VC condition as distracting, or noted its potential to distract from driving. Three quotes of written comments about distraction are presented in figure 7. Three drivers evaluated VC as no more

distracting than SO and one of these drivers also indicated that even SO was sometimes distracting. When asked "Which phone conversation distracted you more from driving?" 4 drivers selected VC, 4 rated both conditions the same and none selected SO (figure 8). Furthermore, 7 of 8 drivers mentioned verbally that being able to see the other conversant did not provide additional information for guessing Taboo words. Only one driver reported a "stronger emotional connection with the speaker" during the VC condition.

### Conclusions

The results above support our first hypothesis and clearly indicate that video calling can reduce visual attention on the road ahead, which has been shown to be correlated with degradation in driving performance in a number of prior studies, e.g. [4; 11]. This should serve as a warning to both designers of in-vehicle user interfaces, and drivers, that video calling presents a real distraction from the driving task.

However, our results do not support the second hypothesis on driving performance. Namely, we did not observe differences in driving performance variables between VC and SO conditions on either type of road. One possible explanation is that as drivers realized the potential for distraction of video calling, they decided not to engage in VC, or at least not engage in it too heavily. This in turn might be why we did not observe differences in driving performance between VC and SO. The PDT results support this hypothesis. On the more demanding curvy roads, PDT was not significantly different between VC and SO, and even on straight roads PDT is only 5% less when using VC (compare this to a much larger 9.4% difference between navigation devices in [4], and an even larger 24% difference

Quote 4 (Driver 2): "*I liked the voice only conversation more because I felt a little bit rude not paying attention to my clue giver [in the VC condition].*"

Quote 5 (Driver 6): "... [in the VC condition] *my partner was focusing on the Taboo questions. Therefore he was not making eye contact with me and I did not feel obligated to make eye contact with him.*"

**Figure 9.** Quotes from two drivers regarding the (western) social norm of making eye contact during conversation.

between some conditions in [11]). The subjective evaluations of VC and SO also support this hypothesis, with drivers expressing willingness to engage in SO calls, but not VC calls in their own vehicles (table 1), and assessing VC as distracting (figure 8).

While drivers' apparent savvy in not engaging heavily in VC and the lack of effect of VC on driving performance is encouraging, we should not overstate the ability of drivers to handle VC. First, note that in our experiment the driving task was simple. Drivers did not have to make turns or contend with unexpected events such as a braking lead vehicle. This might be why the lower PDT on the road ahead in the straight road condition did not lead to worse driving performance. Second, the task of playing Taboo, and the fact that the other conversant was a peer (another student), might not have presented drivers with a compelling reason to look at the other conversant, allowing them to maintain a high PDT. A number of factors, including a different topic of conversation or a more pronounced need to follow the (western) social norm of making eye contact during conversation (addressed by 2 driver comments – see figure 9), might have resulted in different eye gaze behaviors for drivers. These considerations bring us back to cautioning designers and drivers that video calling presents a real distraction from the driving task.

### Acknowledgements

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### References

[1] Lowe, S. Many Workers Have Long Commutes to Work. US Census Bureau Press Release. Date accessed 5/30/2009.

[2] Horrey, W. J. and Wickens, C. D. Examining the Impact of Cell Phone Conversations on Driving Using Meta-Analytic Techniques, *Human Factors and Ergonomics Society*, 48, 1 (2006), 196-205.

[3] Strayer, D. L., Drews, F. A. and Crouch, D. J. A Comparison of the Cell Phone Driver and the Drunk Driver, *Human Factors and Ergonomics Society*, 48, 2 (2006), 381-391.

[4] Medenica, Z., Kun, A. L., Paek, T. and Palinko, O. Augmented Reality vs. Street Views: A Driving Simulator Study Comparing Two Emerging Navigation Aids. In *Proc. MobileHCI 2011*.

[5] Salvucci, D. D., Merkley, D., Zuber, M. and Brumby, D. P. iPod Distraction: Effects of Portable Music-Player Use on Driver Performance. In *Proc. CHI 2007*.

[6] Weinberg, G., Harsham, B., Forlines, C. and Medenica, Z. Contextual Push-To-Talk: Shortening Voice Dialogs to Improve Driving Performance. In *Proc. MobileHCI 2010*.

[7] Fröhlich, P., Baldauf, M., Hagen, M., Suetterle, S., Schabus, D. and Kun, A. L. Investigating Safety Services on the Motorway: the Role of Realistic Visualization. In *Proc. AutomotiveUI 2011*.

[8] Strayer, D. L., Cooper, J. M. and Drews, F. A. What Do Drivers Fail to See When Conversing on a Cell Phone? In *Proc. Human Factors and Ergonomics Society 48th Annual Meeting* (2004), 2213-2217.

[9] Strayer, D. L. and Johnston, W. A. Driven to Distraction: Dual-Task Studies of Simulated Driving and Conversing on a Cellular Telephone, *Psychological Science*, 12, 6 (2001), 462-466.

[10] Claude, B.-A. State Assemblyman: Ban iPhone4 Video-Calling From the Road. New York Magazine. Date accessed 12/20/2011.

[11] Horrey, W. J., Wickens, C. D. and Consalus, K. P. Modeling Drivers' Visual Attention Allocation while Interacting with In-Vehicle Technologies, *Experimental Psychology: Applied*, 12 (2006), 67-78.