AUTONOMICS

IMPACT OF CONVERSATIONAL DEMAND ON DRIVER DISTRACTION

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This article concisely describes three experiments testing the effects of auditory/cognitive distraction deriving from levels of conversational demand. In the pilot study, 8 participants drove three simulated routes with and without the task of holding a conversation with the experimenter. In the pilot experiment, 8 participants drove three different virtual routes with and without conversing with the experimenter. In experiment 1, 24 participants drove one virtual route under three conditions: no interaction with the experimenter, holding an informal conversation and holding a conversation concerning issues at work. The same design was repeated in the second experiment, with the difference that the 12 participants were tested on the Lane Change Task (Mattes, 2003). The results suggest a significant effect for conversation on driver ability to control the vehicle laterally, as well as a differentiation between conversation topics.

Introduction

Driver distraction is now a major research area within transport ergonomics. A considerable amount of research has tested possible performance impairments caused by the use of in vehicle devices such as cellular phones (Direct Line Motor Insurance, 2002; Haigney *et al*, 2000), navigation systems (Tijerina *et al*, 2000) and on board email/internet facilities (Lee *et al*, 2002). All those studies examined combinations of physical, visual and cognitive distraction, depending on the device interface and suggested significant effects on driver performance. However, to the knowledge of the authors, no study has examined driver distraction resulting from conversation. To test this, three experimental studies were undertaken, using a driving simulator. The basic details are presented below.

Method

Pilot Experiment

The platform used was a Sony Playstation 2 (PS2) running the World Rally Championship (WRC) 3 racing simulator. The PS2 is a cost - effective system with excellent performance in driving/racing simulation. WRC3 is one of the few popular simulators that simulate real world routes, it offers a wide variety of weather and road conditions and it can save and replay driving sessions for validation of measurements.

The projection system was a Sony Liquid Crystal Projector. Images were generated at a frame rate of 50Hz, and projected onto a large screen (2m wide), 3m in front of the participant. The participants controlled their direction of motion using a force-feedback steering wheel (Logitech Driving Force). The steering wheel supplies data at the same rate as the 50Hz display, therefore the maximum delay between movement of the wheel and screen position update is 2ms. The experiment took place in a basement during evenings, with all lights out, in order to diminish any external environmental intrusion. A 5-channel amplifier, capable of delivering surround sound, provided realistic engine noise and impact sound effects.

Subjects were drawn from the local population of Athens (Greece). The sample comprised eight young drivers (24 – 29 years old). Two older drivers (age 30+) who initially participated, withdrew from the session due to virtual sickness symptoms. Six of the participants were male and two were female.

The simulated routes were three rural two-lane roads, one with dry tarmac, one with wet tarmac and one with icy spots on the road. The time taken to complete each route was recorded in seconds, as an indication of average speed, and the number of times the vehicle left the road or crashed were measured as an indication of driver control for each condition. For the vehicle to be considered as "lost control/off the road", at least three of its four wheels had to have exceeded the road edge-line. Such an extreme definition is appropriate as an indication of the safety implications of the effect, because simulations have been found to exaggerate minor control failures (Reed & Green, 1995). By dismissing minor departures and failures, the design focuses on instances that are probably associated with severe incidents in real-world driving. The simulated routes were the road that connects the village "Bisbal" with the village "Falsat" in Spain (dry and wet tarmac conditions) and the route "Col de Turini" in Monte Carlo (tarmac with icy spots). Both routes are comparatively twisty, mountainous, single-lane, two carriage-way roads. The icy route was hillier than the other.

Each participant was briefed about the procedure before each session and completed the information sheet and the consent form. Further explanations about the experimental process were given if the participant had questions. When ready, they were lead to the simulator.

There, they adjusted the steering wheel and pedals to their preferred position and drove a route, different from the one used in the experimental conditions, in order to familiarise themselves with the equipment and especially with the steering wheel and pedal responses. When they felt comfortable the first session started (dry tarmac route), followed by wet road and icy road routes. Condition order (conversation/no-conversation) was counterbalanced. During the procedure, the experimenter was seated behind of the driver, so that no visual interaction could be engaged at any point. In the experimental condition, the experimenter would pose one of the following questions to initiate interaction: "what are your hobbies?", "what do you do on weekends?"

After completion of data collection, data was analysed using a T test to compare road departures and time to complete the course. Because of the low sample size order effects were balanced only in terms of the two conditions (conversation-no conversation) and thus differences between stages (dry, wet, icy) were not examined.

Experiment 1

The same platform as in the pilot experiment was used. In addition, the NASA TLX (Hart and Staveland, 1988) was translated into Greek and administered to measure the subjective workload experienced for each condition the participants completed.

The sample comprised 24 young volunteers from Athens (Greece) holding a valid driving license, ranging in age from 20 to 30 years (mean= 25.3), ranging from 500 to 45000 km/year in terms of mileage (mean=20291) and from 1 to 13 years in terms of driving experience (mean=5.7). Twelve of the participants were male and twelve female.

In the first experiment the same objective measurements as in the pilot study were taken (time to complete course and number of lateral control failures). The simulated route was the same in every trial. Weather conditions were light rain and the simulated vehicle had special tires for such conditions. The road surface was optimum-condition tarmac. The experimental design comprised three conditions: baseline-no conversation, experimental condition 1 – informal conversation, and experimental condition 2 – technical/demanding conversation. Any order effects were balanced in the sample as a whole as well as across the groups of male and female participants.

The "informal conversation" condition included 3 conversation topics: hobbies, family or friends. The "technical conversation" condition had as subject either, in the case of professional participants, a difficult issue at work and how they dealt with it or, in the case of students, a difficult exam and how they reasoned their answers.

The procedure was the same as with the pilot study, with the only difference being that the "technical conversation" condition was added and only the "Bisbal-Falsat" route was employed. After the completion of each session, the participants were asked to complete a NASA TLX. Then the next session and another NASA TLX administration followed until completion of all three conditions.

After data collection was complete, the three conditions of the experimental design were compared in terms of the three dependent variables – speed/time, loss of control, and subjective workload. A repeated measures analysis of variance test was used with additional contrasts between each pair of conditions. In all cases the required alpha significance level was set to 0.05.

Experiment 2

The main purpose of the second experiment was to validate the results from the previous study using a standard driver distraction test, the Lane Change Test – LCT (Mattes, 2003). Since there were compatibility issues with the equipment employed in the previous experiment, a premium PC with stereo speakers was used for this experiment with the addition of the new Logitech "Formula Vibration Feedback" steering wheel. The equipment was set up according to the standard layout in LCT guidelines (ISO, 2005).

Twelve postgraduate students, holding a valid driving licence, from Loughborough University voluntarily took part in this study. Six of the participants were male and six female, ranging from 23 to 28 years of age (mean=24.75), from 2 to 9 years of driving experience (mean=5.66), and from 100 to 35000km/year of mileage (mean=12308). Again, as the design followed a repeated measures approach, order effects were balanced. Participants had to drive on the virtual highway changing lanes according to on-road sign indication. Dependent variables were the average departure from the desired course – measuring from the middle of the respected lane, and the subjective responses to the NASA TLX. The LCT sets vehicle speed at a constant 60 km/h, and therefore speed behaviour is controlled. Again the three conditions were: no conversation, informal conversation and technical conversation. The experimental procedure was the same as in experiment 1.

LCT software is equipped with an additional utility which quantifies the departure from the optimum course and can calculate an average of this over a driving session. The average departure from the normative model associated with each session was analysed using Repeated Measures Analysis of Variance. The same analysis was applied to the NASA TLX data. In each case the required alpha significance level was set to alpha= 0.05.

Results

Pilot Experiment

Significant differences were found between participants in the experimental and baseline conditions. Both in "wet tarmac" and in "tarmac with icy spots" p values were found below 0.05 (p=0.038 & p=0.006 respectively). The difference between mean number of road departures was 3.25 for wet tarmac and 8 for icy roads. No significant differences between average speed/time to complete the route were found.

Experiment 1

Analysis of Variance demonstrated an effect for the conversation variable on the dependent variable of vehicle control loss. The overall effect was significant at p= 0.0001 as well as the differences between all three groups. The difference between the average of the baseline (2.62 failures) and the experimental 1 condition (4.5 failures), was significant at the p=0.0001 level, and the difference between Experimental 1(4.5 failures) and Experimental 2 condition (5.63 failures is significant at p=0.0001 as well. Participants tended to lose control of the vehicle more often in the informal-conversation condition than in the baseline condition and even more often than the previous two, in the technical-conversation condition. Analysis of variance of the time to complete course data did not reveal any significant effects of the independent variable.

In terms of subjective workload assessment, no significant differences were found between the three conditions in any of the six subscales of the NASA TLX index.

Experiment 2

Analysis of Variance of the lane departure measure indicated an effect for distraction as in the previous experiment (p=0.0001). Participants performed worse in the experimental conditions than in the baseline condition, however, within-subject contrasts did not support a similar effect between the 2 experimental conditions.

The results from an analysis of subjective responses to NASA TLX revealed significant differences in Mental Demand. Mental demand was differentiated not only between baseline and experimental conditions (baseline mean=2.12, experimental 1=3.7, p=0.001), but also between the 1st experimental and the 2nd experimental condition (mean=4.88, p=0.026). The subjective mental demand of the task was found to be greater in the informal conversation condition than the baseline condition (p=0.001), while in the technical conversation condition mental demand was rated even higher (p=0.026).

Discussion

In general, all three studies indicated a strong effect for conversational distraction on driving performance. The results are congruent with previous studies of hands-free mobile use (Haigney *et al*., 2000) and voice based email facilities (Lee *et al*., 2002). In particular, in both instances conversational interaction was associated with degradation in vehicle control. A significant difference between the conversation and the non conversation conditions in the studies presented here suggests that auditory/cognitive demand of an in-vehicle conversation has an impact on the driving task. If those results are combined with previous results from field and naturalistic driving studies (Regan and Mitsopoulos 2001; Neale *et al*., 2005), then it can be suggested that different types of conversation, either direct or via a device, can be a threat for driver safety and transport safety in general. In addition it seems that the final amount of effect is the result of interaction between auditory distraction and environmental conditions. Although the pilot study suffers some weakness in its sampling properties, the increase in the power of the effect observed in the wet and icy road conditions cannot be neglected. This suggests that distractive effects on performance are boosted by environmental conditions that make the driving task more demanding, however more detailed investigation is needed.

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