DO NOT DRIVE AND TOUCH: EFFECTS OF A MANUAL DESTINATION ENTRY TASK IN A NAVIGATOR ON DRIVING PERFORMANCE

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ABSTRACT: Manipulating an electronic device when driving is regarded as very unsafe. However, it is not unusual to see drivers interacting with all sorts of devices behind the wheel. In Spain, a new legislative initiative pursues punishing drivers with two points in the penalty point system if operating a navigator when driving. In order to illustrate the negative consequences of this behaviour, we set 43 subjects to drive in the driving simulator SIMUVEG while introducing directions in a navigator. Several performance measures were recorded for these subjects. Intrasubject comparisons revealed significant differences for many of these measures providing evidence of the negative consequences of such interactions.

1 INTRODUCTION

There is currently much evidence that In-Vehicle Technology Systems can be a source of distraction and consequently crashes (for a recent review see for example (1)). Thus, some of the potentially dangerous devices that are usually listed as harmful are mobile phones, and navigational, traffic information, and entertainment systems. Drivers entangled in heavy interaction with these devices are more prone to take their eyes away of the road or simply "looking but no seeing", putting in risk both their own lifes and those of other drivers.

Although each of these systems may affect driving in different ways it is expected that systems requiring manual manipulation and visual attention be the most dangerous. Thus, while it is known that conversing on a hands-free mobile phone will have negative effects on driving ((2,3), the consequences of introducing a telephone number or checking the contacts using a standard terminal are still probably worse in terms of safety. Indeed, manually manipulating any device in the car involves a certain risk that should not be disregarded by the drivers (4,5)

However, in spite of the scientific evidence pointing out the risks involved in driving and manipulating devices in cars, there are many steps to be taken before everybody understands and accepts such evidence. On the contrary, the recent years have shown an increase in the number and variety of gadgets that can and are used in the cars. It is therefore important to convey the main results of research to the general population in ways that can be easily comprehended and accepted.

The following paper is a collaboration between a research institute (the Institute of Traffic Safety of the University of Valencia) and an insurance company (Linea Directa Aseguradora) aimed to demonstrate the consequences of carrying out certain tasks in a device (a navigator) in the car on driving performance and traffic signal recognizing. 43 subjects drove in the driving simulator SIMUVEG for about 25 minutes, spending half of the time introducing addresses in a commercial navigator. Dependent variables measured were speed, lateral control and traffic signals recognizing. The experiment demonstrated that all these three variables were negatively affected when the subjects were carrying out the experimental task.

The research here presented was used as part of a national campaign addressing the dangers of getting distracted at the wheel for using a navigator. This campaign had an important impact in the media (newspapers, TV and Internet) and consequently we believe that contributed to raise the awareness of the public about the possible negative consequences of manipulating electronic devices while driving. We believe that the simple experimental setting used at this experiment provided an easy to understand, hard to discuss evidence that undoubtedly contributed to the success of the campaign.

We will discuss the experiment and will present the results. A final section will discuss the results obtained and provide some conclusions.

2 METHOD

2.1 Participants

43 (23 male, 20 female) subjects participated in the experiment. All of them had a valid driving licence at the moment of the study. The participants were contacted at the university mainly, well among students or the administrative staff. Their ages ranged between 18 and 70 years (see Fig.1 for the distribution of ages). All of them had good eye view or used correcting lenses at the time of the experiment.

A fixed amount of 30€ was paid to the subjects for its participation. However, many of them found the experience enjoyable and rewarding and claimed they might have done it for free.

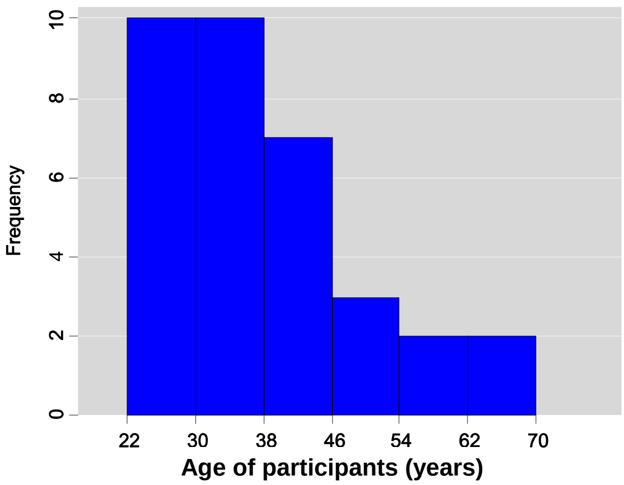

Fig.1. Differences in Speed between drivers manipulating a navigator (WITH) and non manipulating the navigator (WITHOUT). Lines mark the drop in speed of two subjects that were affected the most by the navigator

2.2 Experimental Design

A repeated measures design was used in our experiment. Every individual went through to two conditions of using the navigator while driving (WITH) and not using the navigator (WITHOUT). The two conditions were counterbalanced so half of the individuals did the WITH condition first, and the other half did the WITHOUT condition first. Subjects were randomly assigned to the groups but keeping the balance between male and female participants so the same number of females and males were set in each of the groups. Every subject drove for a training period before the actual experiment started. Data from the training part was not used for analysis.

2.3 Test Materials and Equipment

The driving simulator SIMUVEG was used for this experiment. This is a fixed platform simulator with three screens of big dimensions and 160 degrees angle of view. Three XGA projectors with 2000 lumens display the 3D images in real time in connection with a Renault Twingo with sensors set in the steering wheel, brake, throttle and so forth.

The scenario that our subjects drove through had two parts: first part was a low traffic highway designed to get the drivers acquainted with the basics of driving in the simulator, second part was a two-way rural road with a number of light traffic conflicts. Namely, a truck stopped on the verge of the lane, a tailing car, curves, etc.

A commercial navigator (TOM TOM Go 710) was used in the experiment. The device was presented to the subjects before starting the experiment and they were asked if they knew how to use this particular model and brand of navigator for introducing directions. If the answer was negative, they were instructed in this task until they declared they felt comfortable using it. A list of directions to be introduced in the navigator was prepared beforehand.

One of the experimental tasks involved recognizing traffic signals presented to the drivers on the screen. In order to force the driver to actually process the meaning of the signal we created a set of "pseudosignals" , i.e. signals similar to the actual signals but that were in fact wrong or false (see Fig.2 for an example). This way, the driver was forced to scan the traffic signal to give the correct answer.

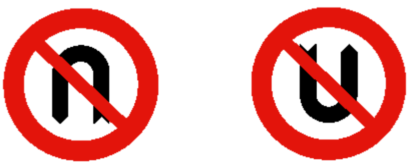

Fig.2. Example of signal and pseudosignal used in the experiment.

2.4 Experimental task

The subjects drove the experimental scenario while performing the following experimental tasks.

- Introducing addresses at the navigator as read aloud by the experimenter. The subjects had to find the address in the navigator that the experimenter indicated them. The subjects could work at their own pace for doing this task. Once they had finished, a new address was provided to them..
- Determining if the signals presented to them were true or false and telling it so to the experimenter.

2.5 Measures

The driving simulator collects a single measure every frame. However, in order to make the datafiles more manageable, we aggregate the measures every 10 meters of driving with the result of 100 point measures per km. In total, 1776 measures per subject are saved. These measures are used to compute averages for the conditions WITH or WITHOUT using the navigator in the experiment. The following measures of performance were used:

- Mean speed: This measure is usually related with larger mental workload. The drivers often try to compensate more workload by speeding down the car
- Percent of lateral control (PLC): We use the Time to Line Crossing (TLC, see (6)) for measuring lateral control. We test if there is any episode of TLC<2 s. in each of the 10 meters subsections and then compute the percentage of subsections with at least one episode of such type with regard to the total. The result is subtracted of 100. The final value is a figure between 0 and 100, where 0 means very poor driving and 100 perfect driving. Previous experiments in our simulator suggest that values above 80 in this measure can be interpreted as good driving, 60 to 80 as average, and below 60 poor driving.
- Percentage of correct identification of traffic signals: Number of signals identified divided by the total number of signals presented by 100.

3 Results

We will present the results for the following three dependent variables: average speed, lateral control, and percentage of traffic signals recognised along the test drive. We will compare the results for the periods using the navigator (WITH) with the results not using the navigator (WITHOUT). Additionally, we will discuss if speeding down as a way to keep up with the normal lateral control was successful.

3.1 Mean Speed

Manipulating the navigator reduced the mean speed of driving in about 15 kms/h t(42)=9.758,; p<0.0001. Thus, while drivers in the WITH condition maintained an average speed of 79.25 kms/h, drivers in the WITHOUT condition dropped this average to 64.73 kms/h.

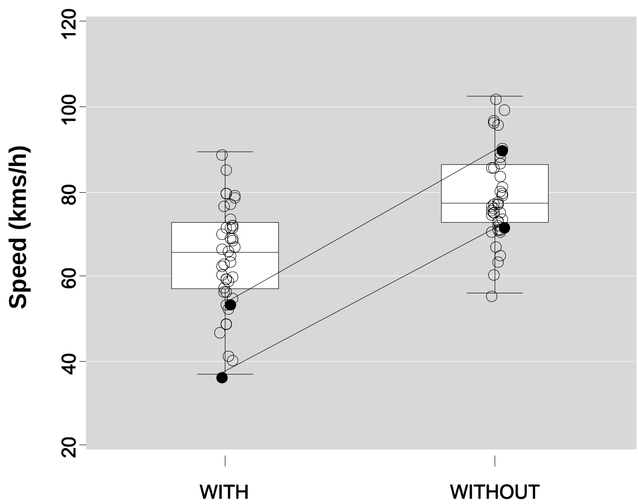

Fig.3. Differences in Speed between drivers manipulating a navigator (WITH) and non manipulating the navigator (WITHOUT)

It is noteworthy to mention that the speed of some drivers changed very dramatically while using the navigator. Fig.3 shows the boxplots for the mean speed of the drivers. Two lines show the change in speed of the two individuals that suffered the largest drops in speed. Of these two, one passed from driving at an average of 90.54 kms/h to 54.16 kms/h, and the second from 72.43kms/h to 36.67 kms/h.

3.2 Lateral Control

Again, the effect of manipulating the navigator while driving had a very clear effect on the performance of the drivers. In this case, while not using the navigator (WITHOUT) the drivers reached an score of 76 PLC in average while those using the navigator (WITH) obtained an average of 60 in PLC. The difference was significant $t(42)=6.67$, $p<0.001$.

Fig.4 shows the boxplot comparing the lateral control in the two conditions. Again, two individuals have been marked in order to display how extreme can be the effect of manipulating the navigator for some individuals.

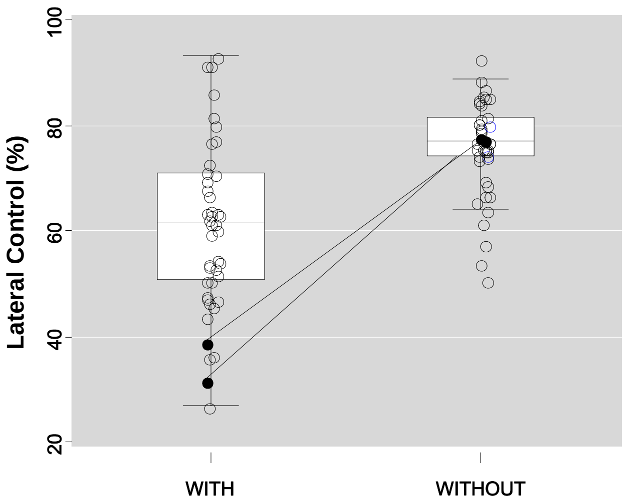

Fig.4. Differences in Lateral Control between drivers manipulating a navigator (WITH) and non manipulating the navigator (WITHOUT). Lines mark the drop in speed of two subjects that were affected the most by the navigator

3.3 The effect of the Speed reduction on Lateral Control

Speed reduction is regarded as a compensatory mechanism used by drivers to avoid the negative consequences of distracting tasks in the car. If drivers are able to keep lateral control using this mechanism (and we chose not to regard low speed as a problem in itself), we might regard the consequences of using the navigator somewhat less harmful.

In our case, however, it is obvious that the compensation mechanism (i.e. the reduction in speed) was not able to avoid the decrease in lateral control. Nevertheless, it is interesting to examine this aspect in detail. The scatterplot in Fig.4 displays the difference in Speed and Lateral Control between the two conditions. Thus, the variable in the X axis can be interpreted as compensation where positive values mean compensation and negative values indicate the reverse. Values are mainly positive in this variable as in general users drove faster not using the navigator than using the navigator. The variable in Y axis can be interpreted as gain in lateral control and was computed as the difference in PLC between the condition WITH and the condition WITHOUT using the navigator. Reductions in speed should produce gains in control of the vehicle and, at a first glance, the regression line in Fig.4 displays just that. However, the test of the slope coefficient gives a non significant result $t(41)=1.42$, $p>0.1$, indicating that reduction in speed did not turn out as a result a subsequent gain in lateral control

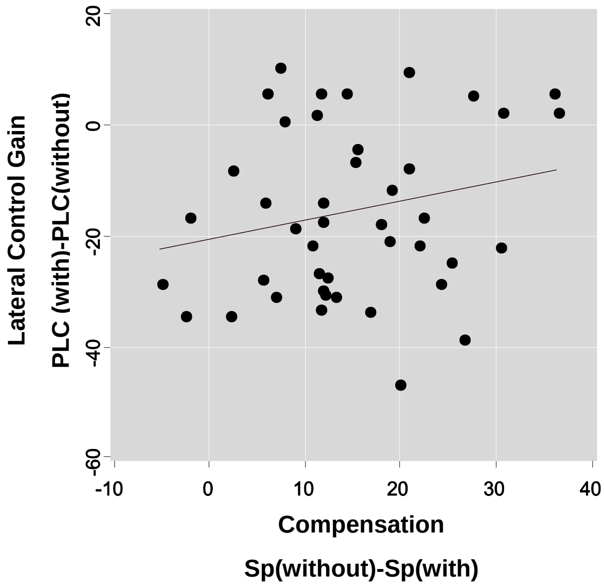

Fig.5. The effect of compensation of Speed on the Lateral Control Gain. The figure suggests a positive relationship but the test of the slope gives non significant results (see main text for explanation)

3.4 Signals recognized

Using the navigator had the effect of reducing a 35% average of the percentage of signals correctly identified. Subjects not using the navigator correctly named 85% of the signals, while those using only named about a 50%. It is important to mention that some of the drivers simply gave up this task and had a 0% of achievement at this task.

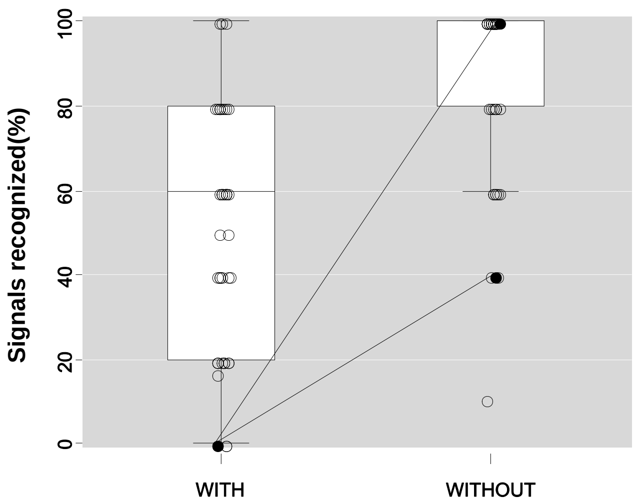

Fig.6. The effect of compensation of Speed on the Lateral Control Gain. The figure suggests a positive relationship but the test of the slope gives no significant results (see main text for explanation)

4 Discussion

At first glance, it seems straightforward, given the results obtained, to arrive to the conclusion that using the navigator while driving has negative effects on driving performance as measured by the three variables considered: speed, lateral control and signal detection. So, in our experiment, the drivers, in average, reduced their performance in the three variables significantly, not being able to keep up with the performance level they had while not using the navigator. In fact, the drop was so dramatic in some subjects that, had this behavior exhibited in real traffic, manipulating the navigator while driving is clearly very dangerous. Indeed, without considering other aspects, this interpretation could not possibly be rebuffed by anybody.

Actually, as these results were to be used as part of an campaign for raising the awareness of danger associated with getting distracted at the wheel, the self evident results were very welcome. However, to be honest, the experimental test was set closer to what is possibly a worst case scenario than to a typical/realistic scenario. So, for example, some of the drivers expressed that they could not conceive getting into the kind of interactions they had to perform in our experiment. Also, the task of introducing a sequence of addresses is not representative of the tasks usually performed with a navigator (where typically only one address is introduced per trip). Finally, many drivers will use the navigator in urban areas and will take advantage of traffic lights stops for introducing the directions. In conclusion, serious as they may look the consequences of using the navigator while driving in our experiment, it is quite possible that in more naturalistic situations the drivers will use it with more precaution than in our experiment.

In summary, the present work shows the consequences on driving performance of manipulating an electronic device can be very noticeable in extreme cases. While it is arguable whether drivers will get into such complicate interactions in practice very often, the simple fact is that if they do, the consequences are very negative in most of the cases.

5 References

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