Mindfulness, distraction and performance in a driving simulator

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## Abstract

The following paper will explore the link between mindfulness measured as an individual trait and a number of variables of driving performance in the SIMUVEG driving simulator. 67 subjects of ages between 18 and 24 filled up the MAAS, ARDES and ARCES questionnaires and were evaluated in two driving performance measures, namely, time to line-crossing and mean speed. The results shown no correlation between the performance measures and the mindfulness measures, and low but significant correlations with the measures of distraction. These results are relevant to the assessment of distraction driving as a personal trait of some drivers.

## Introduction

Driving is a complex process that involves several perceptual and motor subtasks. Three subtasks that are usually mentioned as relevant for keeping control of the vehicle: keeping longitudinal control−for example, controlling speed−, keeping lateral control−for maintaining the car in the road's lane- and avoiding obstacles. Driving is regarded as a rather easy task, where most of the time drivers can successfully carry out these three tasks effortlessly without suffering incidents.

Failures in control of the vehicles have been associated with driver inattention. As Noi states (1), "(…)from a traffic safety viewpoint, it may be pragmatic to define 'inattention' simply as a lack of awareness of critical information". Critical information would be what is required for driving in an acceptably safe context and for avoiding situations that may turn out to be the origin of an accident. Causes for inattention can be external such as those occurring on the road or carrying secondary tasks while driving, or internal, such as fatigue, alcohol, or the own stable traits of the driver. As mentioned by Ledesma et al. (2), individual traits have been researched less than other possible sources for inattention and it would be interesting to know if people who are prone to distraction in everyday life, have also this tendency in driving.

A personality trait that brings an interesting promise is mindfulness. Research on and applications of mindfulness have grown up exponentially in the last decade. It has been related with enhanced well-being, health, creativity, performance and attention among other variables (3). Mindfulness refers to attending the experience on purpose and non-judgmentally. There are not a universally accepted definitions of mindfulness but the elements that are often in them refer to “being aware and pay attention to the present moment”. Mindfulness can be fostered via explicit activities such as meditation or in everyday activities such as eating or, of course, driving.

Hanan et al. (4) have suggested that mindfulness may play a role in predicting speeding behaviour. So, after reviewing the concept of mindfulness and highlight its potential importance applied to driving, they use the operationalization of Brown y Ryan (5) of this concept as the most applicable in this field.

Brown y Ryan (5) regard mindfulness as a more or less stable trait of personality referred to the capacity of being attentive and focus in the present moment. In order to operationalize this concept, they built the Mindfulness Awareness Attention Scale (MAAS). MAAS provides a unifactorial view of mindfulness that emphasizes as its most central aspect the attention/awareness to the present moment, which can be of key importance for driving. MAAS is a simple scale that provides a single score per subject. This scale can be used even if the subject has not experience on meditation. There are two versions of the MAAS, one evaluating mindfulness as a trait, and other measuring this variable with regard to a specific state of the individuals.

On the other hand, Ledesma et al. (2) provide scales for measuring distraction in driving-ARDES, the Attention Related Driving Errores Scale. Ardes has been found to correlate significantly with the ARCES (6) scale, which measures cognitive errors in general, not tied to a specific situation.

This paper explores the power of the attentional and mindfulness scales previously mentioned for predicting performance of drivers in two of the key aspects outlined in the first part of this introduction: longitudinal and lateral control. Speed, one of the variables related with longitudinal control, has been already connected with mindfulness by (4). However, lateral control seems to be a variable that might correlate with it, as it requires a continuous control than can be enhanced if more attention is given to the present moment. Other important subtask of driving, avoiding obstacles, will not be considered in this paper.

The performance variables will be evaluated in a driving simulator as an approximation to real life situations. In short, in the empirical part of this paper, the subjects answered to the scales previously mentioned and they drove in a driving simulator. We expect that the scores in the scales will correlate with the performance measures taken in the driving simulator.

## DESCRIPTION OF THE STUDY

In this study, subjects filled up a number of questionnaires related with mindfulness and distraction−described in the measurements section−and drove for approximately 20 ms. in the SIMUVEG (7) driving simulator. No special instructions were given to the subjects except for driving as they would do normally in situations such as the ones displayed in the simulator.

Half of the subjects filled up the questionnaires before driving and the other half did it after in order to control for the effect of being measured on their behavior behind the steering wheel.

## Participants

72 subject participated in the study although 5 of them had to be discarded because of incomplete data. All the participants were required to have a valid driving license. The subjects were recruited using students enrolled in a course on research. Students in the course contacted with other students not in the course and brought them to the driving simulator facilities. The mean age of the students was 22 with a range of 19 to 27. They have had their driving licenses for an average of 3.22 years with a maximum of 8 years. 35 were female and 32 were male.

The subjects were in a healthy condition and they were encouraged to wear correcting lenses or equivalent if needed. None experienced severe symptoms of simulator sickness but in some cases described low levels of discomfort that were not sufficient to prevent them from going on with the experiment.

## Test Materials and Equipment

The high-fidelity driving simulator SIMUVEG (see Figure 1) was used for this experiment. This is a fixed platform simulator with three screens of a size 6x1, 5m, which guarantees that participants have their field of view completely covered under normal conditions. Three XGA projectors with 2000 lumens display 3D images in real time created using in-house developed software (8) running in a standard computer that is connected to a sensorized car - a Renault Twingo with sensors in the steering wheel, brake, throttle and so forth. The car features manual transmission, a rear view mirror and two side view mirrors. Finally, the audio system of the driving simulator reproduces 3D audio and Doppler effects.

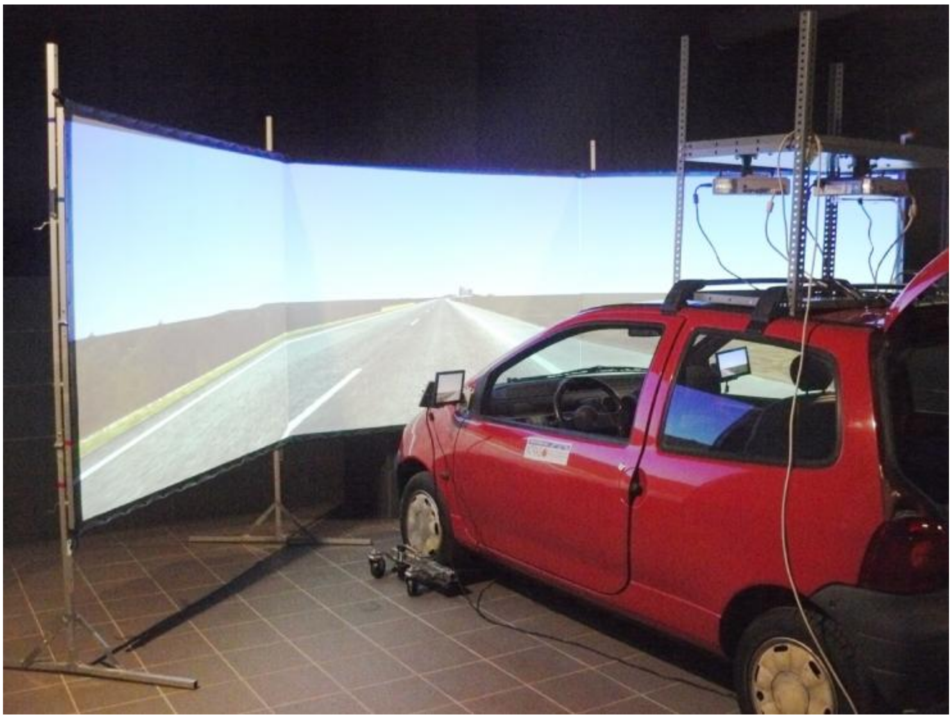

Figure 1 Driving Simulator SIMUVEG

There are two SIMUVEG scenarios, namely, a low traffic highway part designed to get the drivers acquainted with the basics of driving in the simulator, and a two-way rural road part with several traffic conflicts such as a truck stopped on the verge of the lane, a tailing car, curves, etc. The first part (4,5 km of 18 km) is regarded as training and is not included in our analysis. The training track takes place on the same rural road as the experimental track and, by driving through it, drivers get used to the operations of the car such as steering, braking, speeding, and so forth.

## Measurements

The measurements taken in this experiment were of three kinds: general questions about the subject, distraction and mindfulness self-rating scales and driving simulator performance measurements.

### *General questions*

The subjects answered questions about their experience and habits of driving. These questions will not be subjected to analysis in this paper, though.

- How many years have you been driving?
- Frequency of use of the car (1=almost every day; 2=some days per week; 3=some days per month)
- Kilometers per week
- Have you ever gotten a transit ticket? (1=No; 2=Yes, once; 3=Yes, more than once)
- Have you ever had any significant distraction when driving?
- Do you use your mobile telephone while driving?

### *Distraction and mindfulness scales*

The following scales were used for measuring distraction and mindfulness of the subjects in the study

- MAAS: The Mindful-Attention Awareness Scale (5) has 15 items that evaluate general awareness and attention to current events and experiences. All items are negatively worded (e.g., “I find it difficult to stay focused on what’s happening in the present”) and were reversed for the analysis. In this study, MASS items were answered based on a 5-point scale, from *almost never* (1) to *almost always* (5). Notice that we chose not to reverse the results in the scale as it is usually carried out in other studies, so the scores in our test reflects mindlessness rather than mindfulness.
- MAAS State: This scale takes five items from the MAAS scale that are evaluated respect to most immediate present. Thus differs from the MAAS in which this scale refers to what it happens in general to the respondent. We also did not reverse the scores in this test.
- ARDES: The Attention-Related Driving Errors Scale (2), was used to assess driving attention-related errors. This scale comprises 26 items referring to non-intentional driving errors, resulting, in whole or in part, from attentional failures. Participants were asked to read each item and indicate on a 5-point scale the frequency with which the described situations happened to them, ranging from *never or almost never* (1) to *always or almost always* (5).
- ARCES: The Attention- Related Cognitive Errors Scale (6) is a 12-item scale describing everyday performance failures arising directly or primarily from brief failures of sustained attention. As an example, an item states “I have absent-mindedly placed

things in unintended locations (e.g., putting milk in the pantry or sugar in the fridge)." Similar to ARDES, participant's task was to rate in a 5-point scale the frequency with which the described situations happened to them, ranging from *never or almost never* (1) to *always or almost always* (5).

### *Driving simulator performance*

Driving simulators offer a number of measures potentially useful for evaluating performance (9). In this case, *Speed* was chosen as measure of longitudinal control and a variant of *Time to Line Crossing* (TLC) (10) described below was used for evaluating lateral control. Notice that, in a driving simulator, measures are evaluated continuously providing several values per second. As the data analysis here carried out is at subject level, it is necessary to summarize the values in some way. This process of data reduction is described below:

- *Mean speed (MS):* In SIMUVEG this is evaluated as the average of maximum speeds computed every ten meters of driving. This value is very close but not equal to the simple average speed computed dividing the total distance driven by the total time used by each driver. It is assumed that low values in this measure are related to increased mental workload and that drivers often try to compensate increased workload by reducing speed (9).
- *Average of minimum TLCs (MTLC):* This measure is based in the TLC used for measuring lateral control. Thus, minimum TLC value is calculated every ten meters as an indicator of maximum risk of driving off road along them. Then, an average for all the maximum values is calculated per subject. High values in this variable can be interpreted as associated with good lateral control whereas low values would imply repeated episodes of bad lateral control.

## RESULTS

Descriptive results are shown in Table 1. Values are for 67 valid subjects. Notice the high value of asymmetry in the MTLC variable (2.391) and the moderate positive asymmetry values of the other variables.

| | Min | Max | Mean | Std. Dev. | Asymmetry |
|---|---|---|---|---|---|
| MAAS.ST | 6.00 | 19.00 | 10.98 | 3.12 | .90 |
| MAAS | 21.00 | 56.00 | 35.04 | 8.36 | .47 |
| ARCES | 16.00 | 50.00 | 28.14 | 7.83 | .50 |
| ARDES | 19.00 | 50.00 | 30.95 | 6.79 | .37 |
| MS | 61.17 | 105.69 | 82.05 | 9.68 | .70 |
| MTLC | 3.69 | 51.20 | 12.55 | 8.95 | 2.39 |

Table 1: Descriptive Statistics for the variables in the study

Pearson and Spearman correlations were calculated among the variables. Small differences probably due to slightly curvilinear relations between the variables were found between the two types of correlations so it was decided to report only ordinal correlations. These are shown in Table 2 with significant correlations flagged with asterisks (*<0.05;**<0.01). The pattern of the correlations is rather simple with self-rating scales related with mindfulness and distraction displaying strong correlations among them and performance measures showing moderate correlations (MS and MTLC) between them. The ARDES scores, on the other hand, correlated significantly with MS and MTLC, although these correlations were rather moderate. Finally, the ARCES score correlated significantly with MS−again, only moderately−but not with MTLC.

| | ARDES | ARCES | MAAS | MAAS.ES | MS | MTLC |
|---|---|---|---|---|---|---|
| ARDES | 1.00 | .597** | .523** | .468** | .253* | -.320** |
| ARCES | .597** | 1.00 | .617** | .524** | .241* | -.166 |
| MAAS | .523** | .617** | 1.00 | .740** | .165 | -.078 |
| MAAS.ST | .468** | .524** | .740** | 1.00 | .090 | .002 |
| MS | .253* | .241* | .165 | .090 | 1.00 | -.419** |
| MTLC | -.320** | -.166 | -.078 | .002 | -.419** | 1.00 |

Table 2: Spearman correlations among the variables in the study

## CONCLUSIONS

Indeed, the idea of applying mindfulness to driving is very appealing. Contrary to the usual discussion of negative factors for driving−distraction, cognitive workload, perceptual complexity−mindfulness offers instead a positive message: more focus on the present circumstances will reduce the negative factors and improve driving. This hypothesis is very attractive if we consider that, in principle, mindfulness can be trained so that we could improve drivers' behavior using meditation or in other ways. This hypothesis has been already advanced by Hanan et al. (2010) applied to driving and a similar claim has also been made in other areas. If mindfulness demonstrated its potential, we might have a very valuable tool for improving driving and consequently reducing accidents.

Unfortunately, these claims have not drawn much support from our studio. As can be seen in the results, the correlations between the MAAS scores, the usual way of measuring mindfulness, and the two measures of performance while driving were not significant, whereas a questionnaire specifically related with distraction while driving−ARDES-did. On the other hand, a more general distraction measure, one referring to everyday activities displayed correlation with one of the measures-MS, Mean Speed−but not the other−MTLC. Therefore, this suggests that the specific measures of distraction in driving have potential for predicting some general aspect of driving performance but the more general measures such as the ARCES have somewhat less potential. Finally, general measures of mindfulness, either as a trait or as a state, are not associated with this two indicators of performance.

Despite the previous conclusions, we do not think that the whole matter is been settled yet. The current study has several limitations that make the conclusions reached in it preliminary only and consequently they could be modified in the future. These limitations affect mainly to the measures of driving performance taken, the effects of training, the sample limitations and the different effects on groups. We will discuss these limitations below:

In this study, we chose only two general parameters of driving performance related in one case with longitudinal control (MS) and in other with lateral control (MTLC). Although these two parameters are essential for driving, how they are related with good driving is a matter open to discussion. Thus, with regard to speed, driving too fast or driving too slow may be both synonyms of bad driving, but it is unclear which the optimal value for speed is. This reasoning leads to consider non-linear relationships between the mindfulness and distraction measures and speed in a more detailed way than carried out here. Some hint of this type of relationship is evidenced in that ordinal correlations showed stronger effects than linear correlations suggesting a more complicated association between the variables than the one hypothesize here. Regarding MTLC, given the correlation found with MS, there is the possibility that its correlation is partially dependent of MS and consequently a model including it would be of interest.

Additionally, these two measures are both general measures of driving whereas it is arguable that the concepts here discussed are only of relevance in specific situations where the attention or focus in the present may make more difference. In short, avoidance of obstacles, as mentioned by (1) is another key component of driving, and we have simply not considered it here. Therefore, measures such as reaction to hazards or to conditions that require monitoring such as changes in speed limits would be more sensitive than the ones used here. Including subtasks as part of the experimental situation such as responding to a phone call or paying attention to an in-vehicle information system (11, 12) might be of interest here.

Also, in this study we have only measured the level of mindfulness and distraction of drivers and we have correlated it with the indicators. It would be also important to check if manipulation of these levels via training the drivers in mindfulness or perhaps in techniques for avoiding distraction would have an impact on performance. The results shown here hints that focusing on things that produce distraction during driving is possibly useful but this should have to be tested with a specific study.

Still, another limitation of this is that we used a convenience sample composed mainly of young people representative of the general population of drivers. It is possible that the effects here explored are not sufficiently strong to be shown with this sample but special groups such as drivers with a history of accidents, or cognitive or health problems (13) might benefit of compensating their deficits.

Finally, as usual with driving simulator studies, it is convenient to remark that findings in simulators must be confirmed using real life studies. In this case, naturalistic driving (14) might provide an ideal framework for studying this issue in combination with the methodology used here.

## References

1. Noy I, Karwowski W. Motor vehicle safety. International Encyclopedia of Ergonomics and Human Factors. 2001:1537-41.

2. Ledesma RD, Montes SA, Poó FM, López-Ramón MF. Individual differences in driver inattention: The attention-related driving errors scale. Traffic injury prevention. 2010;11(2):142-50.

3. Keng S, Smoski MJ, Robins CJ. Effects of mindfulness on psychological health: A review of empirical studies. Clin Psychol Rev. 2011;31(6):1041-56.

4. Abdul Hanan S, King MJ, Lewis IM. Are you a mindful driver? A review of the potential explanatory value of mindfulness in predicting speeding behaviour. Proceedings of 2010 australasian road safety research, policing and education conference; The Road Safety Research, Policing and Education Conference; 2010.

5. Brown KW, Ryan RM. The benefits of being present: Mindfulness and its role in psychological well-being. J Pers Soc Psychol. 2003;84(4):822.

6. Cheyne JA, Carriere JS, Smilek D. Absent-mindedness: Lapses of conscious awareness and everyday cognitive failures. Conscious Cogn. 2006;15(3):578-92.

7. Sánchez M, Valero-Mora P, Pareja I. Interfaz de usuario en el desarrollo de un simulador de conducción.

8. Sánchez M, Valero-Mora P, Coma I, Pareja I, Rueda S, Sanmartín J. Construcción de escenarios de conducción para el sistema informática de evaluación interactiva de conductores por medio de simulación (EVICA): La realidad no es siempre un buen modelo para la construcción de simuladores. 1999; León. ; 1999.

9. ISO. Road vehicles- ergonomics aspects of transport information and control systems- procedure for assessing suitability for use while driving. Geneve: ISO; 2003.

10. Van Winsum W, Brookhuis KA, De Waard D. A comparison of different ways to approximate time-to-line crossing (TLC) during car driving. Accident Analysis and Prevention. 2000;32(1):47-56.

11. Valero-Mora PM, Stevens A. Human-centred design and assessment of information technologies in traffic. IET Intelligent Transport Systems. 2013;7(2):171-3.

12. Valero-Mora PV, Tarín MB, Tontsch A, Montoro IP, García MS. Effects of manually entering navigator destinations while driving in a simulator. IET Intelligent Transport Systems. 2012;6(4):397-403.

13. Felipo V, Urios A, Valero-Mora P, Sánchez M, Serra MA, Pareja I, et al. Serum nitrotyrosine and psychometric tests as indicators of impaired fitness to drive in cirrhotic patients with minimal hepatic encephalopathy. Liver international. 2013;33(10):1478-89.

14. Valero-Mora PM, Tontsch A, Welsh R, Morris A, Reed S, Touliou K, et al. Is naturalistic driving research possible with highly instrumented cars? lessons learnt in three research centres. Accident Analysis & Prevention(0).