

Protocol for Transferability of Driver Simulator Results to Real Traffic Conditions

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ABSTRACT

The current manuscript presents the research protocol that has been developed in order to enable the valid transferability of driver simulator results in real traffic conditions. It responds to the weaknesses that have been recognised in the driving simulator validity research field, with respect to the validity of the experimental process being followed as well as to the methodology applied for the comparative analysis of the collected measurements. A case study concerning a semi-dynamic driving simulator is presented. The research hypotheses, the experimental plan and the basic conditions of the analysis methodology that have supported it are described. Trials have been conducted in a semi-dynamic simulator and on-road with 36 drivers (12 trainees, 12 novice and 12 experienced), in "following vehicle" and "free driving" scenarios in highway, rural and urban roads in order to prove the established research hypotheses for a series of driving behaviour metrics.

Keywords: Conversion Matrix, Driving Simulator, Experimental Plan, Simulator Validity, Transferability of Driving Simulator Results

INTRODUCTION

Given the multiple benefits of driving simulation and its use in different application areas, from driver training and driving skills assessment to iterative design and evaluation of Advanced Driver Assistance Systems (ADAS), the popularity of driving simulators has increased excessively over the last decade. As a matter of fact that, besides the unquestionable flexibility in terms of use and the elimination of safety risk for the drivers in all application fields, its use implies significant saving of resources,

in terms of effort and cost. However, prior to and for any potential use, it is important to be aware of the adequacy of the driving simulator, in terms of reliability of the emerging results, where reliability counts for closeness to reality. *Fidelity* (or *physical validity*) and *behavioural validity* have been recognised from a series of researchers to be the most important criteria for driver simulators' adequacy (Blaauw, 1982; Jamson, 1999), with *behavioural validity* being considered even more important. There are several reasons having led to this conclusion, the most important of which are as follows:

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- Despite the technological evolution of the last decades, it has not yet been defied which is the motion system which would best fulfill the requirements of a realistic driving simulator (Pelchat et al., 2006).
- Notwithstanding the technical fidelity of a driving simulator is influencing its behavioural validity (Riener, 2010) it has been proved that, regardless from the technical fidelity of a simulator, if its behavioural validity is not equally high, then it is not useful for driver behavioural studies. Fairly frequently, a driving simulator of high fidelity-and, usually, of high cost may be equally reliable to a less expensive simulator (Triggs, 1996).
- Overall, high cost and fidelity simulators may often lead to the opposite results, especially in the education field, since: i) their cost may be forbidding for the wide use in this field, ii) they require specifically trained personnel for their use and maintenance-usually not present in driver training schools, iii) they require quite an investment in resources for the development of new scenarios and quite a space for their installation, whereas, the most important, iv) the existence of many and sequential motions, especially when this is conducted composite articulated mechanisms (“legs”), often leads to a deregulation that may provoke simulator sickness, which cannot be easily dealt with (Bekiaris et al., 2007).
- Last but not least, as noted by Kecklund et al. (2007), it would be worthless for someone to investigate the fidelity of the driving simulator as a technical means itself, as its reliability is anyway associated with the specific research hypothesis. This is why several years ago, Kaptein et al. (1995) supported that, prior to any use of a driving simulator, it should be investigated if it is sufficiently reliable for the specific hypothesis/context whereby it is under research. It could be, for example, that deviation from the reality, from the

technical point of view, may lead to more realistic performance for a specific research context.

Absolute and relative validity of driving simulators are the most common types of behavioural validity. A driving simulator has absolute validity with regard to a research question if the absolute size of the effect in simulation is comparable to the absolute size of the effect in reality, whereas relative validity occurs when the direction or relative size of the measure is the same as in reality (Kaptein et al., 1995).

Research on simulator validity is recorded since the mid of 90’s until nowadays (Blana, 1996; Godley et al., 2002; Blana and Golias, 2002; Lee, 2003; Hirata et al., 2007, De Winter et al., 2009; Riener 2010). In each of the relevant studies, comparative trials were realised in simulator and on-road. In their context, several driver behaviour metrics and road safety measures in various road contexts and driving tasks/scenarios were evaluated.

In most cases, relative validity has been proved, but this was not necessarily the case for absolute validity. The problem is that while the unproved absolute validity might not be a hinder for cases where the tendency and the effect size of the results may matter the most (i.e. when the comparative impact of road safety measures is under investigation), there are cases that numerical proximity is critical, such as in the cases that the warning or intervention thresholds of an ADAS need to be determined.

Nevertheless, even in those cases where any type of validity was proved, the specificity and the variation of the different outcomes reveal the weakness in translating them with consistency with respect to real traffic conditions as well as their strong dependency to the specific research hypotheses. This prevents from applying a common and independent interpretation of driver simulator results with respect to reality and necessitates the investigation of the validity (of any type) of each driver simulator, prior to any experiment, every time adjusted to

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