THE VALIDITY OF SIMULATORS IN STUDYING DRIVING BEHAVIOURS

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INTRODUCTION

Driver simulators provide safe conditions to assess driver behaviour and provide controlled and repeatable environments for study [1]. They are a promising research tool in terms of both providing safety and experimentally well controlled environments. There are wide ranges of driver simulators, from laptops to advanced technologies which are controlled by several computers in a real car mounted on platforms with six degrees of freedom of movement. Simulators can be classified into three levels; low, medium and high fidelity [2]. In addition, the cost of simulators significantly varies.

The **applicability of simulator-based research** in a particular study needs to be considered before starting the study, to determine whether the use of a simulator is actually appropriate for the research. Given the wide range of driver simulators and their uses, it is important to know beforehand how closely the results from a driver simulator match results found in the real word. Comparison between drivers' performance under real road conditions and in particular simulators is a fundamental part of validation [4]. It should be noted that even the **most advanced simulators,** which provide the most realistic driving environments possible, **are not able to make an exact copy of the real world** [1], however **the important question is whether the results obtained in a simulator mirror real world results.**

Validity "refer[s] to the degree that the simulator evokes the same behavior as would be shown in reality under similar circumstances" [2]. Broadly, two kinds of validity can be defined: **absolute validity** is demonstrated "if the absolute size of the effect is comparable to the absolute size of the effect in reality"; **relative validity** is demonstrated "if … the direction or relative size of effect of the measure is the same as in reality" [2]. The following review presents the results of the most recently conducted research into absolute and relative validity of simulators when used to study behaviour.

VALIDITY OF SIMULATORS

A diverse range of studies that used simulators to research driving behaviour was reviewed. **It was found that although simulators demonstrated relative validity in most studies, absolute validity could not be confirmed**. It is believed that **validity of driver simulators is task dependent** [2], so the synopsis of the review is structured according to six categories as follows:

Speed: validity studies on speed received the most attention. Among speed validity studies, **a majority found relative validity** for simulators [5-7]. The main reason for lack of validity was **low risk perception** in simulators. Only McAvoy, Schattler, & Datta [8] found absolute validity for their portable moving base driving simulator.

Author(s)	*Type of validity*	*Type of simulator*	*Reason for lack of validity*
Bella (2008)	Relative	Fixed-base	Low risk perception in simulator; Low physical fidelity
McAvoy, Schattler, & Datta (2007)	No validity	Fixed-base	Low risk perception in simulator
Hirata, Yai & Takagawa (2007)	Absolute	Portable motion base (2 degree)	N/A
Godley, Triggs, & Fildes (2002)	Relative	Motion base	Inconsistencies between the two experiments; Practice effect
Törnros (1998)	Relative	Motion base	Lack of good peripheral speed information; Lack of experience in tunnel driving; Driving repetition in simulator
Reed & Green (1999)	Absolute Relative (with cell phone)	Fixed- base	Not mentioned

Driving errors: Shechtman, et al.[1] investigated the number and type of driving errors when participants negotiated a right and a left turn in a high-fidelity driving simulator and on the road. **Relative validity** of the simulator was found for several types of driving error.

Cognitive and visual performance: Santos, et al. [9] stated simulators and field studies are better approaches to finding differences among various levels of visual searches than instrumented vehicles. **Relative rather than absolute validity** has been demonstrated in this area. Bédard, et al. [10] used neuropsychological testing. They found a relationship, but not absolute, between the simulator data and neuropsychological tests which forecast crashes and safe driving.

Ying Wang, et al. [11] concluded from their study that visual attention and task response time measures can be obtained with a medium fidelity simulation in a safe and effective way.

Author(s)	*Measurement*	*Simulator applicability*	*Type of simulator*
Santos, et al. (2005)	Visual searches	Good approach	Fixed-base
Bédard, et al. (2010)	Attention and perception processes	Relationship	Not mentioned (probably fixed-base)
Ying Wang, et al. (2010)	Visual attention and task response time	Safe and effective	Fixed-base simulator

Reaction time and braking behaviour: Evidence of **both absolute and relative validity** has been found. In a comparative study between a simulator and test track studies, primary reaction time was statistically equivalent in both studies [12]. The results of an NHTSA study [13] showed that the braking instructions affected drivers less in the Iowa Driving Simulator than on a test track, illustrating a weak validity.

Driving test results: De Winter, et al. [14] investigated relationships between driving simulator performance and driving test results. They concluded that driver simulator performance may present feedback similar to a real road outputs, suggesting **relative validity.**

Highway geometric designs: In highway geometric designs **relative validity** occurs more often with simulators than absolute validity. Generally speaking, "in many cases, relative validity is sufficient to give useful direction to highway and traffic engineers" [3]. In most roadway design studies, medium-fidelity simulators were cost effective [3].

DISCUSSION AND CONCLUSION

Driving simulators provide safe environments for assessing diverse driver issues, and enable controlled and repeatable research. However, applicability of simulators in a particular study requires consideration before starting. In other words, **it is important to know whether a particular simulator is appropriate for a study of a certain driving task, and validity is a key concern in this respect.** The review of validity studies indicates that **relative validity is attainable in most cases,** and absolute validity in some. **If a task has some degree of risk in the real world, validity is lower because driving in a simulator has no equivalent degree of risk.** The role of physical fidelity is more complex.

If **a task requires more physical fidelity** to replicate a real world feeling for drivers, it seems that **more advanced simulator characteristics are needed**; however, due to fidelity limitations in many simulator studies, the question of their applicability remains open [16]. Although numerous studies have used simulators, to date there has been little research which categorises **whether various kinds of simulators, with their unique characteristics, are suitable to the research questions/tasks.** Moreover, to date **no validity studies have been conducted for driving while fatigued, driving while distracted, drink driving and drug driving,** although many simulator studies have been reported on these issues. Because field and instrumented car studies for these dangerous behaviours cannot conducted in real environments for moral and ethical reasons**, it is important to find alternative ways of investigating the validity of simulators.**

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