Instruction-prompted objective behaviors as proxy for subjective measures in a driving simulator

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A B S T R A C T

Interactions with other road users and interpretations of traffic situations are important aspects of driving safety. Self-reports are often used to study drivers' perceptions and attitudes but self-reports can be inaccurate and biased because of socially desirable responding. Driving simulators offer objective measures of driver behaviors but have limited ability to elicit natural behaviors. To address this issue, we tested a driving simulator-based approach that combined realistic driving scenarios including potentially frustrating forward obstacles and delays in travel time with two different types of instructions. Participants' vehicle control behaviors and subjective perception of traffic delays were compared. Results demonstrated that behaviors collected following instructions to drive safely did not have significant associations with participants' perceptions of the traffic delays while participants following instructions to drive quickly demonstrated behaviors that were predictive of their subjective perceptions of the traffic delays. The findings suggest that vehicle control behaviors can be used as a proxy for subjective perceptions of traffic delays. We conclude that driving simulator methodology combining instructions, realistic traffic scenarios, and adaptive analytical methods is appropriate for studying drivers' behaviors and interactions with other road users and can minimize the need to rely on subjective self-reports.

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1. Introduction

Drivers' attitudes, perceptions, and experiences are typically studied by self-report questionnaires and interviews. Self-reports, however, are not always accurate, due to individual differences in reporting bias and memory difficulties. A recent study showed that drivers' self-reports about their violations and crashes are largely unreliable (af Wåhlberg & Dorn, 2015). Self-reports can also be biased because some participants might engage in socially desirable responding (SDR), that is, a tendency to give answers that make the respondent look good (Nederhof, 1985; Paulhus & Reid, 1991). When using self-reports in studying personality and motivational factors of traffic behaviors, SDR may cause serious biases and lead to inaccurate conclusions (Lajunen, Corry, Summala, & Hartley, 1997).

The magnitude of bias due to self-reports may be mitigated by using a combination of objective observations and subjective self-reports (af Wåhlberg & Dorn, 2015). However, the extent to which the collected objective observations from a driving simulator reflect drivers' normal or typical tendencies are unclear. Indeed, an on-going debate in the research community

about the similarities of observations collected in a driving simulator and in the real-world suggests that the perceptual cues in the virtual driving scene (Kemeny & Panerai, 2003; Mestre, 2016) and the fidelity of the simulator (Yan, Abdel-Aty, Radwan, Wang, & Chilakapati, 2008) are critical factors in comparing lab-based performance and on-road behaviors (De Winter, Van Leuween, & Happee, 2012; Evans, 2004).

One major drawback in using driving simulators in research is the artificial environment – no matter how realistic or representative the virtual driving scene and the driver's seat look and feel, drivers in a fixed-base simulator do not physically move forward, do not sustain real consequences of actions (e.g., a collision) and their perceptions of the virtual scenes may be distorted as a result of presenting a three-dimensional world on a two-dimensional space (Evans, 2004; Reed & Green, 1999). Therefore, the collected observations may have limited scalability given the simulator environment and experimental manipulations (Wickens, Lee, Liu, & Gordon-Becker, 2004). Whereas observations collected in a naturalistic driving environment, such as a participant's own car, are considered behaviors that include drivers' natural tendencies and habits.

We proposed a new methodology to allow collection of more naturalistic driving behaviors in a driving simulator setting, including examination of both objective behaviors and subjective perceptions via self-reports. Primarily, we sought to compare the use of two instructions – one emphasizing driving safely and one emphasizing driving quickly – on the differences in drivers' perceptions and interpretations of virtual driving scenes. In our earlier work we asked participants to "drive as they normally would" in the driving simulator (Lee, Lee, & Boyle, 2009). We hypothesized that if we provided an instruction that allowed participants to react more naturalistically in a simulator context, the behaviors would more closely represent participant's habitual tendencies, despite being in a lab setting. A pilot study using this instructional approach (Lee, 2010) showed some promise: a count-down clock displayed on the simulator screen and a time-pressure manipulation led to more instances of speeding and missing of visual targets. For our first application of this method, we chose to examine driver aggression because of its sensitivity to drivers' perceptions and interpretations and its safety implications. Our preliminary results (Lee & LaVoie, 2014) showed that the instructional approach led to significant relationships between objective and subjective measurements in the presence of forward obstacles (e.g., drivers who felt more strongly about the resulting traffic delays tried to make up the lost time by driving more quickly). The current paper is focused on additional analyses on the relationships between objective driving data and subjective perceptions of traffic delays in the context of aggressive vehicle handling.

The National Highway Traffic Safety Administration has identified aggressive driving as one of the top priorities for behavioral correction. Aggressive driving behaviors include abrupt and aggressive vehicle handling, honking, cutting across multiple lanes, speeding, and tailgating (Galovski & Blanchard, 2004; Shinar & Compton, 2004; Stephens & Ohtsuka, 2014). Factors such as personality variables (Lajunen & Parker, 2001) and driving environment conditions (Shinar & Compton, 2004) contribute to aggressive driving behaviors. Drivers who are in a hurry tend to report a higher level of frustration and impatience with other drivers (Beck, Daughters, & Ali, 2013). Driving during rush hours and in demanding situations, such as high speed roads, also tend to trigger more aggressive driving (Paleti, Eluru, & Bhat, 2010). In addition, driver's interactions with other road users and interpretations of other road users' behaviors play a role in regulating the amount of anger and aggression a driver has (Stephens & Groeger, 2014). These findings suggest that in a driving context, social interactions with other road users and driving environments are both important motivations behind aggressive driving. Drivers who report committing aggression or being a victim of aggression have a significantly higher risk of collision involvement than do those without aggression involvement (Mann et al., 2007). Prevalence of aggressive driving perpetration is highest for drivers aged 18–34 (51%) and decreases with age (37% among drivers aged 35–54 and 18% among drivers over 55). The same decreasing with age pattern is found for victims of aggressive driving (54%, 47%, and 31%, for each age group, respectively) (Wickens, Mann, Stoduto, Ialomiteanu, & Smart, 2011), indicating the effect of age on the likelihood of aggressive driving behaviors, with the most aggressive drivers being younger than 35 years old (Shinar & Compton, 2004).

In the current study, we hypothesized that there would be differences in objective observations and subjective ratings following the two experimental instructions: in the context of aggressive driver behaviors during encounters with other road users, the instruction that emphasized driving quickly would lead to more variability in vehicle control and larger magnitude of reactions when compared with the instruction that emphasized driving safely. Our method used a driving simulator with programmed driving events for collecting observable vehicle control behaviors during the drive as well as subjective responses (e.g., level of perceived impact of traffic delays and whether traffic delays were due to other drivers' bad intentions) following the drive. This combination of objective and subjective data was expected to overcome the shortfalls of relying entirely on self-reports and provide insights on the degree to which the instructions led to different observations. Additionally, we hypothesized that younger drivers (<35 years of age) would show more aggressive vehicle control behaviors than more experienced drivers (between 36 and 65 years of age).

2. Method

2.1. Participants

Thirty participants (22 females and 8 males) took part in the study. Eighteen were in the younger group (between the ages of 20 and 35, $M = 27.83$, $SD = 4.19$) and 12 were in the older group (between the ages of 36 and 65, $M = 47.42$, $SD = 9.14$). The older group had significantly more years of driving experience, $F(1, 22) = 24.78$, $p < .0001$ ($M = 10.23$, $SD = 3.41$