Driving Together Across Vehicle: Effects of Driver/Co-Driver Pairs

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ABSTRACT

Most research on vehicle-to-vehicle (V2V) communication is technology-driven, or focused on driver-to-driver interaction. Social communication between drivers and passengers across vehicles, with the same destination, is often neglected. Communication is influenced by context and occupant behavior, and has a significant effect on the collaborative driving scenario. An exploratory in-situ study with seven groups of two driver/co-driver pairs each, located in two separate vehicles, was conducted. On a predefined route, different subtasks had to be solved in a collaborative way. The study revealed a significant influence of different social factors, such as driving behavior, and contextual factors such as weather conditions, or vehicle shape and size. Findings delivered important insights and a deeper understanding on collaborative driving that may influence future V2V communication technologies. Additionally, the collaborative driving behavior of the driver/co-driver pairs could be transferred to a multi-agent framework.

KEYWORDS
ADAS, Collaborative Driving, Communication, Cooperative Intelligent Transport Systems, In-Situ Study, LMSNS, Social Interaction, V2V Technology

INTRODUCTION

According to the NHTSA study of connected vehicle technology, Vehicle-to-Vehicle (V2V) communication has the potential to reduce crashes by up to 80 percent (NHTSA, 2014). Especially, Locative Mobile Social Network Systems (LMSNS) are becoming popular, enabling to connect and locate other road users (De Souza, 2010). However, most research is technology-driven, enabling cars to talk to each other, and does not take a fundamental view inside the nature of collaborative driving.

Interactions with other road users are an essential element of the driving activity, mostly negotiating on how to share a common section of a road (Rokotonirainy, Schroeter & Soro, 2014). These negotiations are often limited through the bandwidth of the communication channel and the connectivity between drivers. Although there exist pre-set traffic rules that apply to all road users, additional communication and interactions are necessary to make their intentions clear and to avoid accidents. In addition to the driving behavior itself, drivers often use lights or horns in order to exchange information, both being very limited in bandwidth. Therefore, this can lead to misunderstandings or conflicts, which potentially cause stress and extreme emotional responses such as aggressive driving behavior (Renner & Johannson, 2006; DCPC, 2005). For instance, an impatient driver activates...
the flash light on the highway to force vehicle in front to move to the first lane, which is normally perceived as aggressive by him/her.

Lamas et al. (2014) stated that the usage of innovate communication technologies may address exactly the problem of limited communication channels between different vehicles. Considering the information exchange and the technology readiness level of current V2V technologies, the front-seat passenger could be an intermediate facilitator in order to communicate with the other vehicle until those systems may take over in an automated driving environment.

Compared to the driver/co-driver communication and collaboration inside the vehicle, which is predominantly verbal and face-to-face, the interaction between driver/co-driver pairs across vehicles has specific communication attributes and challenges (Lamas et al., 2014). First, after closing a door of the car, “people are encapsulated in a domestic, cocooned, moving capsule, an iron bubble” (Urry, 2007, p. 120). Therefore, communication partners of different vehicles experience a spatial separation and physical barrier (Wang, 2017). Second, successful communication and collaboration is also constrained by the speed of the two vehicles and their relative position. Often drivers do not have much time to transmit their messages because the vehicles are travelling at high speed (Lamas et al., 2014). Third, drivers have to cope with the lack of visual information. Facial expressions and gestures are hard to recognize at night (Lamas et al., 2014). Fourth, being constrained in front of the steering wheel and interacting with non-human like machines on the road, drivers are detached from their environment and social society. As a result, their feelings of belongingness (Satici, Uysal & Deniz, 2016) are decreased. These and other aspects can make it difficult to verify the precise intent of another driver/co-driver pair as well to communicate with each other.

Previous research focused mainly on driver-to-driver scenarios as well as communication between drivers and front-seat passengers inside the vehicle (e.g., Forlizzi, Barley & Seder, 2010; Brown & Laurier, 2012; Cicil, Perry, Laurier & Taylor, 2013; Perterer, Sundström, Meschtscherjakov, Wilfinger & Tscheligi, 2013; Antrobus, Burnett & Skrypchuk, 2016). The present work departs from these studies aiming to investigate how driver/co-driver pairs, who are located in two separate vehicles, interact and communicate with each other during a shared ride. When a group of people decides to go on holiday together, they often go with more than one vehicle, for example due to, space limitations or to have independence at the holiday destination. These and similar situations have in common that multiple vehicles are driving in one direction, mostly in a convoy.

The communication can be supported through smartphone, i.e., making phone calls or sending messages. The assumption is that this kind of information is not enough, and the rich environment of the vehicle such as sensors or Advanced Driver Assistance Systems (ADAS) could be used for collaboration. Therefore, an exploratory in-situ study with seven groups of driver/co-driver pairs was conducted. Each group had to reach a specific destination by driving collaboratively and in direct sight (if possible) on a predefined route. During the trip participants faced different tasks that facilitated communication and collaboration.

The paper is structured as follows: First, previous research on collaboration and communication as well as current V2V technologies will be described, followed by the presentation of the study setup. Afterwards, the work discusses the obtained results in terms of verbal/non-verbal channels, coping strategies as well as social and context factors that influence collaborative driving. Then, the paper shows how the identified results could be used for human-based augmentation, shape changing approaches, and location and distance information for collaborative driving. Seeing the driver and the co-driver as well as the car itself through the lens of agents, the paper inspires a way to extend the compensation model for mixed traffic scenarios as well as to allow to transfer to a multi-agent framework.
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