ABSTRACT TITLE:

Meaningful Human Control over Automated Driving Systems: Consequences for Driver Training and Driver Testing

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Introduction

Automation is rapidly becoming part of even the most common technological solutions. A wide range of ordinary devices, from cars to smartphones, are receiving a certain degree of intelligence and, as a result, autonomy. Intelligent systems have the ability to plan and take up actions autonomously. In the automotive world, the employment of automated solutions can hide the extent to which a human controller is involved in a certain system's behaviour and conceal the exact relation that links the controller to their automation-assisted action. Undesirable and unpredictable behavior can emerge from a user giving up part of the control *over* the system *to* the system itself. This could jeopardize safety as well result in accountability gaps. These latter are situations where the behavior of the system leads to unwanted outcomes or possibly fatal accidents, but it is unclear whether any human agent can legitimately be deemed accountable for them. Therefore, it has been suggested that drivers should at all times display *meaningful human control* (MHC) over their automated vehicles. This means that drivers should be both fully concious of their responsibility as controllers and fully capable to understand and operate the system.

Aim

"Meaningful human control" has been identified as key for the responsible design of autonomous systems operating in circumstances where human life is in danger. By preserving meaningful human control human safety can be better guaranteed and "accountability gaps" can be averted. However, there is still no satisfactory theory of what meaningful human control exactly means with respect to Advanced Driving Systems (ADS).
Based on the results of this study, designers, manufacturers and road authorities will be provided with recommendations for developing automated systems that achieve meaningful human control. Driver training organizations and driving licensing bodies will receive recommendations for new procedures in training and testing.

Behavioral dimension of MHC

The methodology of "value-sensitive design" is used by an interdisciplinary team of philosophers, traffic engineers and behavioural scientists, working towards a definition of meaningful human control over ADS, which embraces its conceptual, technical and behavioural dimensions.
The *behavioural* dimension of MHC explores the human role within ADS, and its relation towards MHC. From a human perspective, controlling an (automated) vehicle requires skill-

based (effortless task execution), rule-based (remembering how to act for a specific situation), as well as knowledge-based (use of past experience and general knowledge) behavior. With automated driving, many (if not all) of these behaviours will be taken over by the ADS. On the other hand, drivers of those vehicles need to learn new skills, such as driving (interacting) with ADS, and taking on a supervisory role. The behavioural research is conducted by looking at what effects the levels of automation, as defined by the SAE, have on human behaviour, quantifying the number of tasks added or taken over by the ADS, depending on its level of automation. Table 1 is an indication of how the result of this study could look like.

Table 1. Number (#) and type of tasks required for different SAE levels.

	SAE 0	*SAE 1*	*SAE 2*	*SAE 3*	*SAE 4*	*SAE 5*
Skills	#	#	#	#	#	#
Rules	#	#	#	#	#	#
Experience	#	#	#	#	#	#

Relevance of MHC for driver training and driver testing

Understanding the effect the transition of control has on the human driver plays, is significant to establish how to maintain ADS under meaningful human control. This can be achieved by distiguishing what skills, rules and knowledge is being taken over by ADS. Unexpected or unprecedented shifts in the remaining tasks for a human driver during higher levels of automation could prove disastrous for the human driver's ability to act as a fall-back in case of emergency. Given the core components involved with manual driving, from a human perspective, mirrored against how much influence they still have during (fully) automated driving, calls for an overhaul of the current transition of control over the various levels of automation. Moreover, the fact that a driver gets introduced into the unknown role of a supervisor, necessitates that the need for skilled behavior is increasingly replaced by the demand for knowledge-based behavior.

Driving licensing bodies and driver training organizations should step into this caveat, addressing the now unfamiliar situations, incorporating those into driver training and driver testing in order to allow future drivers to have the appropriate amount of skills to meaningfully control Automated Driving Systems.

References

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