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A practitioner's view of driver training for automated driving from driving examiners: A focus group discussion*

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Abstract—**As automated vehicles become increasingly common on the road, the call for an appropriate preparation for its drivers is becoming more urgent. Expert opinions and insights have been acquired via a focus group discussion with eleven Dutch driving examiners to assist in inventorying what types of preparations are needed. The concept of meaningful human control (MHC) as an integral part of the discussion lead to consensual findings regarding ADAS functionality and the drivers' tasks, as well as discussion topics on driver training and levels of automation. It was concluded to have more research into human factors to safeguard proper control over automated vehicles.**

I. Introduction

With the existence of automated vehicles (AV) on the road today, and the imminently expected expansion to higher levels of automated vehicles, questions are being raised regarding the capabilities of drivers to safely interact with these vehicles (e.g., [1], [2], [3]) and of their knowledge of the vehicles' driving systems (e.g., [4], [5], [6]). There is increasing evidence that drivers are not well prepared to perform the tasks that are demanded of them in AVs, such as proper monitoring [7], retaking control [8], understanding the vehicle limitations [9], et cetera. In other sectors where automation and human interact in a critical environment, human training is seen as crucial; the aviation industry is a prime example, with pilots undertaking rigorous training to interact with a semi-automated system that arguably operates in a simpler environment to that of road vehicles [10]. To counteract potential shortcomings of driver deficiencies, driver training is seen as an important part of preparing drivers for AVs.

Current practice does not require a driver to have any knowledge of AV functionality, while AV purchase processes have a limited knowledge transfer regarding the systems, and there appears to be a lack of interest thereof (see e.g., [11], where Table 2-1 presents an overview of all related customer opinions and concerns, yet none about functionality understanding). For example, Sportillo, Paljic, and Ojeda [12] have actively stated that proper driver training for AVs is essential for safe interaction and maintaining and acquiring the appropriate skills. Even though this has been called for several years now, also in relation to licensing (see e.g., [13], [14], [15]), currently, only a handful of private driver training companies offer this kind of training.

Driver training must also account for driver capability and apportion of fair moral responsibility. Meaningful Human Control (MHC) is a concept that is constructed to ensure that this is catered for. The notion of MHC, originated in the debate about autonomous weapon systems [16], [17], has been recently adapted to encompass all kinds of intelligent machines, such as surgical robots [18] and autonomous vehicles [19]. MHC investigates the requirements that both human controllers and controlled systems have to meet to preserve clear human accountability and a rightful attribution of moral responsibility.

To aid preparations for improved driver training development and to gain insights into how current learner drivers may react to automated systems, we have focussed on gaining insights from a vastly experienced group who are at the heart of driver training, namely the driving examiners. In this paper, we report on a driving examiner focus group discussion that was set up to gain insights into how the concept of MHC could be applied to automated driving systems in general. In this paper, we adhere to the definition of MHC as posed in [19], but due to the highly scientific nature of this definition, a more general explanation of its concepts was presented at the focus group members, to allow for a smoother and more fruitful discussion. Its aim is to be able to provide useful recommendations to the authorities responsible for driver training as well as to, for instance, policy makers. The main findings and resulting recommendations from the session are given in this paper. In Section 2, we describe the method applied to conduct the session. In Section 3, we present the main findings of the discussion, while in Section 4 these are discussed, and recommendations based on the findings are given.

II. Method

A focus group discussion [20], [21] was planned to discuss the topic of meaningful human control over automated driving systems. The goal of this discussion was to gain expert opinions and insights into how meaningful human control could be applied to automated driving systems from people in the field. For this, several questions were prepared that concern relevant topics regarding both the concept of meaningful human control (a.o., tracking and tracing) and automated driving systems (a.o., transition of control, SAE levels of automation [22], and the framework of [5]). The target group was determined to be people who actively teach how to drive a vehicle as being part of their day-to-day job, since those people are considered to be experts in safeguarding human control over a vehicle. Therefore, eleven driving examiners from the Netherlands were recruited through the Dutch *Centraal Bureau voor Rijvaardigheidsbewijzen* (CBR) to participate in a focus group discussion on this particular topic.

Prior to the focus group discussion, an invitational letter was sent round to recruit and inform willing participants on the topic of the evening (see Appendix A; in Dutch). The focus group discussion was arranged to be in a central

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location in the Netherlands, to achieve an as balanced representation of the Dutch driving examiner pool as possible. The focus group discussion lasted approximately two hours.

On the day of the focus group discussion, September 11th 2018, the examiners were welcomed, and given a brief introduction on the MHC project and the concept of MHC in general, to allow for a focused discussion on the topics of interest. A semi-structured interview was prepared to maintain pace in the discussion, but was minimally required during the focus group discussion. Example questions were: "What transition of control would allow for MHC?" and "What would/should be the main dimension of such a transition of control?". To get the discussion started, the first question was posed. Throughout the focus group discussion, the driving examiners were encouraged to engage in debate with both the researcher and each other.

From the discussion, minutes were taken that were used to determine which topics reached consensual conclusions, as well as which topics provided a distinguishable amount of discussion among the focus group members. The results (i.e., opinions of the focus group members) were then narrated and positioned into a scientific context, and consequentially translated into conclusions.

III. Focus Group Interaction

A. Topics of consensus

The focus group discussion provided several insights that reached consensus among the driving examiners regarding the introduction of automated driving systems, and how to deal with those in terms of training and driving with it. Their practical experience with driving in general, human behaviour during training and skills for driving, and with driving with a variety of automated driving systems contributed to an in-depth and expert insight into how we could and should drive with automated driving systems.

The following sections elaborate on the topics that reached consensual results between the focus group members, meaning that all members agreed unanimously on the given topic. Section 3.1.1 describes their concerns regarding the introduction of advanced driver assistance systems (ADAS), section 3.1.2 covers key components for automated driving systems, section 3.1.3 discusses the phenomenon of automation surprise, and section 3.1.4 questions the viability of monitoring of an automated system.

1) The introduction of ADAS

The first topic of discussion, as mentioned above, is the introduction of ADAS, which elicited several points of concern from the driver examiners. First of all, it appears there is a lack of understanding on how to work with ADAS, not limited to the consumer, but throughout the vehicle's development chain. For example, understanding not to brake at the first beep of a parking sensor is something that should be part of a driver's skillset. However, the focus group members stressed that this is often not the case. Moreover, they pointed that the driver is not at fault per se, since they often haven't been taught about the systems that are in their vehicle when they buy it. In fact, they do not place the blame anywhere, as they understand no one in the development chain can be considered responsible for this, as much as they acknowledge the fact that they are themselves not responsible for training novice drivers. The reason why they stressed the understanding of ADAS' functionality as important is because of the risk of not responding to any warning signal at all at some point, which is well documented to be the case (see e.g., [23]).

2) Key components for automated driving systems

Relatedly, the group stressed the importance of *intuitiveness* of automated driving systems in general. Furthermore, the system being *easy* and *fun* to use are seen as major components to avoid frustration while using the system. In their experience, they found for instance that different navigation systems vary in how up-to-date they are. Systems that are not up-to-date were considered difficult to use, and therefore frustrating. While intuitiveness is associated with a system's ease of use [24], being an extrinsic motivator [25], fun is attributed to enjoyment, an intrinsic motivator [25]. This emphasizes that also in the field of automated driving systems, in line with the recommendations of [25] stated as far back as 1992, in order to have automated driving systems readily adopted by human consumers, intrinsic motivation such as the fun of using the systems should not be overlooked by designers.

3) Automation surprise

Another consensual finding is the existence of what we shall call "automation surprise". This entails that drivers may experience either automated driving systems they did not know were present in their vehicle, or capabilities of automated driving system features they were not aware of. Sarter, Woods, and Billings [26] discussed seven different unexpected problems with automation when humans aim to interact with them, one of which is automation surprise. These are the result of a disruption in mode awareness, or "the ability [...] to track and to anticipate the behaviour of automated systems" [27]. They discussed that due to the increasingly complex nature of automated driving systems, several factors contribute to automation surprise, namely the absence of commands from its human operator, the amount and complexity of modes a system entails, the systems' increasing autonomy, and the number and origin of the systems' input sources. All of these factors are (increasingly) relevant in automated driving systems, and thus currently appear to still be trailing behind. As an example, the focus group mentioned the adaptive cruise control (ACC) function, which one can forget to turn off while exiting a highway, resulting in a high speed exit, or even an acceleration on the off-ramp when there was heavy traffic on the highway. Since the driver can only turn the ACC on or off, there is no input from the driver throughout the ACC's functioning, which results in the ACC continuing to control the acceleration and deceleration fully automatically. This example covers three of the four factors mentioned by Sarter, Woods, and Billings [26].

4) Monitoring an automated driving system

Lastly, the focus group emphasized that they train people to operate a vehicle, *not* to monitor an automated driving

system. In fact, part of *their own* job is to monitor the candidates, which they indicated to be very demanding and requires extensive training. They did not consider it viable for everyone to be trained for this type of task. Indeed, the fact that people experience a rapid decline in vigilance –and consequentially performance– while monitoring an autonomous system has been known for decades (see e.g., [28]). Since automated driving systems that substantiate to higher levels of automation (i.e., SAE level 3 and 4 [22]) elicit an increasing monitoring role for the human driver, the focus group considered these two stages of automation as ill-defined, and even recommended the removal of these two stages altogether.

B. Topics of discussion

Where several points of concern reached consensus among the focus group, there were several other discussion points that were left open for debate. The following issues were discussed during the focus group discussion, but could not reach consensus: levels of automation (section 3.2.1), and ADAS driver training (section 3.2.2).

1) Levels of automation

One of the purposes of this focus group discussion was to discuss whether there is a need for an overhaul of the current levels of automation (i.e., the SAE levels [22]), to change its perspective on how human behaviour changes with increasing autonomy. Although the members of the focus group assess their candidates based on three components, namely the ability to (1) drive independently, (2) perform special manoeuvres, and (3) assess a situation, some felt that classifying an automated vehicle in a similar way is a good idea, while others were not so sure. In the current situation, an automated vehicle becomes increasingly automated, starting with the simple tasks, like steering and braking [22], endangering the drivers' basic skills. When a driver becomes extensively exposed to that level of automation, this would potentially lead to him/her losing the basic skills to drive independently (1), while still being responsible for performing special manoeuvres (2) and assessing situations (3). Ideally, this should be the other way around, with an automated vehicle assisting in tasks that humans find difficult in driving, while letting humans continue with the easy tasks. The argument raised was that without the basic skills to drive independently, one would be unavoidably unable to perform the more complex tasks too. But some argued this may not be the case at all, and that the skills to perform special manoeuvres will not be lost. Regardless, the issue of skill degradation with increased automation is a long-standing one [15], [29], [30]. It is still to be determined whether, and if so, to what extent this skill degradation is a point of concern whilst driving with automated vehicles for extended periods of time. For one, the issue of increasing fatigue due to long-term exposure by automated driving has been shown many times (e.g., [31], [32], [33]), but to what extent this decreases their performance of driving manually is not well documented.

2) Driver training with ADAS

Related to how learner drivers are assessed and trained, the focus group members also discussed the case of driver training with ADAS. The group was divided about *how* drivers could learn from their (assisted to fully automated) vehicle. Assuming a higher level of autonomy (e.g., SAE level 3 or 4), it would be difficult to learn from the vehicle and its behaviour, as its decision-making will be construed predominantly from within a 'black box'. Only by repeated exposure to the automated driving system, one would be able to learn from experience. It is supported by literature that with experience, we are able to learn from our automated vehicle, for instance when using adaptive cruise control (ACC), as shown by Larsson, Kircher, and Hultgren [34]. They found that ACC-experienced drivers were quicker to respond to a potentially dangerous situation, although this effect did not appear for active steering, or a combination of both. The other part of the group argued that drivers could anticipate ADAS' decision making by training them to drive with automated driving systems so that we can understand and anticipate on its decision making step by step. Indeed, according to a study on fully automated driving by Payre, Cestac and Delhomme [35], it was found that appropriate training could mitigate potentially dangerous side-effects of extensive exposure to automated driving, such as overly trusting the performance of the automated driving system. But since companies that offer driver training with ADAS are currently sparse, and the fact that the amount of ADAS on the market is steadily increasing, there is still work to be done on that regard. For one, (possibly mandatory) basic driver training with ADAS needs to be realized. Second, a way to keep up with the pace of technological development needs to be thought out, or an ADAS driver training that is all-encompassing in terms of the wide range of expected ADAS (see e.g., the Wikipedia page on ADAS, listing 36 different ADAS as of December 4th 2019) needs to be developed.

C. Summary of main findings

In summary, the focus group discussion delivered both consensual ideas that could promote meaningful human control over automated driving system, as well as discussion topics that need further elaboration in order to decide upon a direction in which to go for meaningful human control to be achieved. A concise summary of the main findings, listed in newspaper header style, can be found in Table 1.

The focus group members consensually agreed that the current procedure of introducing new ADAS on the market is flawed, due to the lack of instruction and information of the given ADAS during this stage, as this causes unknowing or even unwilling users of said ADAS. Understanding of ADAS' functionality is considered to be key for maintaining a meaningful form of human control over their automated driving system. Furthermore, for better adoption of ADAS, or automated driving systems in general, the systems should be intuitive, easy, and fun to use. Relatedly, they pointed out together that they regularly encounter automation surprise, where the automated driving system behaves in an unexpected way, which they consider to be a serious safety issue. Lastly, they consensually urge to not aim for drivers having to monitor their automated driving system, as they have personal experience as to how difficult it is to maintain vigilance for extended periods of time.

What the focus group members could not agree upon is whether the current levels of automation, as defined by the SAE [22], need a thorough overhaul in order to have a

human-oriented focus instead of the technology-oriented focus it has right now. As a final point of discussion, further consideration needs to be made as to how driver training with ADAS should look like. Although some argued to learn by experience, others argued for thorough training classes to be ahead of any possibly troublesome experiences.

TABLE I. MAIN FINDINGS OF FOCUS GROUP DISCUSSION

	Main findings in short
	Consensual findings
#1a	Current ADAS market introduction is flawed
#1b	Understanding ADAS' functionality is key
#2	ADAS should be intuitive, easy, and fun
#3	Automation surprise is a serious safety issue
#4	Do not aim for having drivers monitor their system
	Discussion points
#1	Levels of automation to have human-oriented focus
#2	The form of ADAS driver training

IV. DISCUSSION AND CONCLUSIONS

A. General remark

A focus group discussion with professional driving examiners who experience the problems human novice drivers encounter on a daily basis provided important insights into what direction we ought to be going towards in terms of driving with advanced driver assistance systems (ADAS). Their expertise elicited caveats between driver capabilities and current expectancies whilst driving with ADAS. Note, however, that the conclusions drawn from this focus group discussion are based on personal opinions and experiences of the eleven focus group members expressed during the focus group discussion held that day. Although representative of the Dutch driver examiner pool, the conclusions drawn in this paper ought not to be considered the conclusions of the focus group members, but rather from the authors of this paper based on the opinions of the focus groups members. The minutes taken and recollection of the lead author of the day of the focus group meeting were combined and translated to position the opinions and conclusions of the focus group members into a scientific context. Consequentially, the following sections describe the authors' translations of the results of the focus group discussion into conclusions within a scientific context. Relatedly, the qualitative nature of this focus group discussion does not allow for statistical analysis.

B. Six issues of concern regarding automated driving systems

First, the lack of understanding of ADAS functionality is a concern that needs to be resolved rather sooner than later, in order to avoid ADAS misuse, abuse or disuse (cf. [23]). However, since no one appears technically professionally responsible for raising or facilitating that understanding, this caveat needs to be filled somewhere along the development chain. Only then a human can be considered to be in control of its vehicle to a meaningful extent [19]. Second, Human Factors such as motivation factors should be given more thought when designing ADAS. When incorporating those factors within the implementation of human-machine interfaces (HMIs), usability and the fun of driving should be taken into account as well. This does not change general recommendations that were made decades ago (see [25]). Third, which is related to the previous recommendation for HMI design, is that automation surprises should be avoided. To avoid, for instance, mode error (cf. [26], [36]), clearly conveying what mode the vehicle is in at any given circumstance (whether it is through a visual, auditory or haptic modality, by means of a tone, voice, or otherwise; see [37], who conducted a large-scale survey on people's preferences) appears warranted. Fourth, the role expected from drivers of automated driving systems is considered to be misplaced, as they are not being trained for supervising autonomous systems, but instead for handling a moving vehicle. Moreover, considering that it is well-known that humans are not suitable for prolonged monitoring of uneventful situations (e.g., [38], [39], [40]), other solutions should be sought for. Cabrall, Eriksson, Dreger, Happee, and de Winter [41] provided an overview of six different solutions the academic literature suggests in relation to the engagement of a human driver in an automated driving system. Which of these six (avoid, mitigate or alter the supervision, or train, support or inform the driver to enable supervision), however, is the best solution is yet to be explored. Fifth, it needs empirical evidence that skill mitigation in driving automation is a real thing. Although the literature has been warning us for this potential hazard for decades (e.g., [5], [29], [36]), currently no empirical research has been performed to investigate this phenomenon. Sixth and last, a feasibility study on ADAS driver training implementation is warranted, for two main reasons: (1) it has been shown that we can learn to drive with certain types of ADAS [34], but currently there is no organised layout for this type of training, and (2) the list of ADAS is growing so rapidly, it needs to be inventoried whether or not a training of this extent can be either overarching or all-encompassing in order to keep the pace.

C. How solving these issues could help safeguard meaningful human control

This paper and the focus group discussion described in it were designed to steer towards answering how meaningful human control could be practically applied over automated driving systems. By asking experts in the field about major topics surrounding both meaningful human control as a concept, and automated driving systems in general, this paper aims to gather key insights as to what the main hurdles are, and how they ought to be tackled best in the eyes of those who teach people how to drive a vehicle for a living. Therefore, it should be noted that it was not our aim to solve any existing issues with automated driving systems, or plead for driver training with ADAS as the solution to it, but rather a means for opening up the debate, and creating ideas and suggestions that could serve as gateways for implementing

meaningful human control over automated driving systems as a whole.

The issues mentioned above need addressing. This much is clear, according to our focus group members. How these issues can help with ensuring automated driving systems to allow a meaningful form of human control, can be explained by emphasizing the two main conditions surrounding the concept of meaningful human control, namely tracking and tracing. Where tracking involves both agents and reasons [42], [43] and entails a system that always tracks its users' (proximal to distal) reasons, ranging from moral values to steering actions, at least two of the six issues mentioned above (i.e., 3.1.1 & 3.1.3), when solved, could help by ensuring a trackable system. Since tracing involves the knowledge, capability, and awareness of the system and its limitations [44], addressing (but not limited to) the remaining four issues could help make a system traceable. Combining the two conditions would significantly improve the degree to which a driving system is meaningfully under the control of a human being (not necessarily the driver). Initial steps have already been taken to explore in which areas MHC can play a role and how the concept can be made practice ready to influence driver training and proper control over automated vehicles [44]. Nevertheless, a broader effort is required on a higher level to address the above mentioned issues and ensure that control of automated vehicles can be maintained by drivers in the future, regardless of type of technology they encompass.

D. Conclusion

After decades of the determination or prediction of such issues, practical solutions to, among others, the lack of information and instruction with regards to ADAS functionality, underrepresented user-oriented ADAS design, and automation surprise appear to be greatly lacking. Unanimously, the members of this focus group discussion urged us to investigate the human factors involved in driving (and monitoring) an automated driving system. When considering our human capacities, and adapt our automated driving systems to those, we might facilitate a better interaction, coordination, cooperation, and communication between human and machine. This is compatible with the suggestions coming from the theory of Meaningful Human Control [45]. A better understanding of capabilities and limitations of a human controller can not only grant a safer operability, but a more accountable one, especially when skills are not yet fully developed, as in the case of learner drivers. This endeavour could start by taking regular driver training protocols, and attempt to weigh driver tasks, to inventory which tasks are most prominent during driving, and which are most suitable to be replaced by an automated driving system.

APPENDIX

APPENDIX A: INVITATIONAL LETTER TO RECRUIT DRIVING EXAMINERS – IN DUTCH.

Programma examinator focus groep over MHC

11-09-2018

Beste examinator(en),

Hartelijk dank dat u wil meewerken aan deze focus groep discussie over het onderwerp Meaningful Human Control (MHC), ofwel "Zinvolle Menselijke Controle" over automatisch rijdende systemen.

U bent allen uitgenodigd voor deze avond, omdat u over belangrijke expertise beschikt aangaande de menselijke controle over een voertuig, en waar men daarbij op moet letten om die controle te realiseren. Wij zijn daarom zeer geïnteresseerd in uw mening en visie omtrent de ontwikkeling van automatisch rijdende voertuigen, en de rol van de menselijke bestuurder hierin.

Met het oog op de toenemende aanwezigheid van automatisch rijdende voertuigen, en de daaropvolgende automatisering van de rijtaken die ervoor zorgen dat de menselijke bestuurder steeds minder hoeft te doen (met alle gevolgen van dien), zijn wij als onderzoekers bezig met het bepalen van een strategie die er voor zorgt dat de menselijke bestuurder ook nog altijd een relevante ("zinvolle") controle over zijn of haar voertuig kan uitoefenen.

Wij zullen vanavond in het kort uitleggen waar ons project precies over gaat, en wat dit inhoudt, en zullen u vervolgens enkele voorbeelden geven in welke richtingen u zou kunnen denken om ons te helpen met het ontwikkelen van een raamwerk dat deze zinvolle menselijke controle over automatisch rijdende systemen zal kunnen waarborgen.

Uw persoonlijke expertise op het gebied van menselijke controle over voertuigen is uitermate van belang hierin, en daarom hopen wij vandaag op een rijke discussie met waardevolle inzichten die uiteindelijk een veilige toekomst met automatisch rijdende systemen kan garanderen.

Met vriendelijke groet,
Het MHC-team

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