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Understanding drivers' perspectives on the use of driver monitoring systems during automated driving: Findings from a qualitative focus group study

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ABSTRACT

The ability to measure psychological states such as fatigue will become increasingly important with the introduction of automated driving systems (ADS) to everyday driving. Driver monitoring systems (DMS), which will soon be a required feature in all new vehicles, will be responsible for assessing the driver's mental state in real-time. This will help to maximise the safety and social benefits of ADS. However, little is known about drivers' perceptions of DMS. This qualitative focus group study used a reflexive thematic analysis approach to understand drivers' perspectives on the use of DMS during automated driving. Seventeen drivers with no prior experience of ADS or DMS were interviewed across three focus group sessions and were shown a video outlining some of the capabilities of both systems. A semi-structured interview guide was used to gather qualitative data concerning drivers' perceptions of the prospect of driver monitoring within automated driving and the expectations that they have. Reflexive thematic analysis was used to develop five themes. The findings show that drivers have more favourable attitudes towards DMS than ADS, due to an expectation that the latter will require a greater sacrifice of the driver's control. Nonetheless, participants were sceptical of the reliability, security and privacy of driver monitoring, and expressed that it could detract from the enjoyment derived from driving. Participants were also concerned regarding the potential for driver data to be sold to third parties and used against them in various ways. Overall, drivers are sceptical of the value of driver monitoring and ADS and perceive them as separate entities as opposed to two systems working in partnership. This highlights an emerging challenge for researchers and system manufacturers, which will need be addressed in order to fully realise the individual and societal benefits of these new forms of technology.

1. Introduction

Driver monitoring systems (DMS) represent an emergent form of advanced vehicle safety technology that relies on the collection of a combination or subset of behavioural, physiological, and ocular data in real-time to make assessments concerning the driver's ability

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to perform the driving task (Hayley et al., 2021). The nature of the driving task is currently undergoing a series of rapid changes with the introduction of automated driving systems (ADS) to the automotive sphere. During automated driving, the driver's role shifts from an active operator of a system to that of a passive supervisor (Kyriakidis et al., 2019). This results in a more monotonous task which, due to lapses in the driver's attention and alertness, can pose a threat to the safe transition from automated to manual driving when the automated system encounters limitations (Feldhütter et al., 2018). Despite the driver's ability to delegate vehicle control to an automated driving system, the ability to assess the driver's mental state in real-time will be an integral part of driver safety for two reasons. One, during conditionally automated driving (SAE 'Level 3′, currently available in a small handful of territories), the driver must be 'fallback-ready'; in other words, they must be available to respond to a request from the automated system to resume manual control should the automation fail, which could occur for a variety of reasons (e.g., unclear road markings). Two, there is evidence that as the level of automation increases, drivers display increasing difficulties in maintaining attention and awareness during automated driving. For example, an increase in fatigue has been found during automated driving (Jarosch et al., 2019), as well as reductions in the driver's situation awareness (De Winter et al., 2014). Drivers may also engage in a variety of more individualistic behaviours, such as mind-wandering (McKerral et al., 2023; Gonçalves & Bengler, 2015). This has implications for the driver's ability to respond to requests from a system to regain manual control in a timely manner.

DMS will therefore play an integral role in the future of driving, particularly as more vehicles move from manual to automated control. These systems will be responsible for detecting driver states such as distraction and fatigue, with the aim of improving road safety and mitigating driver impairments. Within the context of ADS, the interaction between these two systems supports drivers in experiencing the benefits of automated driving (such as reduced stress and workload) in a safe manner. DMS within ADS could also help to proliferate more societal-level benefits of automated driving, such as reduced traffic congestion (Milakis et al., 2017). This could be achieved by reducing accidents caused by driver drowsiness and fatigue, which can cause significant traffic delays (Mašanović et al., 2019), or by improving traffic flow through sharing real-time information from DMS with traffic management centres, who can in turn manage traffic flow more effectively (Patel et al., 2012).

However, these individual and societal impacts are dependent upon drivers perceiving these technologies as trustworthy; otherwise, they may choose not to adopt them. Within the technology acceptance literature, trust in automation is recognised as a multifaceted and dynamic concept that is influenced by several factors, including system reliability (Gegoff et al., 2023), perceived privacy risks (Waung et al., 2021), and system transparency (Oliveira et al., 2020). A classical definition describes trust in automation as "the attitude that an agent will help achieve an individual's goals in a situation characterised by uncertainty and vulnerability" (Lee and See, 2004, pp. 51). An appropriate level of trust in a system will support good cooperation between a system and its user, thus ensuring the user can take advantage of the system's benefits and use the system as intended (Hergeth et al., 2017).

Theoretical models such as the Technology Acceptance Model (TAM; Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2016) have also been applied to understanding the factors that predict behavioural intentions towards the use of automated systems. Smyth et al. (2021) examined acceptance of driver monitoring for automated vehicles using the UTAUT and found that constructs such as effort expectancy and performance expectancy were positively related with behavioural intention to use this technology, whereas anxiety was negatively related. There is therefore a need to interrogate these nuanced psychosocial factors more deeply. While technology acceptance models are undoubtedly useful, they have the potential to reduce complex interactions between humans and technology to a handful of predictive factors. Conducting qualitative research (particularly in an area with such a small knowledge base, such as attitudes towards DMS), can garner fresh insights about how a system is perceived, that may not be captured by existing quantitative measures.

Thus, very little is known about drivers' attitudes towards the prospect of in-cabin monitoring, and how this data will be used. According to the General Data Protection Regulation (GDPR) the data collected by a DMS, which includes behavioural and physiological data, is considered as health data, as it can be used to make inferences about the health status of an individual. In terms of ADS, previous research has found that drivers have concerns about the security and privacy of these systems, including the fear of driver data being sold to third parties (Hilgarter & Granig, 2020). The recently developed General Safety Regulation (GSR), states that the data collected from so-called "*driver drowsiness and attention warning and advanced driver distraction warning systems*" (European Parliament and Council, 2019, pp. 2) should not be shared with third parties at any time. Nonetheless, drivers may still have concerns about the extent to which they can trust that their privacy will be protected, particularly in light of growing concerns from the public about the potential for the data generated by an individual to be gathered, sold and used in previously unforeseen ways, amidst the rise of so-called 'Big Data' (Rubinstein, 2012). Therefore, understanding the nature of drivers' concerns about driver monitoring systems, and the data that it collects, is of importance to both researchers and fleet operators as this technology begins to play a role in everyday driving.

For this qualitative focus group study, drivers not currently in possession of an automated driving system (ADS) were provided with an overview of both driver monitoring systems (DMS) and ADS. Drivers were shown a brief presentation detailing the functions and capabilities of an ADS operating at SAE Level 3, and how a DMS is used to assess driver mental states such as drowsiness. They were then asked to discuss their attitudes towards this technology, the perceived benefits, challenges, or issues that they associated with driver monitoring systems, and what they anticipated it would be like to use this technology. Therefore, using a reflexive thematic analysis approach, a qualitative focus group study was conducted with the following research question in mind: ***What are drivers' perspectives on the use of driver monitoring systems during automated driving?***

The aims of this study were as follows:

To explore drivers' perceptions of the prospect of driver monitoring within automated driving systems (ADS), which was achieved through the following objectives:

Identify and explore the perceived barriers and facilitators to the adoption of this technology from the perspective of a road user who is not currently in possession of either an automated driving system or a driver monitoring system.

Identify and explore drivers' attitudes towards the proposed functionalities and capabilities of driver monitoring during automated driving.

To understand the expectations that drivers have surrounding the use of driver monitoring within automated driving systems, which was achieved through the following objectives:

Identify and explore the ways in which drivers anticipate that driver monitoring during automated driving could change, positively or negatively, their current driving behaviours.

Identify and explore ways in which drivers anticipate that driver monitoring during automated driving could change, positively or negatively, the subjective experience of driving.

2. Methodology

2.1. Design

This study employed a qualitative design using a series of semi-structured focus group interviews. Ethical approval was granted by the University of Galway Research Ethics Committee on November 28th, 2022. Participants were interviewed between February and April 2023 about their perceptions and attitudes towards the use of monitoring technology during automated driving. Each focus group session lasted between 60 and 90 min. An interview guide was developed for the focus groups; the eight questions were informed by (but not limited to) constructs within the UTAUT and by previous qualitative studies that have investigated acceptance of automated vehicles (e.g., Joisten et al., 2021; Madigan et al., 2016). The interview schedule was flexible, whereby if participants wished to express opinions not covered by the interview schedule, but relevant to the research question, the moderator allowed the session to deviate from the schedule.

2.2. Participants and study context

A total of 17 participants were recruited. Individuals aged 18 years or older and holding a full driving license for at least one year at the time of the study were eligible to participate. Participants were recruited through online flyers displayed on social media, and physical flyers displayed on the University of Galway campus. The flyers contained a link to a Qualtrics form where participants could express their interest in taking part, and where they were screened for eligibility. The final analytic sample were ranging in age from 19 to 52 years (M=29.59, SD=10.85), and comprised 11 women, five men, and one non-binary person. All participants had a full driving license, and all participants had at least one year of driving experience prior to being interviewed. As participants were all local to the area around University of Galway, they all had experience driving on the Irish road network and drove personally as opposed to professionally. Participants all had no prior experience with either automated driving systems (i.e., SAE Level 3 and above) or with driver monitoring systems. Three focus group sessions were conducted: the first session had six participants, the second session had four, and the final session had seven participants. Recruitment was stopped after the third session. The concept of information power (Malterud et al., 2016) asserts that the quality of the data and the aims of the research dictate the necessary sample size. This approach was favoured over the concept of 'saturation', which some have criticised for not being consistent with the values and assumptions of reflexive thematic analysis (Braun & Clarke, 2021). Given that the aims of this study were focused and precise, and that a rich dataset was obtained from these three sessions, a sample size of 17 participants was deemed sufficient to address the study's aims.

In Ireland, private car ownership is estimated to be at 445 private cars per 1,000 inhabitants, which is below the European Union average of 500, according to a 2020 report (Department of Transport, 2020). The private car is also the dominant mode of transport in Ireland: it was used for 73.7 % of all journeys in 2019 (compared to just 6.5 % of journeys that were made using public transport). The most common reason for making a journey in the 2020 report was work and/or education reasons, accounting for 26.3 % of all journeys. In 2023, there were 177 fatal collisions, which resulted in 188 fatalities on Irish roads; an increase of 21 % compared with 2022 data (Road Safety Authority, 2024). Driver drowsiness and fatigue were contributory factors in 10–20 % of road traffic collisions, and 28 % of motorists in Ireland have reported falling asleep or nodding off while driving (Road Safety Authority, 2020). The highest level of vehicle automation currently available in Ireland is SAE Level 2, or 'partial' automation.

2.3. Procedure

The moderator introduced the focus group interview by providing an overview of the structure of the session. Participants were informed that the purpose of the interview was not to establish consensus; rather, the researchers were interested in understanding a range of different opinions. The moderator began each session by showing the participants a brief video clip. The video clip was two minutes in duration and provided the participants with a brief overview of driver monitoring systems, and how they can be implemented within the context of automated driving. The video also demonstrated some of the features of automated driving. It is important to emphasise that the purpose of the video was not to provide participants with one 'true' understanding of driver monitoring systems and/or automated driving. Indeed, if participants' understanding of the technology had previously been shaped by the media or personal experience, they were encouraged to bring those perspectives to the focus group, as this would facilitate a much more diverse range of meanings to be captured. Practically speaking, this entailed the moderator informing participants that in discussing the technology, they did not have to limit their discussion to what was shown in the video. Therefore, the purpose of the video clip was to provide a starting point and introduction to the topic, and as an 'icebreaker' to allow participants to ease into the discussion. A full transcript of the video can be found in Appendix A.

2.4. The analytic process

A six-phase reflexive thematic analysis approach was taken to explore patterns of meaning in the interview data. Reflexive thematic analysis is a widely used method in qualitative psychology (Braun & Clarke, 2022a), and has been applied extensively for the purpose of analysing qualitative data across the applied, health and social sciences (Campbell et al., 2021). A worked example of reflexive thematic analysis can be found in Byrne (2022). Reflexive thematic analysis was chosen for this study for two main reasons. Firstly, it facilitated both an inductive, 'bottom-up' analysis and an orientation that seeks to capture both latent and semantic meanings. This was important for this study as the aim was to capture a broad and rich set of understandings, without trying to use an existing theoretical framework to interpret the data. Secondly, it supported an analysis that aligned with the epistemological stance taken in this study: one of social constructionism (the idea that reality is understood through language, and that knowledge is generated

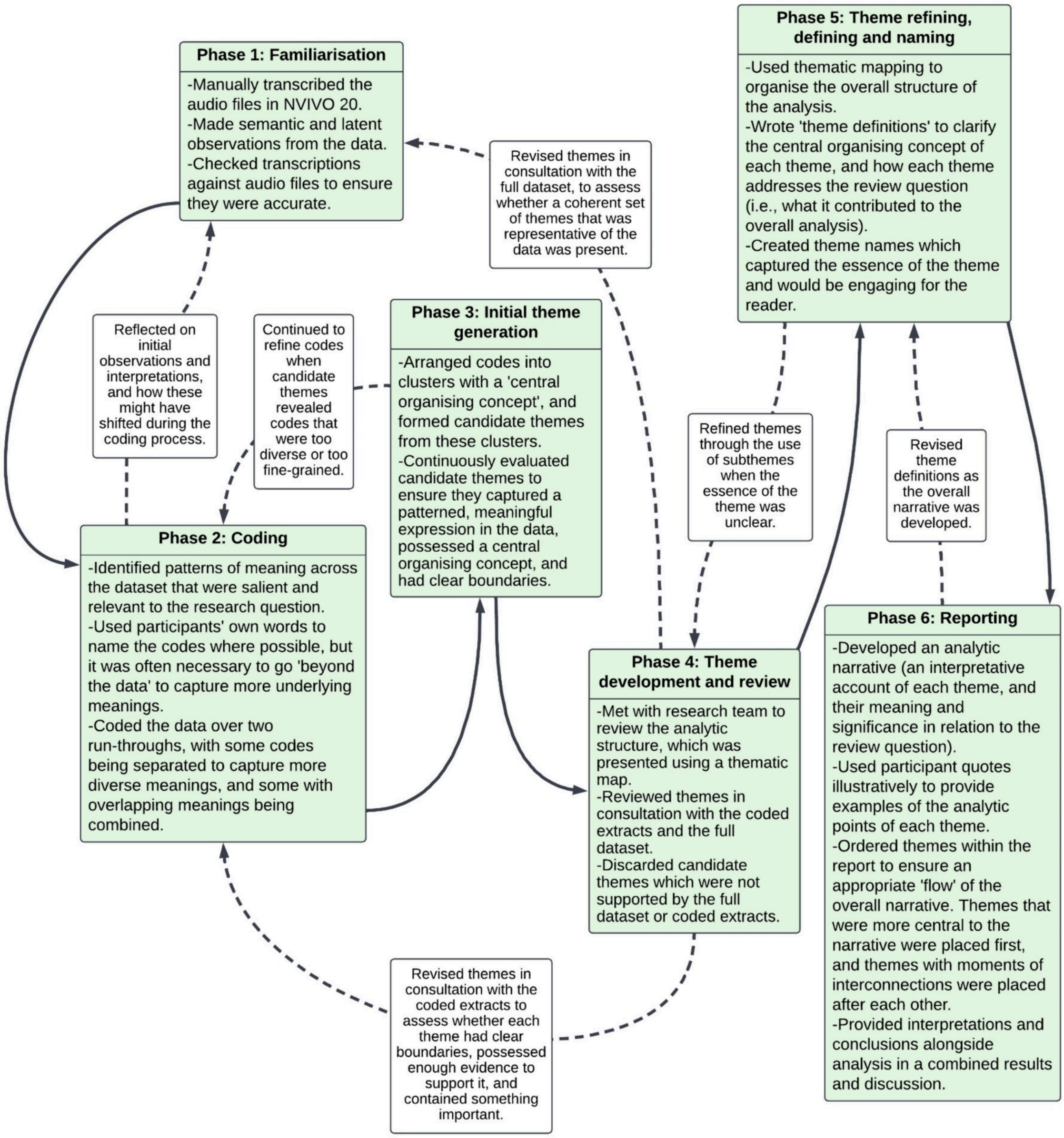

Fig. 1. Overview of the analytic process, highlighting the recursive six-phase reflexive thematic analysis that was conducted with the dataset. Broken lines represent instances of returning to a previous phase during the analytic process (to emphasise the recursive nature of reflexive thematic analysis).

through a historical and cultural lens, Burr & Dick, 2017; Willig, 1999). A social constructionist epistemology was adopted for this research because the aim was to understand how drivers 'make sense' of driver monitoring systems, and the implications that this has.

An overview of the analytic process can be seen in Fig. 1. The initial phase of familiarisation began by manually transcribing the audio files using NVIVO 20. Because the interviews were conducted and transcribed over a period of three months, this allowed time to reflect on initial observations and interpretations, and how these might have shifted during the data collection process. The observations from the transcribed data were initially at the semantic level, but more latent meanings behind the participants' words were subsequently interpreted. The constructionist approach oriented analytic observations towards how participants attempted to *make*

Fig. 2. Thematic map overviewing the analytic structure, including the themes and subthemes (in purple) and the codes associated with each theme (in lilac). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Supportive quotes used for each theme and subtheme during the reflexive thematic analysis.

Supplemental, Not Integral		**Taking the Driver Out of Driving**		**Real-Life Driving Is Unpredictable**	**‘Big Other Is Watching You’**	**Data Exploitation**
An Informational Tool	*A Safety Net*	*Dependency on Technology*	*A Lesser Experience*			
“Obviously, you have that little lapse in concentration when you’re tired… […] *…I’ll be half an hour from home and* ***I know I should really pull over, but I’m only half an hour, so I’ll just push through****…* […] *… But the, that sort of thing, that would be really helpful if there was a thing going on going* ***”hang on a second, you need to pull over!“****, and not just the voice in my head saying ”you should really pull over“ and the other voice going ”nah, we’ll just push through“.*	*“Yeah I definitely think in city driving anyway,* ***you have to be so vigilant, and it’s very tiring****, like you’re looking for pedestrians crossing, you’re looking for traffic in front of you, stopping/starting, stopping/starting, yeah […] there’s a lot to do, a lot to look out for, and it’s kind of* ***that overload in your brain*** *if you’re then coming from a day of work can all be quite stressful”.*	1: *Like, even on the way* [to the interview]*, a guy switched lanes without indicating, and I kind of knew he was gonna do it before he did it, you know?* 2: *“You always know”* [laughs]. Moderator: [laughs]. 1: *“I was like “I’m watching you… Yeah, you did it, ok”. And I feel like if you’re not doing, like* ***if you’re not practicing a skill, that little bit of intuition is gonna… maybe not go away completely, but like deteriorate****, and I feel like that’s a very important skill for when you’re driving.”*	*“…when you’re driving and you enjoy what you’re doing, it’s not much, but* ***you’re enjoying what you’re doing****, but if you have this external element, coming to you, monitoring you when you’re doing it,* ***maybe it could diminish that enjoyment*** *for people like me that actually enjoy driving.”*	*“It could be… like what you were saying earlier, the thing where it says ”****oh, you’re too tired to drive“ or something like that, but you have to drive****, or you have to get to wherever you’re going, or whatever, that could be like a nuisance, but again, it comes back to as long as I can override it, like ”no, I need to do whatever I need to do“.*	*“That’s kind of interesting, too. I didn’t think about that, like does the automobile company have the data, then? Is the new car, or like same car but a different driver, is it just more or less wiped and then you’re kind of like… or does your data follow you when you get a new car?”*	1: *“Especially in the case of, like, visual recordings, I just thought about this whole wave now of deepfakes, where they’re using, you know, people’s images and you know making them say things they didn’t say, and the more available intel they have of your face captured, the more they can make…”* 2: *“What rights do you have, over let’s say, who can and can’t use this?”*
“What I personally think would be pretty cool is if… based on that data, ***if I could almost set kind of goals around stuff*** *almost, so if it could alert me that I’m about to enter into the context that I typically am a bad driver, and not paying much attention, it could say, like ”hey, you’re about to get on the highway“, or whatever it is, and like ”oh yeah, like I can… I can do this today“.* [laughs]*”.*	*“I’ve a friend who’s in a situation where a family member is developing dementia […] can you imagine* ***the freedom that potentially something like this would give someone****, that their family would be able to check in and make sure that they’re still able to get from A to B in a safe manner for them and everyone around them?”*	*“I suppose, the situations where you do see people on their phones, or with their phones in their laps, and they’re texting as they’re driving, and you do see all of these situations kind of happening, and like the drunk driver thing as well, is this really gonna get rid of all those things?* ***Is that not kind of taking something away from what we should be doing?****”*	*“…you’re supposed to be observing what’s out there, and I’ve already seen cars go to now – cause it’s a touch screen – you have to touch it in the right place, versus having a knob that you didn’t have to look at all for your volume, so* ***you’re already splitting your attention in ways that you wouldn’t have been*** *in a car that was ten years older. So I would have that concern as well”.*	1: *“…on a day like today when you’ve got low winter sun, does that mean you can’t wear sunglasses?”* 2: *“Or squint?”* 1: *“Yeah, or even if you drive around a bend and suddenly the sun’s in your eyes, and you go like this* [waves hand in front of face]*, does the car go ”oh, suddenly you’re not fit to drive“. You know?”*	*“I mean, I’m assuming the best, that they have the best, you know, intentions, but then* ***this always leaks****, and data breaches, you know, I wouldn’t say, you know, ”they’re collecting data because they wanna do bad things with it“,* ***but I think there’s always hackers and leaks****.”*	*“If I get into an accident with someone who has all this driver monitoring, will their insurance company consider their driver monitoring more valuable than any of the information I present, regardless of who’s at fault,* ***will that be considered as more objective rather than any potential witnesses****, or any other circumstance?”*
1: *“…could this data be given to me in a digestible way, if it’s gonna be used anyway? Even if that came down to like stats on driving over a month, and like* ***it could tell you a little bit about yourself*** *and be like “maybe we*				*“Really often I guess, and I think many people will say that, that you’re aware of what you’re doing, but you can’t know what other people are doing around you, so you’re more careful of the other than of yourself!”*	1: *“Yeah.* ***You’d feel like you were doing your driving test every time you sit into the car.”*** 2: *“Yeah. And as someone who failed the first test because that pressure was –”* 3: *“Panic”.* 2: *“Yeah, I can see it*	1: *“It kind of links into kind of the… the car turning into a product rather than a vehicle to get you from A to B, and I think that’s where it kind of sounds like a lot of concerns are as well,* cos *it’s like ”oh, is my data now part of that brand“, you*

(*continued on next page*)

Table 1 (*continued*)

Supplemental, Not Integral		Taking the Driver Out of Driving		Real-Life Driving Is Unpredictable	'Big Other Is Watching You'	Data Exploitation
An Informational Tool	*A Safety Net*	*Dependency on Technology*	*A Lesser Experience*			
recommend you don't keep driving at midnight because actually it's a bit mad to be doing a commute at that time", and see if you can-". 2: *"That would be really interesting, yeah".* 1: *"Something like that, I feel like it gives me a tiny bit more trust of like, at least it's a two-way relationship".*					*being a little like,* ***it could throw you.*** *Especially if you're getting like "oh, you braked really sharply just there, what's going on?", and you're like "someone decided to cross the road in front of me!"* 4: *"It could have* ***the opposite effect****, of making people drive worse."* 2: *"Yeah, I think you would get used to it. But I think there would be this adjustment period, or if it does kind of give you an alert or something, that might give you a couple of minutes of being more conscious again, and like that could go either way for you."* 3: *"****Potentially the world's worst backseat driver of yourself.****"* 2: *"Exactly".* 4: [laughs].	*know?"* 2: *"Yeah, like the car as being a tool for doing something, like from getting from A to B, but there's more, you become part of this productivity environment."*
				"I would prefer a system where maybe it needs to monitor me, but it improves my alertness by giving me extra senses, giving me extra capabilities, as opposed to just "oh yeah, you need a coffee break"."	*"Like the trade-off that we're kind of talking about here is like, well for order for it to work as safely as possible, you have to be surveyed the whole time".*	

sense of the technology. Language that was interpreted as adversarial (such as the notion of having one's data 'used against them') when participants described their understanding of the technology was also noticed. Once the data was fully transcribed, the transcriptions were checked against the audio files to ensure they were accurate and representative.

Moving into the second, more systematic phase of coding the data, patterns of meaning across the dataset were identified that were salient and relevant to the research question. The data was coded in NVIVO 20 from a critical, constructionist perspective, capturing both semantic and latent meanings. Often, multiple expressions at both levels of meaning within the same data item were identified, so careful and rigorous coding was needed to capture the richness that existed in the dataset. Where possible, participants' own words were used to name the codes, but to capture more underlying meanings, it was often necessary to go 'beyond the data' (in other words, to make interpretations of the data that were relevant to the research question; Braun & Clarke, 2022b). For example, the code 'environmental variation' was named as such to capture articulations surrounding changes in the environment that a driver monitoring system may have to contend with. While participants' own words were not used to name this code, the name still attempted to faithfully represent the underlying meaning. The dataset was initially coded over two successive run-throughs; a second round was deemed important as interpretations shifted and evolved. This meant that codes needed to be continually refined, either by separating a code into multiple codes to capture more diverse meanings, or through combining codes that were repetitive or overlapping.

Having coded the entire dataset, clusters of codes that could be arranged under a 'central organising concept' were then identified. Moving into phase three (initial theme generation), candidate themes were formed from these clusters, thus using codes as the 'building blocks' for the analysis. The candidate themes were continuously evaluated to ensure they captured a patterned, meaningful expression in the data, possessed a central organising concept, and had clear boundaries (i.e., that ideas did not overlap across themes). Phase four (theme development and review) required a willingness to "let things go" (Braun & Clarke, 2022b, pp. 147) through revision in consultation with the full dataset, to assess whether a coherent set of themes that were representative of the data was present. The research team then met to review the analytic structure, which was presented using a thematic map created using LucidChart (Faulkner & Contributor, 2018). This meeting was instrumental in the refinement of themes; the feedback prompted the judicious use of subthemes to highlight facets of the central organising concept of two of the themes, which the team felt were not otherwise apparent. Through engaging with this six-phase reflexive thematic analysis approach, an analytic structure with five themes was settled upon. A reflexivity statement from the perspective of the lead researcher is available on the Open Science Framework: https://osf.io/d4b29/.

3. Results and discussion

An analytic structure with five themes was developed (see Fig. 2). Each of these five themes represent critical issues with respect to how driver monitoring systems (DMS) within automated driving systems (ADS) are perceived by drivers.

3.1. Overview of findings

Overall, the findings of the thematic analysis show that drivers have a more positive perception of DMS than of ADS, due to the expectation that the latter requires a greater sacrifice of control. In terms of DMS, drivers are sceptical of the reliability of this technology, emphasising how the unpredictable and varied nature of driving could act as a barrier to placing trust in such a system. Security and privacy concerns were also highlighted – specifically, the potential for driver monitoring to feel invasive. Another key concern was that driver data could be sold to third parties and used against the driver in various ways. Some positive perspectives on DMS included the potential for DMS to provide additional information about the driver which could be useful at certain times, and to act as a safety net in instances where the driver experiences lapses in attention and vigilance. This overall narrative is elaborated upon through the five themes. A selection of supportive quotes has been provided for each theme and subtheme below. Interested readers are directed to a list of additional quotes that were attributed to each theme and subtheme, which can be found in Table 1.

3.2. Supplemental, not integral

This theme encapsulates the way in which participants construed driver monitoring systems as an *added layer* of safety and information – and *only* an added layer, rather than an integral component of automated driving. This idea is represented across two subthemes.

3.2.1. An informational tool

Participants expressed favourable attitudes towards the potential for driver monitoring systems to be used as a means of receiving additional information about their driving practices that they may not otherwise have. Driver monitoring was represented as a tool for gaining deeper insight into one's own habits and behaviours while driving, allowing drivers to subsequently modify their behaviour if information about themselves could be provided to them in an understandable format. Participants also saw the value in a driver monitoring system being able to make drivers aware of their unsafe driving behaviours, and to serve as an intervention when corrective action was needed. To articulate this, driver monitoring systems were construed as an objective decision-maker about driver safety: an impartial source of information regarding the need to respond to hazards. They recognised the value of a DMS acting as a third party in assisting the driver to make objective decisions about the safety of their behaviour.

Interestingly, participants made an effort to distinguish their attitudes towards DMS from their attitudes towards ADS. They generally expressed more favourable attitudes towards DMS, and this was tied to their perception of DMS as an informational tool. The idea of a DMS was seen as 'harmless'; an extra feature that could provide helpful feedback at pertinent times, but one that could be switched off or ignored if desired. This stood in marked contrast with their perception of ADS, which were seen as a form of giving up control of the vehicle. To participants, DMS were a more attractive proposition as they allowed the driver to remain in control of decisions about their fitness to drive: *"I think the monitoring, like the sleepiness thing, I think that's brilliant, I think that will definitely have, like, benefits in terms of like preventing crashes and stuff. But the monitoring thing of like the alerts and stuff, like that's kind of harmless…… **I would view that as kind of harmless,** as long as it's not like physically braking the car, or you know, doing anything wild like that. If it was just alerting me, or I don't know if there's one that kind of monitors your stress and stuff, and says "oh, pull over, and get a coffee", or whatever, you know, that kind of thing is harmless to me, **I wouldn't mind that at all, but the one where it's controlling the car kind of freaks me out a bit**".*

3.2.2. A safety net

Participants frequently evoked the concept of a 'safety net' when talking about driver monitoring systems as supplementary, and to describe how they saw the technology being used in their everyday driving. To participants, this safety net, or 'fall-back device' as they also framed it, could act in emergency situations when the driver is unable to respond to or detect an event within an appropriate time: *"Personally for me, […] I think **to have that as a backup** would be fantastic. Definitely 100 %. Because I had to travel a lot there to go to Dublin, and that's something I'd be very aware of, so I was stopping at every available opportunity along the way to get a coffee. Even if I wasn't* *tired, it was more to give my mind a break. So I think having something in place that would like… **it's a comfort almost.** But again, I wouldn't give over full responsibility, but I definitely think it would reduce my stress levels in that context."*.

Participants also imagined that they would feel more at ease on the road with the knowledge that a driver monitoring system was overseeing their safety and could alert them when intervention was needed: *"…just that little safety of **"oh, if I do need it, it will be there"**, is very reassuring"*. They believed that driver monitoring could help to alleviate some of the everyday stresses that they experience while driving. DMS could help the driver to more effectively deal with the ever-changing features in their environment that they are expected to attend to. There also existed potential for driver monitoring as a safety net to be particularly beneficial for groups of people that face challenges while performing everyday driving. The vulnerable groups identified by participants included older drivers with a cognitive impairment, and long-haul drivers who may be prone to driving while drowsy.

Overall, this theme yields several interesting insights that have implications for the literature concerning attitudes towards DMS and ADS. Firstly, it is important to acknowledge that participants in this study recognise the potential for DMS to meaningfully improve their driving behaviours through the provision of valuable information. The perceived usefulness of a technology has been shown as an important predictor of its acceptance. Several previous studies have demonstrated that perceived usefulness is a determinant of one's intention to use ADS (Choi et al., 2015; Yuen et al., 2021; Zhang et al., 2019). Another study to measure pre-adoption attitudes to driver monitoring observed that perceived usefulness was the single most important determinant of intention to use the system (Ghazizadeh et al., 2012). Therefore, the findings of this qualitative study complement those of existing quantitative studies by examining how exactly drivers perceived DMS as potentially useful. Specifically, participants in this study saw DMS as being valuable in instances where alerts were necessary at critical times, such as when the driver becomes drowsy.

However, this theme also demonstrates that while drivers acknowledge the existence of benefits of using a DMS for themselves and others, they are embedded within a perception that the technology is a non-essential accessory to driving. This perception is in contrast with how DMS is often construed by the media and by researchers in this area: namely, that it is the 'next generation' of driver safety technology (Hayley et al., 2021). Clearly, there is a contrast in how DMS and ADS are perceived by regular drivers and how they are marketed to these same drivers. This contrast could represent an emerging challenge, given that DMS will soon be a required feature of all new vehicles on European roads (European Parliament and Council, 2019). It is possible that the perception of DMS as non-essential and supplementary could lead to users ignoring a system at critical times, system misuse or even disuse entirely.

Lastly, it is noteworthy that participants in this study made a distinction between their attitudes towards DMS and their opinions of ADS. There existed a dividing line between assistance features which served to complement but not replace the driver, and those which were perceived as requiring the driver to relinquish control. It is well-documented that driver assistance features are perceived as most useful when they provide warnings in safety–critical situations only (De Waard & Brookhuis, 1999; Weber et al., 2020). On the other hand, drivers may respond negatively when a system attempts to initiate action on their behalf. Attitudes towards DMS may therefore manifest quite differently than attitudes towards ADS, given the different ways in which they are understood to interact with the driver.

3.3. Taking the driver out of driving

The name of this theme is intended as a 'double entendre' to describe how participants saw driver monitoring as having a potentially negative impact on the experience of driving: both in terms of physically removing the driver from the control loop (represented by the subtheme '*Dependency on Technology*') and subtracting from their experience, on a more subjective level (encapsulated by the subtheme '*A Lesser Experience*').

3.3.1. Dependency on technology

This subtheme encapsulates the idea that using a DMS may negatively affect drivers' attention behind the wheel, due to the delegation of responsibility to the system. Participants expressed the concern that placing trust in a DMS to detect hazards could lead to drivers over-relying on the system, and thus encouraging risky driving behaviours, such as mind-wandering and a loss of focus. In this way, participants spoke about DMS potentially having a counterproductive effect by fostering a sense of complacency:

1: "But that really kind of interests me as well, because again are we not kind of saying, "**it's ok if I forget** that they're there". So cognitively you're almost being kind of lazy in that you're kind of allowing the car to do the work. But then what if it doesn't work in that particular moment? **What if there's a fault of some kind**, or whatever, you know? So you're kind of looking at stuff like that as well.".

2: "People becoming more dangerous because they don't have to focus.".

1: *"Exactly, yeah. Because they're losing their focus because, you know, **they're just becoming more cognitively lazy**, you know?"*.

A related thought shared by participants was that delegating responsibility for maintaining safety to a DMS could diminish a driver's own capabilities over time. It was felt that while a DMS could have the potential to improve driver safety, this could come at a cost to the driver's own ability to detect hazards and respond appropriately. In this sense, becoming dependent on a DMS to oversee safety could lead to a drop-off in drivers' overall skill level in the long-term. Moreover, participants were sceptical of the very nature of delegating responsibility to a DMS. Contemplating the wider implications of becoming dependent on such a system, they felt that it represented a form of absolving the driver of responsibility entirely. They expressed the concern that it could lead to drivers misusing the system by taking the opportunity to engage in dangerous behaviours, knowing that a system will be able to oversee safety. According to participants, the onus should remain on the driver to act responsibly.

3.3.2. A Lesser experience

This subtheme speaks to the potential for DMS to diminish the *enjoyment* that drivers derive from driving. Integral to this subtheme is the idea of the car as a 'sanctuary' – a haven from the technology that drivers interact with in their everyday lives. Participants felt that their time spent driving offers respite from being monitored, and the introduction of DMS into the car could challenge this. For participants, part of the enjoyment that they derive from driving is related to this opportunity for space between them and the technology they otherwise constantly engage with: *"**There's a little bit of safety in a car that there isn't in a lot of other areas in life.** Obviously there's also different dangers in the car, but like I feel like it would kind of reduce, like if there's something there that's always watching you in your car, it kind of reduces that like control that you get by being able to drive and just get in your car and go somewhere."*.

Another salient notion was that of 'driving for pleasure': participants expressed that they found the simple act of getting into a car and driving somewhere to be enjoyable. They were concerned that if a DMS was introduced to the car, they would feel less inclined to view their car as a source of recreation and would come to view it merely as a means to an end. Indeed, participants were also concerned that the self-consciousness they might feel from being monitored would also lessen the enjoyment they felt from driving their car. Furthermore, participants were somewhat resistant to the idea of needing a DMS in the first instance, expressing that they were happy with the level of technology that was currently in their car. Participants felt that in-vehicle displays or interfaces introduced into the car by a DMS could introduce new sources of distraction and detract from their overall experience of driving. In this sense, they felt that DMS could be perceived as a nuisance, particularly if it requires the driver to attend to new sources of information.

Taken together, this theme encapsulates the perceived risk that driver monitoring poses to the practice and experience of driving as we know it. Participants were apprehensive about the notion of placing trust in a system of this type, and speculated on how it could result in drivers forming an overreliance on the system, and in lapses in drivers' vigilance and attention. Indeed, there is evidence that increasing automation of a system can result in the development of passive fatigue. In a vehicle equipped with an ADS, the role of the driver changes from an active operator to a system supervisor (Kyriakidis et al., 2019). Placing too much trust in an automated system can have deleterious effects on an operator's performance – in this case, the driver's ability to respond to a takeover request in time. Too much trust can also lead to the development of what has been referred to in the literature as 'automation complacency' (Parasuraman et al., 1993; Wickens et al., 2015). However, the term automation complacency has been criticised for potentially placing undue blame on operators (Liu, 2023), particularly given the extreme difficulty of passively monitoring the environment whilst maintaining constant alertness (Shinar, 2019). Therefore, drivers who use this technology need to be supported in calibrating their trust levels relative to the capabilities and reliability of the system they are using.

With the introduction of automated driving systems (ADS) and driver monitoring, the definition of what is considered 'normal' with respect to driving is changing rapidly. Participants in this study felt that the introduction of these new technologies to the driving environment could diminish the enjoyment they derive from driving. A growing body of evidence suggests that comfort and enjoyment are important predictors of drivers' acceptance of ADS (Hartwich et al., 2018). Furthermore, studies examining comfort have found that a driving style that is similar to manual driving is associated with greater acceptance of fully automated vehicles (Haghzare et al., 2021). Similarly, driving styles that are human-like are rated as more comfortable and more natural (Peng et al., 2022). The findings of this study expand on those of previous studies that have focused on ADS exclusively. They do so by showing that drivers are resistant to engaging with driver monitoring systems when they are seen as less enjoyable, less comfortable, and less natural than the traditional driving experience. Future work should investigate how driver comfort can be optimised when driving monitoring features are present in a vehicle. As driver monitoring systems become more commonplace, user comfort and enjoyment will become increasingly important concepts for understanding user acceptance.

3.4. Real-Life driving is unpredictable

The general scepticism held by participants arising from the assumption that driver monitoring can never reliably interpret the wide-ranging and often unpredictable behaviours that drivers engage in, in all contexts, is the essence of the theme '*Real-Life Driving Is Unpredictable'*. A key reason cited for holding such scepticism was the idea of the 'edge case' – a situation (or in this case, a person or a behaviour) outside the boundaries of what participants felt that a DMS would be able to respond appropriately to. Participants explained that the variation in how drivers might respond to the same stimulus would prove problematic for a DMS, and these existing person-to-person differences were a barrier to drivers perceiving themselves as being able to trust the system: *"…because I think there are such a large range of people and how they move, how they interact, even physical differences from one person to another… I wonder how difficult it is I suppose to, again, account for those edge cases"*.

Similarly, participants were keen to emphasise the complex and unpredictable nature of *the driving task* itself – one that requires a wildly different set of responses depending on the circumstances at hand. What may be interpreted by a monitoring system as dangerous driving in one context could be an appropriate course of action in another. Participants felt that driver monitoring could fail to recognise the nuance and complexity that exists within driving, and they anticipated the risk of being mischaracterised as a risky driver in exceptional circumstances. Participants felt that driver monitoring could run further risk of misinterpreting certain behaviours if it fails to recognise the influence of the external environment. Factors such as weather or road conditions could require drivers to perform certain actions that a DMS may have been coded to interpret as unsafe driving.

A further source of scepticism for participants arose from the distinction they made between the environment they imagined these systems being developed within – that is, the freeways of North America – and Irish roads, particularly those of rural Ireland. For participants, the unpredictability and variability inherent to driving is further exacerbated by the unpredictability and variability inherent to *driving in Ireland.* What a system may be well-equipped to respond to may not translate to Irish roads, which were perceived as drastically inferior by participants, thus serving as a barrier to trust: *"…like if we're just talking about the Irish context, like if it was an* *interstate in America then maybe, but just the nature of the infrastructures in place in Ireland, like I just wouldn't be comfortable with… and just the amount, even on good roads, the amount of variability in driving in particular is just, it wouldn't* […] *there' just so much margin for error in…* […] *there's just so much variability in the external environment that like I could never trust it enough, that technology enough to do it for me."*.

The unpredictable nature of driving was connected to the belief that participants had that the behaviour of *other people* was more relevant to their safety than their own behaviour. For participants, a DMS could fail to consider what they saw as a critical risk factor – that is, the actions of other drivers and pedestrians, which they currently feel is a larger source of concern during their regular driving. Finally, unpredictability and external factors were used to articulate the idea that driver monitoring may not be the solution to improving driver safety. Participants felt that a more holistic approach – one that augments the perceptive capabilities of the driver vis-à-vis their environment – would be preferable to an approach where the driver merely receives alerts or feedback on their own behaviour.

Taken together, this theme sheds light on the importance for participants of having an accurate mental model of the reliability of driver monitoring systems during automated driving. Close comparisons can be drawn between this theme and the literature concerning automation reliability, which has been identified as significantly impacting trust (Gegoff et al., 2023). It has been observed that humans tend to initially underestimate the reliability of an automated system (Hutchinson et al., 2022), and that greater exposure to an automated system can help an operator to correctly calibrate the reliability of that system to its true reliability. However, mere exposure to an automated system may not be enough to foster trust, and previous work has stressed that situation-specific reliability must also be considered (Masalonis & Parasuraman, 2003). In other words, operators of a system need to be aware of the situations that can have an impact on the reliability of a system. This method of managing an operator's expectations could have implications for user acceptance. In the context of vehicle monitoring, there are numerous environmental factors that can affect the accuracy of the sensors used to acquire data by these systems. They include weather conditions, illumination sources, and temperature variations (Linnhoff et al., 2022; Betke et al., 2000). Increasing the transparency of an automated system has been associated with increased trust (Gegoff et al., 2023). For drivers to place trust in this technology, they need to be informed of not only their benefits but also their limitations.

3.5. 'Big Other is Watching You'

The term 'Big Other' is used by Shoshana Zuboff in 'The Age of Surveillance Capitalism' (2019), to describe the large network of surveillance and monitoring strategies employed by technology companies – so-called 'Big Tech' – to obtain vast amounts of data about individuals. It was used as the basis for the name '*Big Other Is Watching You',* the next theme, as it captures feelings of discomfort and self-consciousness that participants described at the prospect of being watched by a driver monitoring system.

This sense of discomfort was tied to a general perceived ambiguity and uncertainty regarding what happens to the data collected by a driver monitoring system, and who can access the data. For participants, there was an uncomfortable lack of clarity with how driver monitoring data would be managed. One assumption which served as the basis for this feeling of discomfort when it came to being monitored was the idea that no data is ever completely safe. In other words, the idea that data, once collected and stored, will inevitably fall victim to hacking, leaks, or other data breaches, and this perceived inevitability was an added source of unease associated with the prospect of being monitored. Driver monitoring was also construed as a strange, invasive form of surveillance on an uncomfortably large scale. Participants articulated this by emphasising the potential for a DMS to collect vast quantities of data from drivers. Such extensive monitoring was perceived by participants as overstepping the boundaries of how they might expect to be monitored, or the kinds of data that they might expect to generate about themselves:

1: "I suppose my worry is would this company have in theory, depending on how much I'm driving, potentially hundreds of hours of just recordings of my face? **That's weird to me**. Do other people find that idea weird?".
2: *"Yeah, I would agree with that. **There's something quite invasive about it.** I mean, the video was all kind of positive and, you know, you'll never leave your child alone in the car, and that's all great, but there's a kind of offset to that… the amount of data they're collecting about us, and what they're doing with it."*.

Relatedly, the feeling of invasiveness was accompanied by a sense that drivers would have no say in the amount or types of data collected about them by a DMS. Participants felt that if they were to purchase a vehicle with an accompanying DMS, they would have little choice but to agree to have vast quantities of data about them collected and would have no control in how much data was to be collected. This expectation formed the basis for participants construing driver monitoring as having the potential to be coercive in how it collects driver data: *"I think it seems to come down to that thing of……. it seems to happen a lot, where just by clicking on "buy this product", it seems to be that yeah, you're just signing up to all of this, which seems very... **I can't find a better word than "coercive"**."*.

Another key facet of this theme related to anticipated feelings of self-consciousness or shame as a result of being monitored while driving and receiving feedback on 'incorrect' driving practices. Participants felt that the presence of sensors or cameras recording and interpreting their every move could make them feel as though they were being examined. This anticipated self-consciousness was interpreted as potentially being counterproductive for driver safety. In other words, it could have the potential to make drivers more anxious, resulting in less safe driving behaviours than they would normally exhibit without the presence of a monitoring system assessing them. Finally, the concept of vast and extensive monitoring was framed as an unfavourable trade-off: exchanging the entirety of one's privacy while driving for a modest improvement in their safety. Driver monitoring was seen as potentially offering fewer benefits to the party being monitored than it would to those doing the monitoring. In this sense, the prospect of constant surveillance behind the wheel was not seen by participants as entirely 'worth it'.

This theme shows that drivers have serious privacy concerns when it comes to driver monitoring systems. Perceived privacy risks have been documented in the literature has having a negative impact on intention to use a system (Harborth & Pape, 2019; Waung et al., 2021). In the context of automated driving, Josten et al. (2017) looked at individuals' willingness to share data, and the types of data that were considered acceptable to share. They found that all driver-related data was not considered shareable by the majority of participants. Furthermore, participants expected that their privacy would not be protected while using an automated vehicle. A parallel can also be drawn between DMS and usage-based driving insurance (UBI), in which an insurance company collects driver data using a telematics device. It has been documented that a perceived cost to one's privacy can negatively impact adoption rates of UBI programmes – however, economic incentives result in higher adoption rates (Soleymanian et al., 2019). Therefore, if data obtained from a DMS is to be shared with insurance companies, drivers need to be convinced of the financial benefits of doing so; safety benefits may not be enough to encourage adoption.

3.6. Data exploitation

The final salient concept resulting from the focus groups was the notion that driver monitoring could introduce new ways in which data could be utilised in undesirable ways. This recurrent idea formed the basis for the theme '*Data Exploitation*'. Participants were concerned that adopting driver monitoring technology could have negative consequences for the driver themselves – in particular, that their data could be *used against them* in some way. This fear of having data about oneself weaponised against them was seen as a particular concern if third parties had access to this data. For instance, participants contemplated the risk of an increase in their driving insurance premium if driver monitoring data was used to infer the presence of a health condition:

1: "Yeah, I wonder how it's calibrated, because a lot of – just pretty basic health conditions – if someone has high blood pressure, they're more likely to have a higher heart rate. How is that being calibrated? Is it being calibrated against their baseline normal, or against a population baseline normal? Because those can be two wildly different categories…".
2: "And then do you have to tell your car that you have a health condition so it can recalibrate and now that is officially on record.".
1: "On record. And then it goes back to the insurance thing of can your insurance company access that information. **Because if they think you have health problems, they will put your insurance policy up**. I am well aware of this because I pay more for mine.".

Participants also speculated on the potential legal consequences of driver monitoring data being exploited for purposes other than safety. One concern that was tied to this perception of exploitation was the prospect that driver monitoring data could be used to falsely accuse drivers of wrongdoings, either through inaccurate interpretations of their data, or through the creation of AI-generated 'deepfakes' (i.e., a falsified video in which one person's likeness has been altered to impersonate another), that participants feared could be created using images and videos collected by DMS.

The risk of driver monitoring data being exploited was seen as particularly concerning due to the participants' perception of this type of data as 'objective' – in other words, the ultimate form of evidence. Participants anticipated that decisions based on driver monitoring data would be very difficult to argue against due to this perception. They felt that in a road traffic accident scenario, all other forms of evidence could be seen as inferior, and that as a result, data from a DMS could be exploited to assign blame. A key source of exploitation for participants was the potential for driver monitoring data to be turned into a commercial product. Participants were resistant to the idea of an 'ecosystem' being created – one in which driver data can be bought or sold for purposes other than improving their safety.

This theme highlights the grave concerns that participants have about the potential for driver data collected by a driver monitoring system to be used for secondary, harmful purposes. There is some precedent for biometric sensor data being used as evidence in criminal proceedings. The data obtained from wearable and medical devices has been used in a personal injury case in 2014 (Paton et al., 2016), and to charge a man with arson and insurance fraud in 2017 (Maras & Wandt, 2020). Users of technology are growing increasingly aware of the ability of technology companies to predict, modify and monetise behaviour based on vast amounts of data collected about themselves – otherwise known as instrumentarianism (Zuboff, 2019). This has implications for future work exploring acceptance of DMS and ADS, as it demonstrates that users want transparent information about how their data is being used before they are willing to place trust in a system.

Participants in this study also had concerns for the potential commodification of driver data as a result of using this technology. The data collected by a driver monitoring system, such as cardiovascular and eye-tracking data, are data concerning health under the General Data Protection Regulation (GDPR). This category of data warrants special considerations to ensure that it is protected – one of which being that the data must be collected only for a specific, explicit, and legitimate purpose (referred to as purpose limitation; Mulder & Vellinga, 2021). In relation to the sharing of driver data with third parties, the General Safety Regulation (GSR), which began to apply in the European Union in July 2022, stipulates that the sharing of driver data with third parties is prohibited, and that the data should be deleted immediately after processing (European Parliament and Council, 2019). Furthermore, as Mulder & Vellinga (2021) point out, health data collected during an automated drive cannot be sold to an insurance company to make adjustments to the driver's insurance premium under the GDPR, unless the user gives explicit consent to the fleet operator selling their data. Informed consent will become increasingly paramount as driver monitoring systems become more common in privately owned vehicles, and potential sources of data exploitation increase. As voiced by participants in this study, there is potential for ambiguity concerning what drivers are consenting to when they consent to being monitored.

3.7. Summary of practical implications of the study

Some key considerations for future practical work based on the findings of this study can be found in Table 2.

3.8. Strengths and limitations of the current study

The key strengths of this study include an approach to analysis that facilitated both semantic and latent insights into the data to be generated. Secondly, the use of focus groups offered several advantages over one-on-one interviews; it facilitated a deeper and more nuanced discussion, as participants were able to interact with each other to discuss complex ideas. Finally, the use of an open-ended interview schedule brought new and salient insights to the interview data. In terms of limitations, the focus of the interviews may have limited certain insights from being included in the analysis. Specifically, we were interested in understanding drivers' attitudes towards driver monitoring systems *within* vehicles equipped with an ADS, and so comments surrounding ADS that were independent of driver monitoring systems were not included in the thematic analysis. Furthermore, while every effort was made to recruit a diverse group of participants in terms of age, the sample nonetheless included more younger than older adults, with the former tending to be more accepting of new technologies than the latter. Relatedly, it is also a limitation that more comprehensive demographic information about the sample was not collected, such as driving frequency or level of experience with advanced driver assistance systems (ADAS). This was not done to minimise the risk of participants being personally identified. Nonetheless, richer demographic information could have more comprehensively informed the interpretations of the data.

4. Conclusion

This qualitative focus group study used a reflexive thematic analysis approach to understand drivers' perspectives on the use of driver monitoring systems during automated driving. Through the development of five themes, it was found that drivers perceive driver monitoring systems as a supplemental layer of support that has the potential to be valuable during occasional critical moments. However, these modest perceived benefits were contrasted with a considerable perceived sacrifice to one's privacy, a risk of drivers coming to over-rely on advanced safety features, and an anticipated reduction in the enjoyment derived from everyday driving. These findings highlight that the individual and societal benefits of automated driving may not be fully realised unless drivers are also accepting of DMS. Moreover, DMS could enhance the perceived value of automated driving among the public. Security and privacy concerns can also be allayed through the provision of transparent information about how driver data is to be collected, used, and by whom, thus emphasising the importance of informed consent. The nature of the driving task is changing rapidly, and to ensure that public perceptions change with it, the human driver's interests need to be placed at the forefront of the development of these emerging technologies.

Table 2
Considerations for future practical work based on the findings of this study.

Finding	Challenge	Recommendation
Automated driving systems and driver monitoring systems are clearly perceived as separate entities, as opposed to two systems working in partnership to improve driver safety.	There is an impending requirement in the European Union for all new vehicles to feature a driver monitoring system. The individual and societal benefits of automated driving will not be realised unless drivers are accepting of both systems. There is therefore an urgent need to consider driver monitoring systems alongside automated driving systems when seeking to understand and increase acceptance.	In isolation, the value of one system may not be fully recognised by drivers, but with the context of how the two systems work in tandem, the perceived benefits of one system may help to address the perceived challenges of the other. For example, automated driving allows the driver to disengage from the driving task, and drivers can be reassured by the knowledge that this is made safer by a driver monitoring system.
With the introduction of novel sensors into the vehicle, drivers want an experience that is comfortable, natural, and as similar to traditional driving as possible.	Drivers are resistant to engaging with new technologies such as driver monitoring systems when they are seen as less enjoyable, less comfortable, and less natural than the traditional driving experience.	Human-machine interfaces for an in-cabin monitoring system should be designed with both pragmatic and hedonic qualities in mind.
Drivers are sceptical of the reliability of driver monitoring systems and are concerned about the various environments and scenarios that could negatively impact system reliability.	Issues with the perceived reliability of a system will act as a barrier to drivers placing an appropriate level of trust in a system. A mismatch between performance expectations and system capability can negatively impact acceptance.	Drivers need to be informed of the reliability of monitoring systems, including the types of situations that are likely to affect their reliability.
Drivers have concerns about both the security of driver data collected by monitoring technology, and how it could be sold to third parties and used in harmful ways.	Perceived privacy risks can have a deleterious impact on intentions to use a system. Most forms driver data are considered personal data, and as such need to be handled with extreme care, especially if the data is to be shared. There is also potential for ambiguity concerning what drivers are consenting to when they consent to being monitored, which could further negatively impact system acceptance.	There is a need to convince drivers of the personal benefits of sharing their data, in situations where driver data is requested; safety benefits may not be sufficiently compelling. It also emphasises the importance of informed consent in an instance where fleet operators wish to share information with third parties.

CRediT authorship contribution statement

Rory Coyne: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Michelle Hanlon:** Writing – review & editing, Project administration, Investigation, Conceptualization. **Alan F Smeaton:** Writing – review & editing, Supervision. **Peter Corcoran:** Writing – review & editing, Supervision. **Jane C Walsh:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary material

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