



The Select Committee on Science and Technology

Corrected oral evidence: Autonomous Vehicles

Tuesday 22 November 2016

10.40 am

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Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Neville-Jones; Lord Oxburgh; and Baroness Young of Old Scone.

Evidence Session No. 7

Heard in Public

Questions 55 - 62

Witnesses

[I](#): Professor Sarah Sharples, Associate Faculty Pro-Vice-Chancellor for Research & Knowledge Exchange, Professor of Human Factors, Faculty of Engineering, University of Nottingham; Professor Natasha Merat, Professor in Human Factors of Transport Systems, Institute for Transport Studies, University of Leeds; and Andy Graham, Director of White Willow Consulting and Founding Chair of ITS (UK) Connected Vehicles Interest Group.

USE OF THE TRANSCRIPT

1. This is a corrected transcript of evidence taken in public and webcast on www.parliamentlive.tv.

Examination of witnesses

Professor Sarah Sharples, Professor Natasha Merat and Andy Graham.

Q55 The Chairman: On behalf of the Committee, could I welcome our three witnesses to this, the penultimate session of oral evidence on this inquiry? We are being broadcast, so I am going to ask you first if you would like to introduce yourselves for the record. If you would like to make an opening statement, please feel free to do so. Could we start with Professor Sharples?

Professor Sarah Sharples: Thank you. I am Professor Sarah Sharples. I am a professor of human factors at the University of Nottingham where I am also the associate pro-vice-chancellor for research and knowledge exchange in the Faculty of Engineering. I am also the immediate past president of the Chartered Institute of Ergonomics and Human Factors and a non-executive director of the Transport Systems Catapult. As an opening statement I would like to comment on the contribution I can give today. My expertise looks at the impact of automation on human performance in a range of contexts, particularly in transport. From a human factor specialism point of view we know that people respond to automation technologies in different ways and that it changes the way they behave. We need to take their cognitive capabilities into account when we design these automation technologies.

Within the role I have within the Faculty of Engineering I also oversee other groups, particularly a group led by my colleague Dr Gary Burnett, which looks at human-machine interfaces for autonomous vehicles and future vehicles generally, and [colleagues in the faculty] work on other relevant areas, including electric power systems and positioning technologies.

The Chairman: Thank you very much. Professor Merat?

Professor Natasha Merat: Good morning. Thank you very much, first of all, for the invitation. My name is Natasha Merat, and I am a professor of human factors of transport systems at the University of Leeds Institute for Transport Studies. The institute is the biggest place for academic training and research in transport, and my work involves looking at human interaction with technology, particularly drivers in the car and pedestrians outside the car. I will say a little about what I do more specifically in answer to the next question.

Andy Graham: Good morning. My name is Andy Graham. I am director of a company called White Willow, but I am also the previous chair of the ITS (UK) group on connected vehicles. ITS (UK) is a group of about 150 organisations, and we are focusing on the outcomes and solutions from linking automated vehicles, roads, data and drivers together. Although we look at the technology, we are really interested in the problem we are trying to solve rather than necessarily the bits and bytes.

Wearing various other hats, I also work with the Transport Technology Forum, and I have been doing work with one of your other witnesses from the City of York Council on how we can make signals work better with data from vehicles. We note

that your inquiry is into autonomous vehicles, but we believe that a lot could be done with the data from vehicles as they stand, particularly on the capacity and safety of current road networks.

- Q56 The Chairman:** That reminds me to note that our inquiry is not just about autonomous vehicles but very much about connected vehicles, and we recognise that the government strategy is to follow two not necessarily compatible strands of development: one a leapfrog perhaps towards autonomous vehicles, but one that certainly has more credibility at the moment of connected vehicles and incremental improvements to existing technologies. In light of that, I wonder if you could each, as Professor Merat anticipated, tell us how your work relates to these activities and these policies. Perhaps Professor Merat would like to start.

Professor Natasha Merat: Thank you very much. My work looks at the interaction of people with automated vehicles. My background is in psychology, so a lot of my work is understanding the behaviour of people. We have used the University of Leeds driving simulator for the last 10 years or so looking at what people do in the vehicle when it is highly automated: where they look, what kind of activities they might engage in when the vehicle is effectively driving itself, how quickly they resume control of the vehicle if there is an imminent crash/potential conflict, and so on.

In the last few years I have also been looking at the interaction of pedestrians and cyclists outside such automated vehicles. The work I do is funded mostly by the European Commission and the UK Government. We have two particular projects at the moment looking at the driver inside and the pedestrians outside. We have European-funded projects where highly-automated level 4 vehicles are running around in cities in Europe—as we have coming up in the next few months in the UK. We are asking pedestrians and cyclists what they think about these vehicles and what kind of information they want, and so on.

As part of doing more and more work in this area, I also have been involved in workshops and advisory groups for the UK, the European Commission and the US Department of Transportation. I chair a committee in Japan, the US and Europe on the potential implications of these vehicles on society and what it means for informing the driver and the public. The biggest matter for me is managing expectations. The words “driverless” and “autonomous” are very confusing and give the wrong impression to people. You might notice as I am talking that I use the word “automated” rather than “autonomous”. I looked “autonomous” up in the *Oxford Dictionary* recently and it refers to vehicles, but generally speaking it means that the system itself has control and power. We are not in that situation at the moment. I work a lot with the car manufacturers and we are talking about where we are at, where we are going and the user’s understanding of these systems. Considering that on a daily basis is a real challenge. The media et cetera talk about these systems but it is a bit of hype, to be honest.

The Chairman: At which level do you think these issues kick in?

Professor Natasha Merat: At the moment, level 2 is in some vehicles. We still have to monitor the system. The autopilot is mentioned in some vehicles, but we are still in control. There is a desire to come to level 3, but some manufacturers want to skip that and go straight to level 4, where they are then responsible. I must stress that it is very much about prototypes at the moment; it is very much about testing and deployment on a small scale rather than us, at least on the private side, being able in five years' time to get into these vehicles and they drive us from A to B.

On the more public vehicle side, the sorts of things going on in Milton Keynes et cetera are level 4, at very low speed because you are interacting with pedestrians and cyclists in a shared space, and very much under control. There is still an operator in there. It depends who you speak to. Some of my human-factor colleagues are talking about 2075 for level 5, so I am certainly not going to be around. It very much depends on public acceptance of how these will work in our cities. That still has to be decided.

Professor Sarah Sharples: My perspective is slightly different in that I am interested in the fundamental concepts of human behaviour and the human factors knowledge we already have which is of specific relevance to autonomous vehicles, as well as some work that my colleagues have done particularly on autonomous vehicles, which I will explain a little.

There are a couple of notions that it is important to be aware of. The first is workload. We know that humans perform best when there is an optimal level of workload, but identifying that optimal level of workload is quite difficult. We know that human performance can suffer when we are underloaded and overloaded. One of the things that is incredibly important with autonomous vehicles is understanding the implications of the introduction of increased autonomy into the driving task, which is quite a demanding task in its current form, on the capability of humans managing an appropriate level of workload by being able to respond to an emergency situation and to maintain vigilance and attention to the driving task.

Another concept we use in human factors and have a lot of knowledge about from other contexts—I know that in previous discussions you have looked at examples from the aviation industry—is situation awareness. Situation awareness refers to: perception—to what we can physically see or interpret from the situation; comprehension, the understanding, of the situation; and the prediction of the future state of a situation. It is used very commonly in air traffic control, for example, to predict the future position of an aircraft and to help manage aircraft. In autonomous vehicles, understanding how the introduction of these new systems will impact on driver situation awareness is incredibly important. There is work going on on how we design displays or interaction to both maintain situation awareness while a driver is driving and to enable a driver to regain situation awareness very quickly once they move from the autonomous mode to a manual mode. We know that that handover point is important.

The final thing I would note in this context is there is a lot of knowledge out there. An excellent paper was written in the 1980s on the unintended consequences of introducing automation, called *Ironies of Automation*. In this context it was work in

the process control industry. Some of the notions introduced are relevant here. For example, there was interest in deskilling. If we introduce automation, do we lose the capability to maintain skills? On some of the questions that will come up later, this has relevance to the driving test and how we manage that. There are many other relevant concepts. For example, we are asking a human to monitor technology. But the technology is performing with a capability that is of a higher resolution and speed than the human's perceptual system. That is an irony, because we are asking a human to monitor something that is doing a job, theoretically, better than a human is capable of doing it.

The Chairman: Perhaps you could send us the reference to that paper.

Professor Sarah Sharples: Absolutely, yes. It is an excellent paper.

Andy Graham: ITS (UK) has focused on "Where do we get off the ground?" I am glad you mentioned aviation, because in some cases we are trying to build the airliner that flies the Atlantic before we have got one off the ground. We are looking at those kinds of early steps, in particular what the changes to the safety and accident rates would be from the developments in technology for human driven cars that are coming in. That could change the pattern of accidents. We cannot save accidents with highly automated vehicles if they have already been saved along the way.

We are also interested in the impacts on capacity and how we could make traffic signals better with a mix of vehicles. I think it is fairly clear from all your witnesses so far that we will not be able to stop the world. Many of the benefit calculations that we see, the headlines, assume that we can move directly to fully automated vehicles and not have cyclists or pedestrians, everything works and it never rains. When you start diving into the detail there are some quite interesting questions about the evolution and the mix of vehicles, particularly early days.

We are also interested in the way we can use data from vehicles at the moment to improve, for example, emissions. Some good work has been done on reducing the timing problems at traffic signals. You might say that reduces the emissions out of the tailpipe, but it also reduces the amount of tarmac wear. Tarmac is one of the contributors to particulates are the emissions we worry about in cities. There is a double benefit in that in taking data we may be able to make things better and improve road networks without the need for so much automation.

I have mentioned the work that we are doing to look at how we could use data within junctions in the UK without having to change much of the existing infrastructure. The ITS (UK) people I am working with are focusing on where we start from now to get to this "flying the Atlantic" target. I am very much aware of the work done on human factors, and that people are probably the biggest barrier to driverless cars that we see.

The Chairman: Thank you very much. We must move on.

Q57 Lord Mair: My question is for Professor Sharples. You have already referred to emergency situations. I want to know a bit more about what is known about this difficult situation of handing back control from an autonomous vehicle to a human.

You said in your written evidence that much more work is needed on that. Can you elaborate?

Professor Sarah Sharples: My colleague Dr Gary Burnett led a very small-scale study in the summer that identified some of these issues that are starting to emerge. He has worked in a driving simulator. He asked people to come into the driving simulator every day for five days and behave as if they were on their normal commute to work, which he built up as a 30-minute commute on a motorway. He told the participants that they were in a fully autonomous mode while they were driving—they engaged the fully autonomous mode after about two to three minutes—and he observed the behaviours people started to demonstrate through this time.

This very early stage small-scale study, which was done with internal funding rather than external funding, demonstrated a few things. It demonstrated, first, that people very quickly became accustomed to and began to trust the autonomous technology and started to change their behaviour. This was a slightly artificial situation. It was perhaps exaggerating; we were asking people to imagine that it was okay and acceptable for example to read your emails while driving along, and, sure enough, that is what people did. They adjusted their chairs to watch films. Very interestingly, they put their reading glasses on because they were attending to information inside the vehicle rather than outside the vehicle.

On day four, this work introduced an emergency handover request. The drivers were given a small number of seconds to take over manual control from the vehicle. The research team identified a couple of things: first, that drivers did not seem to be continually monitoring the display on the vehicle to alert them of this possibility; secondly, they panicked a bit when they found they had to take manual control and immediately focused on the control element of the driving, taking hold of the steering wheel and the accelerator, and they did not have time to take their reading glasses off. It is a small but very relevant example of the need for a deeper understanding of the different scenarios, how long a realistic time for that handover request should be and what type of information needs to be given to people in the build-up. I know from the written evidence that there is some work at Southampton that talks about a “chatty” display. We could look at the way we design the technologies to maintain the driver’s situation awareness even while the car is an autonomous vehicle, for example.

Lord Mair: Can I follow that up? What you have described is very interesting, and it is essentially in a simulator.

Professor Sarah Sharples: Yes.

Lord Mair: What is your view on full-scale trials and investigating that same behaviour but in the real thing, where a vehicle is moving and again there is this hand back of control?

Professor Sarah Sharples: My recommendation would be that we look for a mixed-methods approach. Simulators are incredibly useful for looking at safety critical scenarios; Natasha has more expertise on this, so I will let her add to this later. They

are also very good for what we call “relative validity”. If you are comparing two different set-ups and two different scenarios, a simulator is very good at distinguishing between the effects of those different scenarios on behaviour, but full-scale trials are the only way we can get that systems and situated understanding of the implementation of new technologies. As I said, I am associated with the Transport Systems Catapult, and some of the early data from the demonstration they ran a few weeks ago was very positive, for example the public attitude towards those vehicles. It is only when the public see those vehicles deployed in a real situation that we can start to understand what people might think when they see these new technologies implemented in the context they are so familiar with.

Lord Hennessy of Nympsfield: I am very interested in those early results, but can I come back to something Andy said? He thinks that people will be the biggest barrier to all this. You know about people’s psychology and I do not, but it seems to me that since the chariot some people have seen wheels as an extension of their personality. I would imagine that the people you used in these early trials are nice, herbivorous types; they are not boy racers. We are going to have to change human nature for this to work, are we not, on quite a grand scale?

Lord Maxton: We already have. My grandfather never saw a motor car.

Professor Sarah Sharples: Let us think about how quickly we become accustomed to technology. First, I agree with you. From past work I did as part of a digital economy funded project with the Horizon Digital Economy Research Institute, where we looked at car sharing, we found that some people were willing to engage in car sharing and others wanted their own cars. Some people love their cars; we know that. We also know that people will change their behaviour. Think about how accustomed we have become to satellite navigation devices, for example. Think about the fact that we are all so accustomed to using our tablet computers, but the iPad was only in the shops in 2010. That is a really short time ago, yet we have changed the way we work so quickly in response to these deployed technologies.

If you will forgive me, I will give another example from another context. I do not know how many of you have played Pokémon Go, but it is a game that was launched in the last few months and has absolutely changed the way humans behave in that particular environment and context. Some very nice research by some of my colleagues at Nottingham 10 years before looked at those sorts of games in a deployed context in which they put people in towns using technologies. That sort of simulated but full-scale trial identified a number of the issues that were evident when Pokémon Go as a game was deployed in real life. These full-scale trials can be very powerful at predicting how people will adapt.

One of the things that I say to my students is that humans are fallible but humans are brilliant. We know that humans are great at adapting to new situations and changing the way they work with new technologies, but we need to be aware of their capabilities and limitations when we design those technologies.

Baroness Young of Old Scone: Can I ask about one other issue and see whether there is any research evidence on it? There has been quite a lot of talk about the

fact that we will all move quite rapidly to buying mobility services rather than owning vehicles. Your car-sharing research might cast some light on this. In some respects, for many people cars are a very convenient way of moving their life around with them.

Professor Sarah Sharples: Absolutely.

Baroness Young of Old Scone: Is there any evidence that that will be a resistance factor if we are no longer vehicle owners?

Baroness Neville-Jones: You mean the junk they keep in it?

Baroness Young of Old Scone: Yes. My horse gear never moves from the car.

Professor Sarah Sharples: Yes, but, again, I would use an example. Uber has absolutely transformed the taxi as a service context in the last two years. Uber is not a transport company; it is a technology company. Uber's key success is that it has thought about the human requirements: the requirement for safety—for assurance about the driver; the requirement for ease of payment and the business model, and ease of access. Human behaviour is driven by a multitude of things. One of those is convenience, some of them are safety and some of them are business models. Thinking about all those different aspects together is one of the important things. Autonomous vehicles will succeed when there is an appropriate business model and appropriate safety model and it fits our societal and behavioural needs.

Professor Natasha Merat: As for us liking driving, absolutely, but, as I have already mentioned, we do change our behaviour. In our research we found that it is very attractive to older people who were thinking that they might not be able to drive for much longer, and to younger people; there is real evidence now that young people do not want to spend money on a new car; they would much rather spend money on an iPad or an iPhone. They do not see the value. It is expensive, the insurance is high and you cannot park it, et cetera, et cetera. Society is already changing, hence the attraction, I guess, on the part of the manufacturers, for bringing what people will likely want in 10, 15 years' time—to sit in their vehicles and watch a video, as you say.

I love the quote from a French guy who held a TEDx event at the University of Leeds that cars will be like horses in the future; we will have these things that we will take to a place and ride around, or we might take them to the country roads and enjoy them. But for getting from A to B and it being practical mobility perhaps in 2050, we will see.

Lord Oxburgh: In considering the interaction between the vehicles you are describing and their surroundings—pedestrians, cyclists and other motorists—do you anticipate that they will be distinguished in some way; that there will be clear, visual signals to those outside that this has some level of autonomy or automation? Has much thought be given to this? It will influence a lot of things in vehicle design, I guess.

Professor Natasha Merat: Yes, they are definitely recognised as obstacles and the vehicle sensors stop before they hit them, so that is quite nice. But we are really not

there yet in interaction and communication. There are some fantastic examples. Google had one, obviously, which made the news. Our CityMobil2 European project put the vehicle in a very mixed environment along the beach in Sardinia, and it cannot be busier than that. A couple of guys are chatting in the pedestrianised area, the vehicle comes along and stops because these guys are in its way, they look over and carry on chatting because in a normal situation the vehicle would be able to go past the pedestrians. It does not. Nor does it say anything. Unless there is an operator on board who can manually take the vehicle out of the way or say, "Get out of the way", or whatever, that is where we are at the moment.

I do not know whether they were thinking about it beforehand, but in the last couple of years the manufacturers have definitely been saying, "Okay, we are in a very, very complicated situation where we will have to understand all the gestures and behaviours that pedestrians have, and there will be no car driver, so how do we now interact so that we can all work together in a mixed environment?"

Lord Oxburgh: My question is slightly different. How did the pedestrians know that it was safe to stand there and continue chatting?

Professor Natasha Merat: A good point. I do not know.

Professor Sarah Sharples: This issue is being looked into quite actively at the moment, because it has been raised. The first thing to note is that as pedestrians we already judge the behaviour of a vehicle before deciding to cross the road. Interestingly Volvo, I believe, has declared that it will make its more automated vehicles look the same as conventional vehicles, because it is worried that people might behave irresponsibly. I was surprised, because my instinct is that we need to give pedestrians a little more credit and allow them to make an informed judgment about the vehicle approaching.

The sort of thing that we can think about is the lighting display on the front of the vehicle. We have to remember that it is probable that an autonomous vehicle would brake more gracefully than a conventionally driven vehicle, so it might be slightly harder to detect that braking. Of course, with autonomy comes the increased use of electric vehicles, which are quieter, so we do not necessarily have the same auditory cues to the movement either. I agree that it is an essential area where we need more research and understanding.

Professor Natasha Merat: May I add a couple of points?

The Chairman: We have a lot to get through, so I will try to press on. I am sorry.

Q58 **Baroness Neville-Jones:** My question is also about human behaviour and human reactions. A driver knows, even if they are not very good at it, that at some point they will get control handed back. I want to ask you about situations that are unanticipated and unwelcome, such as an accident. One bit of evidence we have heard is that in this world of autonomous vehicles—and I would be interested to have your comments on the other aspect of the highly automated vehicle—this will help to reduce accidents. Do you reckon that we know enough about human behaviour to make that kind of assertion with confidence? What are the

considerations that lead to a conclusion of that kind, and do you agree with it?

Andy Graham: The accident statistics for the UK fall into two very broad groups. One is “did not look properly” in an urban area. You can see that a higher level of automation might help that. Increased sensors in human-driven vehicles that identify something you have missed might also help that. The other one, on rural roads, is loss of control: you were going too fast, you went round the bend too fast, and hit something. Again, vehicle sensors at the moment could contribute to that, and connected vehicles could tell you that round the corner there is a tractor going quite slowly. There is a lot of news at the moment about human behaviour in relation to things that already happen, such as mobile phones in cars. There have been 22 deaths associated with mobile phone use over the last few years. There are also ludicrous things such as running out of fuel and not having enough air in your tyres. More people may have been killed by having underinflated tyres than through mobile phones. There is a whole load of accidents that we will not necessarily deal with: a drunk pedestrian walking in front of a vehicle may still be hit because the automated vehicle still cannot stop quickly enough.

There are a lot of behavioural things, particularly if you look at the way the accident risk changes: it is highest when you are young and when you are old. Middle-aged people like me have had some experience of driving but we are not yet at the stage where we are a very large risk. It is in connection with young drivers and elderly drivers where perhaps the biggest benefits could come, subject to all the problems that if you do not have a driving licence and the vehicle hands back to you, what do you do? I would argue that the business case for a very high level of automation relies on not having to hand back, otherwise anyone under 17 will not be able to use this. There are lots of indications of elderly people finding this quite an attractive proposition, but if it suddenly hands back to them it might not be.

Similarly, you see lots of pictures where people are sitting enjoying a drink in these pods. What if it hands back to you? The hand back is not just about control but is a responsibility and legal area, and there is a lot of work, which I am sure you are exploring, on where accident problems might become worse with it, and equally on the sort of people we might get large benefits with. On the control side, we do not have a measure of how often it hands back. In aviation, pilots get handed back from autopilot reasonably regularly, but those are very, very complicated systems. My car does not hand back control of the engine management system to me; it degrades automatically. We do not have a feel for whether this will be a regular event, a once in 10 years event or a once in 100 years event. That would be worth exploring, because we all see that it could be a problem but we do not know how often it will occur.

Baroness Neville-Jones: It sounds as though there are still a lot of unknowns.

Andy Graham: Absolutely. We will explore all this stuff: real people in simulation, real people in on-road trials and real people with vehicles on tracks where, if they do go wrong, the safety driver can take over. But we do not know the answers at the moment.

Lord Hunt of Chesterton: Andy Graham, most previous witnesses to this Committee seem to have assumed that they will drive along with plenty of space between the vehicles. A friend of mine was in Tehran and took three hours to go about two or three miles. One of the biggest practical questions is how elements of automation will lead to people behaving. We know from a mathematical point of view that waves travel along, but if you have much better connections between the cars you could reduce that. I wondered whether the primary benefits will be the movement of cars and people's behaviour in highly dense situations, which is not how most of the discussions we have been hearing about have gone.

Andy Graham: Indeed. To get a benefit of capacity, say for the M25, you would need to have vehicles driving closer together than they already do on the M25, which in the fast lane is already quite uncomfortable. Quite a lot of work has been done at junctions. John Polak at Imperial has shown that to get vehicles to move through junctions you may get them to perform an acceleration that might feel very uncomfortable, and human-factors people have done a lot of work looking at people being car sick. There is a big question mark here in that, in order to get this high-capacity you might be very, very close to the vehicle in front and you might feel uncomfortable accelerating and decelerating, which in a way undermines the business case, because you have your laptop out and your cappuccino but you feel uncomfortable. We do not know. There is some evidence from other areas.

On the capacity side, there is also a problem with traffic signals in urban areas. We think there is some evidence that data from vehicles could be used to set signals better. You see all these examples of vehicles firing themselves through junctions without signals, but that assumes that there are no pedestrians or cyclists. Our gains in the short term would be marginal, but once we get to a higher level of penetration there will be higher capacity. There are also benefits in that we may have fewer accidents that cause delays, and if we can get four or five people into one of these mobility pods, that is four vehicles fewer on the road.

There is another point in that a mobility pod might drive a much further distance than it did previously, because "I can now work very comfortably, so I do more vehicle miles". Again, we do not know, which is why practical real-world tests in Britain are so important.

Lord Maxton: To be honest, taking Lord Hennessy's question and reversing it in a sense, motor cars have only been around for a very, very, short time in human history, yet we have adapted to the regular changes. The first motor cars had to have a man walking in front of them, if I remember rightly—from my history, by the way. My grandfather never saw a motor car, my father never had to pass a driving test, and so on. To what extent is the ability of the human race to adapt very quickly to change part of the research you are doing?

Professor Sarah Sharples: The Transport Systems Catapult did a study that I think is of relevance here, the *Traveller Needs* study, which identified different groups of people and their different attitudes. I forget the exact phrase, but I think it was "progressive metropolitans"—the people they identified who lived in urban environments, such as London, who were regular users of public transport, very

much engaged with smart phones and very willing to change and respond to disruptive technologies. We talk about disruptive technologies in a positive way from a research point of view. We know that those types of people and populations are very quick to adapt to change and are driven by business models, social needs and behavioural capabilities. I would agree with you that we need to acknowledge that human behaviour will adapt quite quickly.

We need to consider whether we are therefore going to end up excluding parts of the population. It is worth remembering that not all the population has a smart phone. I come from Nottingham, which has areas of significant deprivation and significant poverty, so accessing wi-fi is still a challenge for many people who live in many parts of our urban and rural environments in the UK. Making sure that we accommodate all in the developments we are investing in is very important.

We also need to think about whether we need to make sure that currently held skills are retained. We may need to do that almost artificially. Again, thinking about the capabilities for driving—I know there is a question about the driving test, which I must not pre-empt—we need to think about how to adopt changing behaviours and how to maintain the behaviours and skills that we currently have.

Q59 Lord Cameron of Dillington: First, picking up on Lord Hunt's point about traffic, in a rural market town you can always tell the people who have driven in the city, because when they come to a junction they push out into the moving traffic. Sometimes the country folk just sit there. In your automatic cars, will you have a knob that you turn up to make you slightly more aggressive or not? That is an aside.

My real question is that we are told that automated vehicles cut accident rates, as Baroness Neville-Jones has already said. We already have quite a low accident rate in the UK. I wonder whether automated vehicles are the best way of continuing our downward spiral of accidents or whether there are other methods of doing this, and whether there is anything in the psychology that you academics can work out, outside the whole automated vehicle sector, to reduce our accidents.

Professor Natasha Merat: They are coming, whether we like it or not. We cannot stop them now, in a way.

The Chairman: When you say "they are coming", what do you mean?

Professor Natasha Merat: They are being developed everywhere by all manufacturers, and others as we see, so there is a desire to have these vehicles. Our responsibility is making sure that they are used appropriately. Sarah has already alluded to the fact that drivers text and do things they are not supposed to do when they are in charge of the vehicle. They sit in a traffic jam—this is anecdotal evidence; nothing has looked at that recently—they look down and look up again. Those sorts of things are dangerous and we want to avoid those. Driver distraction has been a real challenge for the last 10 years or so. There have been many ways of trying to reduce them—fines have been increasing, et cetera—but people still do that. However, it is important to make sure that these vehicles are used and deployed correctly and that we do not have unintended consequences from the

vehicles and they are not used properly. You mention throughput, and we want to reduce emissions. Does that mean we are going to have more of these cars on the road, because they drive closer to each other?

On the safety side, if the systems are designed as we know how to use them, and we use them appropriately, they can be a good thing; they should be a good thing. They can do things that we cannot do: a blind spot warning, for example, or driving at night. I am starting to have that problem with glare, et cetera, and if the vehicle can identify things that I cannot with my naked eye, that is a good thing. But we have to make sure they are used properly.

Lord Cameron of Dillington: From what you say, it sounds as though we will have to move straight to level 5, because driver distraction is the biggest danger.

Professor Natasha Merat: I am sorry, but we cannot for a long time. We are not capable of doing that. The technology is not there. The sensors and cameras, et cetera, are still developing. If there is a bit of rain and the sensors get wet then they will not work. Level 5 is a long, long way away. In the meantime, we have to manage expectations and allow the driver to understand what this vehicle can and cannot do. Resumption of control is a very big question. All manufacturers want to know how long it will take for the driver to take back control. It depends very much on the situation and on the speed of the vehicle, et cetera. In the meantime, it is very important for the driver to understand when they should and should not use these systems, and when they should and should not intervene with a perfectly working system. It is a massive challenge that we are looking at very basically in driving simulators, and we are hoping to go on to the real road to look at them.

Andy Graham: We should not see connected and autonomous vehicles as the only solution. There is a great big toolkit of things you could do. We have young driver telematics; the sorts of cars that young drivers are getting now are far safer than the sort of cars I had when I was younger, so the trend is going down. The sorts of technologies you talk about, such as the blind spot and so on, are in human-driven cars. Lots of stuff can be done; more engineering can be done, more enforcement and more education. The key point—I have worked this out—is that you have to drive 600 million miles on a UK motorway per fatality. All of us who work in this autonomous vehicle industry have to reach that level of reliability before we make an improvement. We ought to strive to keep improving that with some of the tools we have in the knowledge that eventually another tool will come along. At the moment, I see everyone focusing on this as a way of reducing accidents when there are many that are all small pots and we keep eating away at them one level at a time.

Q60 Lord Oxburgh: The question I was going to raise follows on naturally from the discussions we have been having and that to some extent have been covered. It is the question of driving tests and what qualification one is going to look for. When I was living in the US, some states, if I remember rightly, had different driving tests for people with automatic transmission, for example, and if you only had an automatic transmission licence you were not licensed to drive a conventional

vehicle with a gear change. How is this going to come into these partially automated vehicles that we are talking about? One notices among the young—I find it slightly surprising—much less interest in getting a driving licence. These are the people who perhaps want this mobility and would not be able to take back control, as we have been discussing at the moment. How do you see this going?

Professor Natasha Merat: One of the things we are pushing for very much is some standards with respect to the systems coming into vehicles. Each manufacturer has its own version of how these things work, how you turn it on, how you turn it off, where it will work, et cetera, and they have also accorded different things. That provides big confusion for the user. Never mind automation, if we get a relatively simple car with hardly any automation—some handbrakes are a button and some you pull up—one of the biggest challenges is the user's understanding of how these things work. For that, the car manufacturers need to work together, I think, to look at what is the best thing.

Sarah has already mentioned a loss of skills, and we have to think about the responsibility of drivers. Aviation has very, very skilled pilots who are tested regularly and have a big space, but let us bring that down to what we have as car drivers. Licensing is very simple for 14 year-olds in the US to manage to drive, and they have bigger roads, but bring that into Paris or somewhere similar and we have a big challenge. Yes, it is really important to think about how we are going to do this and whether we need training for drivers. Making it as simple as possible, I think, is the best thing, but it is a challenge.

Professor Sarah Sharples: There are two things that we need to think about here. There is the control task of the vehicle, and for the control task of the vehicle we need to maintain those skills and maintain the understanding that people have an appropriate level of competence through a driving test. Even with fully automated vehicles we need to build in for the contingency that the driver will need to take control.

Natasha mentioned the aviation context. Of course, pilots learn to control an aircraft, but they also have familiarisation with each model of aircraft they use. I am not suggesting that every time you buy a new car you need to have a familiarisation test, but within this conventional driving test we could consider introducing an understanding of the capabilities of those different types of vehicles. I hesitate to say this, as someone who has not done a driving test for a long time, but there is perhaps an argument that we should also be considering for people like me who have a long time until—I think it is 70—the renewal of the driving test. It is a long time since I did my driving test, so a refresher might be useful.

Lord Maxton: It is 70, but you do not have to pass a driving test unless you have an accident.

Professor Sarah Sharples: I will make sure that I do not have an accident. Cars will change an awful lot in that period of time. We need to consider that.

Finally, we need to remember the responsibility for the interface in communicating how technology works. My first car had a choke. When you have a choke, that tells

you something about how a vehicle works and how the fuel is injected into the vehicle. We are becoming more and more removed from an understanding of how the vehicle works. That affects how we interact with that vehicle. Our mental model of how the vehicle works affects our behaviour. We need to consider that a driving test would not test just control but an understanding of how a vehicle will behave.

Baroness Neville-Jones: You were focusing in your answer on the control of the vehicle and how it works. The other part of a driving test is understanding road conditions and, indeed, the rules that govern driving. Do you see a difficulty over maintaining that level of skill as we move into a more highly automated or autonomous world? People will not exercise those skills as often and only essentially on a periodic basis. You learn these things, but then you experience them, practise them, and so get better.

Professor Sarah Sharples: Yes, absolutely.

Baroness Neville-Jones: Is there a potential hazard there or not, in your view?

Professor Natasha Merat: You may already have a parking aid, for example, in your car. I listen to my parking aid and use it, but if I get into my mum's car and she does not have one I must remember to look. Even with something as simple as that, absolutely. Again, the challenge is that you do not necessarily come across critical situations that often. We are looking at remembering how to come back into the driving task, to know where to look and how to resume control before you crash, and how long it takes in different situations—definitely.

Baroness Young of Old Scone: You have quite rightly been sceptical about the rate at which full automation will take place. What do you think the human factors are about a mixed economy when we have some people in automated cars and others who are not?

Professor Natasha Merat: At the moment we can say that, on the level 2 side, there are vehicles out there that can do some of the level 2, ACC or lane-keeping or something like that, but we do not have a knowledge because we have not really done any studies out there. The European Commission is hopefully intending a large trial of level 2/level 3 cars, including in the UK, in the next year or so, and I know that the UK itself is looking at trials. We need that kind of information. There are microsimulations of what would happen with network and with different levels of automation, but we do not know enough about the human side of it and whether these systems will be used by the human. One of the things is that ACC, for example, is in the vehicle but is not necessarily picked up by drivers—they do not like it if it beeps, or whatever. That is one of the places where we need to understand where there is a mixture of these vehicles what happens to the network and so on.

- Q61 **Lord Borwick:** You and other witnesses have said that we should have much more research into this subject. How are we going to get this research done? Who is going to pay for it and how long is it going to take? Do you think it will ever come from any of the private companies or does it have to be government sponsoring of research?

Professor Natasha Merat: Who is going to pay for it?

Professor Sarah Sharples: I do not mind answering that. In one of my other roles I sit on the EPSRC—the Engineering and Physical Sciences Research Council—strategic advisory network. This is one of the research councils that looks at the fundamental research. It is important that the research councils have sufficient funds to look at these fundamental questions. The fundamental questions are where we look at the advancing of the sensor technologies and the things covered under the digital economy programme in that research council at the moment—the interaction between what happens when we deploy these novel technologies in situations from a multidisciplinary point of view.

Innovate UK is an incredibly important actor in this context because of its role in bringing together industry, organisations such as the catapults and academia. Innovate UK has already been one of the major funders, as has EPSRC in conjunction with industry in funding research into this. Innovate UK research, both through the catapult and through fundamental research programmes, is important.

Lord Hunt of Chesterton: If I can follow that up, we have Innovate UK and it does the research, but perhaps 80% of cars in Britain are made in Germany. How will that work out? Will Innovate UK do all this development and Germany make even better cars? The questions of ownership and the economics of this are just as important as doing the research.

Professor Sarah Sharples: There is a difference between the research that is directly informing the design of vehicles and vehicle technologies—and of course when that becomes a commercial competitive advantage we should look to the car companies themselves to support that activity—and then the impact of these vehicles as part of a mixed modality transport system on UK plc. Whenever we do research for research councils, whether it is EPSRC or Innovate UK, we know that our job is to look at the appropriate outcome, from the UK perspective, of a productive, resilient, connected and healthy nation. There is a need to think about that impact on the UK as a whole, the productivity of the UK as a whole, the safety of individuals within the UK and healthiness.

Q62 **Lord Hunt of Chesterton:** One of the ways in which we will commercialise this is through the data that comes out of this work. How do you expect that to happen?

Andy Graham: There are a number of companies in the UK that lead the world in using data from vehicles, and have done so for many years, so that we do not have to install sensors at the side of the road. There is a whole way of seeing that you could manage traffic much better in the future by knowing much more about where the vehicles are. There is also the point that if we are funding these projects—the phrase “the rubber hits the road, the tyres hit the tarmac” has been used—we need to test how they work in cities, and it is very difficult for local authorities sometimes to see how to do that. Monetising all this is a big question, and the industry in the UK does not necessarily make vehicles but we make a lot of the elements inside them. A lot of the computer software, gearboxes and equipment are built by someone and branded by somebody else. If you start exploding vehicles you see—

Lord Hunt of Chesterton: That requires a good exchange after Brexit, does it not?

Andy Graham: Indeed. There is a large amount of evidence that we could make a lot of things cheaper. For example, we are building roads but we could make them better and cheaper if we knew more about who to build them for and allowed for the building in of data now. What tends to happen is we plug it in later on once it has been built. There is the opportunity to make savings for GB plc on things such as emissions and so on, and there is also the opportunity to make GDP grow.

Professor Natasha Merat: I have a couple of extra points to make. One is that it would be lovely if we could make the most of this. Every car company and a few countries are saying, “We are doing it first. Come and test it here”, “We are ahead of it”, et cetera. Sarah has mentioned that we want to be safe, et cetera, but we want to be happy and able to move around in our cities. These vehicles can help with that. One way is to let us have everyone come and test it and perhaps cause a lot of congestion. Instead we can think about what these vehicles can do for us as citizens. If we are happy citizens, that will be a good thing for UK plc.

On the other hand, this is the Science and Technology Committee and we are academics. We are very good in the UK at our training and in academia. The rest of the world looks at us, and we are training these people who are then creating the things in vehicles. When it comes to UK plc that is definitely one area where we could invest. It is all about computers now, and car manufacturers are not computer scientists, necessarily. There are skills being developed by our academics in Oxford, et cetera, that people are dying to get and need access to. That is really where we could benefit, I think.

Lord Maxton: Are other countries in front of us?

The Chairman: I am going to bring this session to a close because we have two Ministers waiting outside. We have had the allotted time, we have covered a lot of ground and, as I feared, we could have gone on a lot longer—you had much to tell us. If you feel there are matters you have not been able to articulate fully, please follow it up with evidence. I think you have agreed to give us a reference, Professor Sharples.

Professor Sarah Sharples: Yes.

The Chairman: We are most grateful to Professor Sharples, Professor Merat and Mr Graham for the evidence today. Thank you very much for helping us.