LITERATURE REVIEW

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Human Factors in Connected and Automated cars (CAVS)

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Databases: Google scholar, TRID, TRB, ASCE, Science direct, Taylor & Francis, Springer, Research Gate, SAGE, Proquest,

Search Terms: Semi autonomous control, usability, human factors, ergonomics, human in the system, Human Centred design, User centred design for ‘automated, autonomous’ vehicles, vehicle autonomy, human drivers autonomous vehicles, human factors implications, human factors concepts, human factors interaction, automatic control, manual control, intelligent vehicles, driving simulator, human machine systems, cognition, real time information, machine learning, trajectory control, autonomous land vehicles, driver vehicle interfaces, human automation interaction,

1. Autonomous driving in the real world: experiences with tesla autopilot and summon
   Murat Dikmen, Catherine M. Burns
   2016 Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 2016, pp.225-228
   As autonomous driving emerges, it is important to understand drivers' experiences with autonomous cars. We report the results of an online survey with Tesla owners using two autonomous driving features, Autopilot and Summon. We found that current users of these features have significant driving experience, high self-rated computer expertise and care about how automation works. Surprisingly, although automation failures are extremely common they were not perceived as risky. The most commonly occurring failures included the failure to detect lanes and uncomfortable speed changes of the vehicle. Additionally, a majority of the drivers emphasized the importance of being alert while driving with autonomous features and aware of the limitations of the current technology. Our main contribution is to provide a picture of attitudes and experiences towards semi-autonomous driving, revealing that some drivers adopting these features may not perceive autonomous driving as risky, even in an environment with regular automation failures. (SAGE) https://dl.acm.org/citation.cfm?id=3005465

2. Autonomous Driving Systems: A Preliminary Naturalistic Study of the Tesla Model S
   Mica R. Endsley
   Autonomous and semiautonomous vehicles are currently being developed by over 14 companies. These vehicles may improve driving safety and convenience, or they may create new challenges for drivers, particularly with regard to situation awareness (SA) and autonomy interaction. I conducted a naturalistic driving study on the autonomy features in the Tesla Model S, recording my experiences over a 6-month period, including assessments of SA and problems with the autonomy. This preliminary analysis provides insights into the challenges that drivers may face in dealing with new autonomous automobiles in realistic driving conditions, and it extends previous research on human-autonomy interaction to the driving domain. Issues were found with driver training, mental model development, mode confusion, unexpected mode interactions, SA, and susceptibility to distraction. New insights into
challenges with semiautonomous driving systems include increased variability in SA, the replacement of continuous control with serial discrete control, and the need for more complex decisions. Issues that deserve consideration in future research and a set of guidelines for driver interfaces of autonomous systems are presented and used to create recommendations for improving driver SA when interacting with autonomous vehicles. (SAGE)

3. **Autonomous driving: technical, legal and social aspects**
   This book takes a look at fully automated, autonomous vehicles and discusses many open questions: How can autonomous vehicles be integrated into the current transportation system with diverse users and human drivers? Where do automated vehicles fall under current legal frameworks? What risks are associated with automation and how will society respond to these risks? How will the marketplace react to automated vehicles and what changes may be necessary for companies? Experts from Germany and the United States define key societal, engineering, and mobility issues related to the automation of vehicles. They discuss the decisions programmers of automated vehicles must make to enable vehicles to perceive their environment, interact with other road users, and choose actions that may have ethical consequences. The authors further identify expectations and concerns that will form the basis for individual and societal acceptance of autonomous driving. While the safety benefits of such vehicles are tremendous, the authors demonstrate that these benefits will only be achieved if vehicles have an appropriate safety concept at the heart of their design. Realizing the potential of automated vehicles to reorganize traffic and transform mobility of people and goods requires similar care in the design of vehicles and networks. By covering all of these topics, the book aims to provide a current, comprehensive, and scientifically sound treatment of the emerging field of “autonomous driving”. (TRID)

4. **Autonomous vehicles and smart mobility related technologies**
   Cristina Olaverri
   Information Communications Journal, 2016, Vol. VIII, No.2
   Smart Mobility is associated with a sustainable mobility performance that in turn affects quality of life. Current technology makes it possible to compile massive amounts of real-time data to optimize the urban infrastructure, consequently improving the efficiency of public transport services, from both user and service-provider perspectives. The analysis of these location-based data enables us to determine which services could be useful for citizens at a certain time, for example, thereby improving citizens’ ability to navigate the most efficient routes and modes of travel. Various aspects of technologies that enable smart mobility in cities, including autonomous vehicles are presented in this paper.

5. **Autonomous vehicles: human factors issues and future research**
   Mitchell Cunningham, Michael A. Regana
   ARRB Group Ltd, Proceedings of the 2015 Australasian Road Safety Conference 14 - 16 October, Gold Coast, Australia
   Automated vehicles are those in which at least some aspects of a safety-critical control function occur without direct driver input. It is predicted that automated vehicles, especially those capable of “driving themselves”, will improve road safety and provide a range of other transport and societal benefits. A fundamental issue, from a human factors perspective, is how to design automation so that drivers understand fully the capabilities and limitations of the vehicle, and maintain situational awareness of what the vehicle is doing and when manual intervention is needed – especially for first generation vehicles that require drivers to resume manual control of automated functions when the vehicle is incapable of controlling itself. The purpose of this paper is to document some of the human factors challenges associated with the transition from manually driven to self-driving vehicles, and to outline what we can be doing in Australia, through research and other means, to address them. (Scholar)

6. **Autonomous vehicles need experimental ethics: are we ready for utilitarian cars?**
   Jean-François Bonnefon, Azim Shari, Iyad Rahwan
   Research in Management, 2015
   The wide adoption of self-driving, Autonomous Vehicles (AVs) promises to dramatically reduce the number of traffic accidents. Some accidents, though, will be inevitable, because some situations will
require AVs to choose the lesser of two evils. For example, running over a pedestrian on the road or a passer-by on the side; or choosing whether to run over a group of pedestrians or to sacrifice the passenger by driving into a wall. It is a formidable challenge to define the algorithms that will guide AVs confronted with such moral dilemmas. In particular, these moral algorithms will need to accomplish three potentially incompatible objectives: being consistent, not causing public outrage, and not discouraging buyers. We argue to achieve these objectives, manufacturers and regulators will need psychologists to apply the methods of experimental ethics to situations involving AVs and unavoidable harm. To illustrate our claim, we report three surveys showing that laypersons are relatively comfortable with utilitarian AVs, programmed to minimize the death toll in case of unavoidable harm. We give special attention to whether an AV should save lives by sacrificing its owner, and provide insights into (i) the perceived morality of this self-sacrifice, (ii) the willingness to see this self-sacrifice being legally enforced, (iii) the expectations that AVs will be programmed to self-sacrifice, and (iv) the willingness to buy self-sacrificing AVs.

http://pdfs.semanticscholar.org/13d4/56d4c53d7b03b90ba59845a8f61b23b9f6e8.pdf

7. **Develop in-vehicle information dissemination mechanisms to reduce cognitive burden in the information-rich driving environment**

Peeta, Srinivas, 2017

In-vehicle information systems (IVIS) are poised to provide drivers with several types of information under the connected and autonomous travel information. Such real-time information can include traffic conditions, weather forecasts, warning/emergency alerts, and infotainment and commercial services. Such an information-rich environment can increase driver cognitive workload in the inherently multitasking driving context, further exacerbated by the multiple sources of information (such as variable message signs, personal devices, global positioning system (GPS), radio, etc.). This can reduce safety and decrease the effectiveness of the disseminated information, especially if the information delivery mechanisms are not well-designed. This study will conduct interactive driving simulator-based experiments to understand the impacts of real-time information characteristics and multiple dissemination sources on driver cognition, and its effects on the driver decision-making process and ability to comprehend information safely. Data will be collected on driver route choice behavior and physiological factors (such as eye movements, brain electrical activity and heart rate) under real-time information provision. These physiological factors will be used to determine cognitive effects (such as cognitive workload, distraction, and level of engagement). The collected data will be used to develop behavior models to investigate the impacts of cognitive effects induced by real-time traffic information, situational factors (such as trip purpose and traffic congestion), real-time travel information characteristics (such as amount, content and source) and individual driver characteristics (such as age, gender and education). These models will be used to design safe and effective information dissemination mechanisms. (TRID)

8. **Driver brake vs. steer response to sudden forward collision scenario in manual and automated driving modes**

Blommer, Mike, Curry, Reates, Swaminathan, Radhakrishnan, Tijerina, Louis, Talamonti, Walter


In autonomous vehicle operation, situations may arise when the driver is required to re-engage in manual control of the vehicle. Whether the control handoff from vehicle to human is done in a structured or unstructured manner, the process may be affected by the driver’s state, i.e. distracted or not. The study reported here was designed to measure a non-distracted driver’s response to a sudden forward collision (FC) event, in which the driver would assume manual control of the autonomous vehicle. Three driving scenarios were investigated: autonomous vehicle driven with full collision avoidance support, autonomous vehicle driven without collision avoidance support, and vehicle driven in manual mode. Forty-eight volunteers participated in a simulator study conducted in VIRTTEX. It was found that, at handoff, (1) drivers in manual mode tended to use evasive steering, rather than braking, compared to drivers in both the autonomous modes, (2) between subjects variations in speed were higher for the automation with collision support condition than for the other two scenarios, (3) for both autonomous driving scenarios, drivers reaction times were longer than for manual driving. In some cases the driver response was so late and the distance remaining so reduced that crash avoidance might be unfeasible. At a minimum, results of this study suggest that drivers may benefit from appropriate driver assistance technologies when a crash imminent situation is suddenly encountered.
10. End to end learning for self-driving cars

Mariusz Bojarski, Davide Del Testa, Daniel Dworakowski, Bernhard Firner, Beat Flepp, Prasoon Goyal, Lawrence D. Jack, Mathew Monfort, Urs Muller, Jiakai Zhang, Xin Zhang, Jake Zhao, Karol Zieba

We trained a convolutional neural network (CNN) to map raw pixels from a single front-facing camera directly to steering commands. This end-to-end approach proved surprisingly powerful. With minimum training data from humans the system learns to drive in traffic on local roads with or without lane markings and on highways. It also operates in areas with unclear visual guidance such as in parking lots and on unpaved roads. The system automatically learns internal representations of the necessary processing steps such as detecting useful road features with only the human steering angle as the training signal. We never explicitly trained it to detect, for example, the outline of roads. Compared to explicit decomposition of the problem, such as lane marking detection, path planning, and control, our end-to-end system optimizes all processing steps simultaneously. We argue that this will eventually lead to better performance and smaller systems. Better performance will result because the internal
components self-optimize to maximize overall system performance, instead of optimizing human-selected intermediate criteria, e.g., lane detection. Such criteria understandably are selected for ease of human interpretation which doesn't automatically guarantee maximum system performance. Smaller networks are possible because the system learns to solve the problem with the minimal number of processing steps. We used an NVIDIA DevBox and Torch 7 for training and an NVIDIA DRIVE(TM) PX self-driving car computer also running Torch 7 for determining where to drive. The system operates at 30 frames per second (FPS).

https://arxiv.org/abs/1604.07316

11. Formalizing human-machine communication in the context of autonomous vehicles
Harwood Leslie, Gopalswamy Swaminathan, 2017
While driving behaviour is generally governed by the nature and driving objectives of the driver, there are many situations (typically in crowded traffic conditions) where tacit communication between the drivers and pedestrians govern the overall driving behaviour, significantly enhancing driving safety. The project will intend to study and formalize the communication pattern between human drivers and pedestrians, as also investigate effective communication mechanisms between an autonomous vehicle and humans. Current autonomous vehicles engage in decision making that is primarily driven by onboard or external sensory information, and do not explicitly consider communication with pedestrians. The project will incorporate the formalized communications from this study into decision making algorithms of an autonomous vehicle. Use of the results of this study would lead to improved safety of both autonomous vehicles as well as conventional vehicles.

12. From here to autonomy lessons learned from human–automation research
Mica R. Endsley
As autonomous and semiautonomous systems are developed for automotive, aviation, cyber, robotics and other applications, the ability of human operators to effectively oversee and interact with them when needed poses a significant challenge. An automation conundrum exists in which as more autonomy is added to a system, and its reliability and robustness increase, the lower the situation awareness of human operators and the less likely that they will be able to take over manual control when needed. The human–autonomy systems oversight model integrates several decades of relevant autonomy research on operator situation awareness, out-of-the-loop performance problems, monitoring, and trust, which are all major challenges underlying the automation conundrum. Key design interventions for improving human performance in interacting with autonomous systems are integrated in the model, including human–automation interface features and central automation interaction paradigms comprising levels of automation, adaptive automation, and granularity of control approaches. Recommendations for the design of human–autonomy interfaces are presented and directions for future research discussed. (SAGE)

13. Human dynamics based driver model for autonomous car
Li, Lin, Liu, Yanheng, Wang, Jian, Deng, Weiwen, Oh, Heekuck
IET Intelligent Transport Systems, 2016, Vol.10, No.8, pp.545-554
This study presents a new driver model based on human behaviour dynamics for autonomous cars, which allows driverless cars to move appropriately in accordance to the behavioural features of driver owners. This model is established through analysing drivers’ various properties, e.g. gender, age, driving experience, personality, and emotion. These attributes collectively determine all the actions occurred during the driving process. Through analysing the statistical data gathered during the simulation, the authors find that the proposed model can reflect the power-law distribution with respect to the concerned human behaviours. Finally, the proposed model is validated by the hardware-in-loop simulator and real driving experiment. (TRID)

14. Impact of training and in-vehicle task performance on manual control recovery in an automated car
Payre, William, Cestac, Julien, Dang, Nguyen-Thong, Vienne, Fabrice, Delhomme, Patricia, 2017
Automated driving (AD) introduces new skills needs for drivers to handle manual control recovery (MCR). In the scope of traffic safety, such skills should be investigated before this technology is available on public roads, especially in critical situations such as emergencies. The aim of the present study is to examine to what extent lack of training and in-vehicle task performance may impair MCR in...
15. In the passenger seat: investigating ride comfort measures in autonomous cars
Mohamed Elbanhawi ; Milan Simic ; Reza Jazar
IEEE Intelligent Transportation Systems Magazine, 2015, Vol.7, No.3, pp.4 - 17
The prospect of driverless cars wide-scale deployment is imminent owing to the advances in robotics, computational power, communications, and sensor technologies. This promises highway safety reductions and improvements in traffic and fuel efficiency. Our understanding of the effects arising from commuting in autonomous cars is still limited. The novel concept of the loss of driver controllability is introduced here. It requires a reassessment of vehicle's comfort criteria. In this review paper, traditional comfort measures are examined and autonomous passenger awareness factors are proposed. We categorize path-planning methods in light of the offered factors. The objective of the review presented in this article is to highlight the gap in path planning from a passenger comfort perspective and propose some research solutions. It is expected that this investigation will generate more research interest and bring innovative solutions into this field. (IEEE Explore)

16. Incorporating driver behaviours into connected and automated vehicle simulation
Songchitrucks, Praprut, Bibeka, Apoorba, Lin, Lu (Irene), Zhang, Yunlong, 2016, 104 p.
The adoption of connected vehicle (CV) technology is anticipated at various levels of development and deployment over the next decade. One primary challenge with these new technologies is the lack of platform to enable a robust and reliable evaluation of their benefits given the complexity of interactions among wireless communications, algorithms, and human behaviours. Underlying driver behaviour models in microscopic simulation are not always well-suited for modern applications using CV and automated vehicle (AV) technology. This study proposed a framework for incorporating realistic driver behaviours into a microscopic traffic simulation for AV/CV applications using VISSIM microscopic simulation software. The framework consists of three levels of driver behaviour adjustment: event-based, continuous, and semi-automated/automated driver behaviour adjustment. The framework provides several examples and details on how various applications can be properly modelled in a traffic simulation environment. To demonstrate the framework, researchers conducted a case study of a simulation evaluation of cooperative adaptive cruise control (CACC). CACC enables the vehicles to follow each other in a very tight spacing (also known as platooning) using wireless connectivity and automated longitudinal control. The case study shows that a modified driver model can be successfully used in the simulation to evaluate the benefits of AV/CV applications such as CACC with respect to their mobility, safety, and environmental performance. (TRID)

17. Interpersonal communication and issues for autonomous vehicles
Interpersonal roadway communication is a vital component of the transportation system. Road users communicate to coordinate movement and increase roadway safety. Future autonomous vehicle research needs to account for the role of interpersonal roadway communication. This literature review synthesizes research on interpersonal interaction between drivers, bicyclists, and pedestrians while also directing attention to implications for autonomous and connected vehicle research. Articles were collected from TRID, PsycINFO, Google Scholar, and ScienceDirect using search terms relevant to driving, communication, and vulnerable road users. The synthesis documents that interpersonal communication not only takes place but is also an important and understudied aspect of safe roadway travel. The review also found that road users employ a variety of communication methods that include gestures, facial expressions, and built-in vehicular devices. Comprehension of messages is influenced
by a number of factors including culture, context, and experience. These results shed light on potential issues and challenges of interpersonal communication and the introduction of autonomous vehicles to the roadway. (TRID)

18. Investigating the importance of trust on adopting an autonomous vehicle
Jong Kyu Choi & Yong Gu Ji
The objective of this study is to examine the user’s adoption aspects of autonomous vehicle, as well as to investigate what factors drive people to trust an autonomous vehicle. A model explaining the impact of different factors on autonomous vehicles’ intention is developed based on the technology acceptance model and trust theory. A survey of 552 drivers was conducted and the results were analyzed using partial least squares. The results demonstrated that perceived usefulness and trust are major important determinants of intention to use autonomous vehicles. The results also show that three constructs—system transparency, technical competence, and situation management—have a positive effect on trust. The study identified that trust has a negative effect on perceived risk. Among the driving-related personality traits, locus of control has significant effects on behavioral intention, whereas sensation seeking did not. This study investigated that the developed model explains the factors that influence the acceptance of autonomous vehicle. The results of this study provide evidence on the importance of trust in the user’s acceptance of an autonomous vehicle. (Taylor & Francis)

19. Negotiating the traffic: can cognitive science help make autonomous vehicles a reality?
Chater, Nick, Misyak, Jennifer, Watson, Derrick, Griffiths, Nathan, Mouzakitis, Alex
Trends in Cognitive Sciences, 2018, Vol. 22, No. 2, pp.93-95
To drive safely among human drivers, cyclists and pedestrians, autonomous vehicles will need to mimic, or ideally improve upon, humanlike driving. Yet, driving presents the authors with difficult problems of joint action: ‘negotiating’ with other users over shared road space. They argue that autonomous driving provides a test case for computational theories of social interaction, with fundamental implications for the development of autonomous vehicles. (TRID)

20. On creative self-driving cars: hire the computational logicians, fast
Selmer Bringsjord Rensselaer, Troy NY, Atriya Sen Rensselaer
There can be no denying that it is entirely possible for a car-manufacturing company like Daimler to build and the deploy self-driving cars without hiring a single computational logician. However, for reasons we explain herein, a logician-less approach to engineering self-driving automobiles (and, for that matter, self-moving vehicles of any consequence, in general) is a profoundly unwise one. As we shall see, the folly of leaving aside logic has absolutely nothing to do with the standard and stale red-herring concern that self-driving cars will face exotic human-style ethical dilemmas the philosophers have a passionate penchant for.

21. Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations
Daniel J Fagnant, Kara Kockelman
Autonomous vehicles (AVs) represent a potentially disruptive yet beneficial change to our transportation system. This new technology has the potential to impact vehicle safety, congestion, and travel behaviour. All told, major social AV impacts in the form of crash savings, travel time reduction, fuel efficiency and parking benefits are estimated to approach $2000 to per year per AV, and may eventually approach nearly $4000 when comprehensive crash costs are accounted for. Yet barriers to implementation and mass-market penetration remain. Initial costs will likely be unaffordable. Licensing and testing standards in the U.S. are being developed at the state level, rather than nationally, which may lead to inconsistencies across states. Liability details remain undefined, security concerns linger, and without new privacy standards, a default lack of privacy for personal travel may become the norm. The impacts and interactions with other components of the transportation system, as well as implementation details, remain uncertain. To address these concerns, the federal government should expand research in these areas and create a nationally recognized licensing framework for AVs,
22. Rage against the machine? Google’s self-driving cars versus human drivers
Teoh, Eric R, Kidd, David G
Automated driving represents both challenges and opportunities in highway safety. Google has been developing self-driving cars and testing them under employee supervision on public roads since 2009. These vehicles have been involved in several crashes, and it is of interest how this testing program compares to human drivers in terms of safety. Google car crashes were coded by type and severity based on narratives released by Google. Crash rates per million vehicle miles travelled (VMT) were computed for crashes deemed severe enough to be reportable to police. These were compared with police-reported crash rates for human drivers. Crash types also were compared. Google cars had a much lower rate of police-reportable crashes per million VMT than human drivers in Mountain View, Calif., during 2009–2015 (2.19 vs 6.06), but the difference was not statistically significant. The most common type of collision involving Google cars was when they got rear-ended by another (human-driven) vehicle. Google cars shared responsibility for only one crash. These results suggest Google self-driving cars, while a test program, are safer than conventional human-driven passenger vehicles; however, currently there is insufficient information to fully examine the extent to which disengagements affected these results. Results suggest that highly-automated vehicles can perform more safely than human drivers in certain conditions, but will continue to be involved in crashes with conventionally-driven vehicles. (TRID)

23. Supporting the changing driver’s task: exploration of interface designs for supervision and intervention in automated driving
van den Beukel, Arie P, van der Voort, Mascha C, Eger, Arthur O
Transportation Research Part F: Traffic Psychology and Behaviour, 2016, Vol.43, pp.279-301
Driving automation leads to a changing role for drivers, that is, from manual vehicle control to supervising automation. Supervision of partial automation requires now and then intervention. Since the automation causes low vigilance and out-of-the-loop performance problems, this changing role is not well suited for human operators. To explore how driver-vehicle interfaces can support drivers in their changed role, the authors tested three concepts. Concept A was a baseline reference, providing only acoustic warnings. Concept B presented status-information and warnings behind the steering wheel. Concept C used illumination and haptic feedback in the seat-pan to direct attention outside the vehicle and to stimulate response. Concept C only provided vibrotactile feedback when intervention was needed. Results of the study show improved support for supervision with the illumination-concept, i.e. better hazard-detection and raised levels of Situation Awareness in some scenarios relevant for supervisory control. Knowing that supervision will be the dominating driver’s responsibility during partially automated driving, the illumination-concept is a recommended solution for support of the driver’s changing role. Nonetheless, neither concept B, nor C, showed additional support for intervention compared to the baseline. It was hypothesized that the combination of concept C’s stimuli for intervention-support caused counter-productive levels of annoyance. Furthermore, the authors concluded that intervention and supervision benefit from different interface-features and discussed possible causes underlying ambiguity between support for supervision and support for intervention shown with concept C. Therewith, the considerations in this paper contribute to further development of – and knowledge about – appropriate driver-vehicle interaction while vehicle-operation advances into operating partially automated driving systems. (TRID)

24. Teaching autonomous vehicles how to drive under sensing exceptions by human driving demonstrations
Guo, Longxiang, Manglani, Sagar, Li, Xuehao, Jia, Yunyi
WCX™ 17: SAE World Congress Experience, 2017
Autonomous driving technologies can provide better safety, comfort and efficiency for future transportation systems. Most research in this area has mainly been focused on developing sensing and control approaches to achieve various autonomous driving functions. Very little of this research, however, has studied how to efficiently handle sensing exceptions. A simple exception measured by any of the sensors may lead to failures in autonomous driving functions. The autonomous vehicles are then supposed to be sent back to manufacturers for repair, which takes both time and money. This paper introduces an efficient approach to make human drivers able to online teach autonomous
vehicles to drive under sensing exceptions. A human-vehicle teaching-and-learning framework for autonomous driving is proposed and the human teaching and vehicle learning processes for handling sensing exceptions in autonomous vehicles are designed in detail. Experimental results acquired from a 1/10-scale autonomous driving vehicle illustrate the effectiveness and advantages of the proposed approach. (TRID)

25. Transfer from highly automated to manual control: performance & trust
Schwarz, Chris, Brown, Timothy L, Keum, Clara, Gaspar, John, 2016, The development of automated vehicles is ongoing at a breakneck pace. The human factors challenges of designing safe automation systems are critical as the first several generations of automated vehicles are expected to be semi-autonomous, requiring frequent transfers of control between the driver and vehicle. A driving simulator study was performed with 20 participants to study transfers of control in highly automated vehicles. The authors observed driver performance and measured comfort as an indicator of the development of trust in the system. One study drive used an automation system that was able to respond to most events by slowing or changing lanes on its own. The other study drive issued takeover requests (TORs) in all cases. Thus there was a change in reliability over the course of the study drives; some participants experienced the more-capable system first followed by the other, and others had the opposite experience. The authors observed three types of people with respect to their comfort profiles over the course of their three drives. Some started out very comfortable, while others took a long time to become comfortable. Takeovers were split into physical takeover, visual attention, and vehicle stabilization. Response time and performance measures showed that there was a 15- to 25-second period between the physical takeover and a return to normal driving performance. This confirms some observations in previous studies on transfer of control.

26. The social dilemma of autonomous vehicles
Jean-François Bonnefon, Azim Shariff, Iyad Rahwan Science, 2016, Vol. 352, No. 6293, pp. 1573-1576 Autonomous vehicles (AVs) should reduce traffic accidents, but they will sometimes have to choose between two evils, such as running over pedestrians or sacrificing themselves and their passenger to save the pedestrians. Defining the algorithms that will help AVs make these moral decisions is a formidable challenge. We found that participants in six Amazon Mechanical Turk studies approved of utilitarian AVs (that is, AVs that sacrifice their passengers for the greater good) and would like others to buy them, but they would themselves prefer to ride in AVs that protect their passengers at all costs. The study participants disapprove of enforcing utilitarian regulations for AVs and would be less willing to buy such an AV. Accordingly, regulating for utilitarian algorithms may paradoxically increase casualties by postponing the adoption of a safer technology. http://science.sciencemag.org/content/352/6293/1573

27. Understanding the socioeconomic adoption scenarios for autonomous vehicles: A literature review.
Clark, B., Parkhurst, G. and Ricci, M Project Report, University of the West of England, Bristol, UK, 2016 There is great and growing interest in autonomous vehicles (AVs), both in relation to rapid technological developments and the trialling of these developments, and the potential for their far reaching impacts on transport systems and society. The present report examines scenarios and policy and practice challenges for the adoption of AVs. Whilst it has broad relevance for societies, in the industrialised democracies at least, there is a particular focus on the UK context. http://eprints.uwe.ac.uk/29134/

28. What's ‘driving' adoption of automated vehicles?
Noblet, Caroline L, Rubin, Jonathan, Eslin, Allyson, Jennings, Ryan Transportation Research Board 97th Annual Meeting, 2018, 5 p. Connected Autonomous vehicles (AVs) offer great promise for unprecedented improvements in mobility and safety. For this to happen, AVs must be purchased, or shared, and used. However, barriers to implementation exist. Basic questions about consumer knowledge, perceptions and
intended use remain either unanswered or under-investigated. This paper identifies determinants that drive acceptance of automated vehicles with a focus on perceptions of the benefits and risks associated with the technology. The authors contribute to the literature by testing the role of varying levels of automation technology on acceptance. Their findings identify the importance of individuals’ existing technology attitudes, and personal characteristics, in understanding their AV adoption decision. The respondents state that they will change their use of in-vehicle time given different levels of automation. At higher levels of automation, the authors find a stated willingness of ‘drivers’ to engage in four new in-car behaviours: sleeping, watching movies/TV, using virtual reality (VR) and driving intoxicated/using drugs. This change in behaviour is likely to lead to change in the use of private automobiles since vehicle travel time is one of the largest costs associated with travel. The authors also find that individuals focused on prevention of challenges will be less willing to embrace a large scale change such as AV adoption. However, this also provides communication insights where highlighting prevention of motor vehicle accidents, a potential outcome of widespread AV adoption, may enhance opportunities to engage with prevention oriented consumers. (TRID)

29. When human beings are like drunk robots: Driverless vehicles, ethics, and the future of transport
Sparrow, Robert, Howard, Mark
It is often argued that driverless vehicles will save lives. In this paper, the authors treat the ethical case for driverless vehicles seriously and show that it has radical implications for the future of transport. After briefly discussing the current state of driverless vehicle technology, the authors suggest that systems that rely upon human supervision are likely to be dangerous when used by ordinary people in real-world driving conditions and are unlikely to satisfy the desires of consumers. The authors then argue that the invention of fully autonomous vehicles that pose a lower risk to third parties than human drivers will establish a compelling case against the moral permissibility of manual driving. As long as driverless vehicles aren’t safer than human drivers, it will be unethical to sell them. Once they are safer than human drivers when it comes to risks to 3rd parties, then it should be illegal to drive them: at that point human drivers will be the moral equivalent of drunk robots. The authors also describe two plausible mechanisms whereby this ethical argument may generate political pressure to have it reflected in legislation. Freeing people from the necessity of driving, though, will transform the relationship people have with their cars, which will in turn open up new possibilities for the transport uses of the automobile. The ethical challenge posed by driverless vehicles for transport policy is therefore to ensure that the most socially and environmentally beneficial of these possibilities is realised. The authors highlight several key policy choices that will determine how likely it is that this challenge will be met. (TRID)

30. Why ethics matters for autonomous cars
Patrick Lin
Autonomous Driving, 2015, pp.69-85
If motor vehicles are to be truly autonomous and able to operate responsibly on our roads, they will need to replicate—or do better than—the human decision-making process. But some decisions are more than just a mechanical application of traffic laws and plotting a safe path. They seem to require a sense of ethics, and this is a notoriously difficult capability to reduce into algorithms for a computer to follow.