Digital Safety Systems in Light Passenger Vehicles: a Sociotechnical Analysis

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

The landscape of modern vehicular transportation has transformed, driven by the advancement and proliferation of microprocessors. This technological shift has also impacted vehicles' interaction with people and their environment more broadly. According to the World Economic Forum, technological connectivity in passenger cars is nearly doubling every year (World Economic Forum, 2021). The advent of computer integrated vehicles has created an era in the automotive industry with high levels of automation and connectivity when it comes to safety features (World Economic Forum, 2021).

This paper seeks to explore the profound implications of manufacturers' reliance on computer systems to ensure or enhance safety of passengers, vehicle operators, and pedestrians. This shift is the midpoint in a decades-long story of automotive safety progression towards autonomous vehicles (Bradley, Preston, & Preston, 2020). Have the latest twists in that narrative been entirely positive, directing society toward strictly safer vehicles? Or have there been unintended consequences due to the complex relationship between car and driver?

We typically think of automotive safety features as being mechanical. Advertising campaigns, particularly in the 1980's, described the life saving benefits of wearing seatbelts. For instance, in the early 1980's, Ford put a "GET IT TOGETHER" slogan on their Mustangs to encourage seat belt usage ("Mustang 'Get It Together' Seat Belt Window Decal (79-85)," n.d.). Since then, automotive manufacturers have dived head first into reliance on computer systems for safety. Now, they are electromechanical (lane-keep assist, blind-spot monitoring, etc.) (National Survey

Identifying Gaps in Consumer Knowledge of Advanced Vehicle Safety Systems—McDonald, McGehee, Chrysler, Askelson, Angell, & Seppelt, 2016).

The landscape of technological safety is broad and could be approached from a multitude of angles. For one, a sociotechnical argument regarding the environmental impact of increased electronics waste could be evaluated. Similarly, the supply chain involved may raise ethical concerns (Xia & Li‐Ping Tang, 2011). Cars and trucks also cost more than ever, raising questions about ("Bureau of Labor Statistics Data," n.d.). These topics are not within the scope of this paper. Instead, only the direct impacts on human bodily injury are considered.

The increased integration of computerized safety features in the automotive industry has brought about profound implications, both positive and negative, in terms of passenger, operator, and pedestrian safety, necessitating a thorough exploration of its impacts on the evolving narrative of automotive safety progression. In the future, advancements in autonomy for road vehicles have the potential to take these effects to the extreme. The looming nature of these technologies emphasizes the importance of teasing out the ethics of automotive technological transition and understanding the diverse impacts each technological building block imparts on society along the way.

Background and Significance

Cars and light pickup trucks are deeply connected to society. To some, they represent individualism, or americana, or even just transport that enables a particular way of life (Eyerman & Löfgren, 1995). Our expectations from our vehicles have expanded just as quickly as our highway systems; we demand more capacity, power, efficiency, and especially safety. In 2021, almost 12,000,000 cars and trucks were sold in the United States, occupying a huge share of both personal expenditure and domestic manufacturing capacity (Bureau of Transportation Statistics, n.d.). Interacting with a vehicle is a regular part of life.

The way we interact with our vehicles has changed massively over the years of development. Before electronic fuel injection, we had to allow vehicles to warm up before driving. This was simply an accepted part of driving the vehicle, right alongside the requirement to purchase gasoline or turn a key to start the engine. The government requires us to undergo training and licensure to operate a vehicle, and forbids us from doing so under the influence of substances. All of these expectations and requirements from our vehicles form a kind of contract between the driver, the manufacturer, regulators, and even the vehicle itself. This paper posits that when technology pushes the boundaries of that contract, people are slow to respond and adjust.

Any change to this contract can create discordance. For instance, California changed its drunk driving laws in the 1980s, making enforcement and laws about driving after consuming alcohol more strict by reducing the (Laurence, 1988) quantity of alcohol in the blood (BAC) allowed while operating a vehicle on the roadways. This interrupted the status quo relating to how people used their vehicles. Any change to something people take for granted can be disruptive, even though ultimately preventing inebriated driving is a measure that improves safety on the roadways (Barry, 2021).

Similarly to the discordance created by the new law in California, the introduction of advanced cruise control systems in vehicles, ranging from Adaptive cruise to more advanced systems such as Tesla's "Full Self Driving", has impacted the range of behavior of car owners (Ferlis, 2016). Similarly to legal changes, technology can also lead to changes in the aforementioned socio-technical contract. For instance, we used to allow cars to warm up before driving, a limitation of the technology of the time. While this may seem like a minor change, when multiplied by all of the times that drivers start their vehicles in a time period, the social effect can be quite large. A more recent change relates to the advent of back-up cameras. New cars are required to incorporate them (Bomey, 2018). This changes peoples' expectations from their vehicles. It also could be changing the way pedestrians anticipate drivers to behave; which could lead to different pedestrian behavior if people expect drivers to be able to see directly behind them.

Vehicle safety is inherently a socio-technical issue, not a purely technical one. This is demonstrated by the example of motorcycles. I posit that a motorcycle is more dangerous to operate than a car missing safety features like rearview backup cameras, but is legal to purchase nonetheless, unlike that backup camera- less car. Safety standards are not established as unthinking technical hurdles for manufacturers to jump, they are in and of themselves influenced by society, just as they influence society. If not for the historical prevalence and cultural importance of motorcycles, I posit they may not be allowed on the road today. Consider an alternative history where the motorcycle was never developed until the modern era, an era replete with anti-lock brake systems that can process thousands of times per second and hundreds of computer chips per vehicle.

Methodology

This research topic necessitates a variety of scholarly input. Because automotive technology lies at the intersection of governmental oversight, social pressure, and technological innovation, research into the field of automotive safety requires a multidisciplinary approach encompassing information sources in fields such as psychology and sociology. For this research project, assessment of real world advertisements from automotive manufacturers pitching various digital safety systems will be relevant to provide comprehensive understanding of advertising methodology.

Additionally, studies involving driver psychology and reactions can help understand the mentality and reactions to changing technology in the automotive industry. This qualitative approach will complement the quantitative analysis of incident data by providing valuable perspectives regarding the human aspect of driving. From a deontological perspective, such data analysis should be performed during design of the human-interactive portions of digital safety systems. Also, it should be performed by manufacturers prior to selecting an advertising approach in the marketing domain. Integrating ethical considerations into the design process ensures that digital safety systems prioritize user well-being and autonomy. By incorporating driver psychology research, engineers have a duty to design with human interaction in mind, it is part of safe and moral design. Using this framework, it becomes clear that engineers focusing on full self driving technology (where the human operator is eliminated from the system completely) must shift ethical focus when designing the intermediary steps that are released into current, human operated vehicles.

Through the process of combining the methodological approaches, this research aims to develop a nuanced understanding of automotive safety within the context of electronics and explore avenues for enhancing overall safety outcomes.

Literature Review

While much of the literature surrounding vehicular connectivity and safety is either technical or designed to evaluate the efficacy of the same (Hubele & Kennedy, 2018), concerns about the impact of these systems on passenger safety have also been expressed through various other scholarly lenses. Some researchers seek to understand the complex interactions between humans and technology that exists on the spectrum of "self-driving" (Stilgoe, 2018). For instance, one journal article attempts to frame new technologies in automobiles as "tests of social learning" (Stilgoe, 2018). It posits that any safety intervention that does not approach the issue of technological safety features as an issue of education is likely to fail. This perspective might place group psychology as the determining factor in whether self-driving systems aid or hinder driver and passenger safety.

This article takes the view that each individual technological safety feature, up to and including full autonomy, has a diverse set of sociotechnical interactions. Therein lies its scholarly novelty. The designers of ABS and Forward Collision Warnings may have had very similar societal impact goals; they both sought to reduce forward collisions and improve vehicular control, thereby decreasing the prevalence of automotive mortality. However, that does not mean that two scholarly treatments of the actual, real-world impacts of these two technologies ought to be identical, or that they should be lumped together into a nebulous “autonomous driver aid” category. Though the steps from manual control to autonomous driving may seem linear from an engineering perspective, in reality each novel technology along the way creates independent and often distinct societal effects.

Along the same lines, the limitation of the Stilgoe paper is that it views the intersection of technology (autonomous vehicles, specifically) and safety as nearly entirely a social group dynamic. While users’ expectations of vehicular technology may certainly be driven by group learning (including media and advertising representation), driving is fundamentally a solitary activity. Drivers will naturally form their own personal relationship with the technology in their vehicles, and to boil this process down to entirely group influences is to miss out on the other venues of human-technological interaction influencing safety.

Results and Discussion

New active safety features (controlled by a computer based on sensor input) have come to market. For example, Hyundai incorporated Lane Keep Assist, which is a software and hardware tool built into their vehicles designed to assist drivers in maintaining their vehicle within the designated lane. Hyundai used this feature in its marketing scheme with a TV spot called “Paid Attention.” In the ad, a group of young people are driving a Hyundai down the road when the driver pulls out a phone to take a selfie while driving. The driver’s lapse in attention almost causes an accident, but the car’s Lane Keep Assist takes over and corrects.

This ad treats distracted driving like an inevitability, excusing irresponsible behavior. It is easy to see how this type of portrayal might lead to overconfidence in a vehicle’s ability to drive itself and correct for a driver's mistakes ("2021 Hyundai Kona TV Spot, 'Paid Attention' [T2]"—iSpot.tv, n.d.).

That Hyundai ad was released in 2021. Since then, there have been rapid developments in the technology implemented in cars and trucks. In one 2024 advertisement from Chevrolet called, "Silverado - Drive You Home," a narrator states, "Only Super Cruise lets you drive hands-free and tow hands-free. It'll help get you to the adventure energized, and it will help drive you home."

Meanwhile, a truck towing a trailer is shown, and the driver's hands are folded away from the steering wheel (Drive You Home, 2023).

Chevrolet has taken the prior 'self-driving' systems further than before, offering the ability for the system to drive without even a drivers' hands on the wheel. In contrast with the Hyundai system, the Chevrolet system advertises a higher level of automation, allowing drivers to go hands-free while a driver camera tracks their level of attention on the road. Chevy is looking to design features that force the user to pay attention, at least until truly full-self driving is ready (both from a technological and legal perspective) (Chevrolet, 2023). Whether this truly promotes safety or is mostly a way to advertise features to reduce workload on the driver is unclear. Implicitly, by saying that the system will help a driver get to an 'adventure' more energized, it is stating that the need for attention from the driver is reduced, despite the attention tracking sensors in the cab.

The fundamental difference between these advertisements and the advertisements for traditional safety equipment such as seat belts or crumple zones is that these active devices are designed to *prevent* accidents rather than lessen accidents' dangerous impacts once they do occur, like a seatbelt. The advertisements seem to be saying that advanced computer technology can obviate the need for you to pay attention to the road, rather than being an extra layer of protection. Rather than promoting safer driving habits, these advertisements may inadvertently encourage a culture of overreliance on technology, ultimately increasing the likelihood of accidents as drivers become less engaged and vigilant on the road.

A research team from the Chalmers University of Technology developed models for the driving behavior of heavy truck drivers (Markula, 2015). It found that drivers, when in a "near-crash" state (one where they are attempting to correct a dangerous instability), instinctively use a poor correction strategy. "When stabilizing a skidding vehicle, drivers were found to employ a rather simple and seemingly suboptimal yaw rate nulling strategy."

The researchers further found that electronic stability control (ESC) or advanced emergency braking systems (AEBS) were very effective in returning control to the driver faster than if the driver were operating alone. It is clear that in these types of acute driving situations, where an operator is wrestling with the controls in order to return the vehicle to stability, advanced vehicle safety systems (as long as they are well designed) are nothing but a boon. At that point, social effects are largely moot and the only factors impacting safety are driver skill and design of the vehicle. Therefore, certainly there exists a critical role for these systems.

While traditional safety features focused on mitigating the consequences of accidents, active safety systems aim to prevent accidents from occurring in the first place. Additionally, they require an order of magnitude more complexity, and understanding how they work and when they are active may not be as simple as with seat belts. And even seat belts required a public awareness campaign about their importance.

These newer systems may not be as reliable. Chevrolet recalled many of its pickup trucks due to defective emergency braking systems (Barry, 2024). In some cases, the cure may be worse than the disease, particularly when it comes to false positive rates. It is a fine line between a feature that is useless because it never activates and one that is useless because it activates too much. False positives can diminish drivers' confidence in the reliability of active safety systems, leading drivers to either disable the systems entirely or become less reliant on them, thereby negating their intended safety benefits.

Regulation is often a combination of consumer direction and top-down decision making. Consumers, through advocacy groups, market demand, and public outcry about safety, can influence policymakers to enact regulations that prioritize safety. Rear view backup cameras are now required for all new vehicles domestically. This increases the cost of vehicles, as well as their complexity, but can improve safety. At the same time, such systems might train drivers to rely solely on technology rather than developing and maintaining their own situational awareness. In this way, consumers can not always be relied upon to drive regulation in a positive direction from a safety perspective.

Consumers can also drive the direction of the automotive industry by voting with their purchasing decisions. Car and truck manufacturers attempt to sway consumers by implying that advanced safety features take pressure off of the driver to pay attention.

Conclusion

The impacts of any change to a vehicle are inevitably multifaceted. From a purely technological and mechanical standpoint, advanced computer systems have advantages in safety. They never get tired or sick or distracted, and having an extra “set of eyes” on the road is broadly a good thing. However, from a social perspective, drivers do not exist at a fixed level of safety, onto which arbitrary safety features can be added. Adding those safety features necessarily alters driver behavior, because of the human and social reasons discussed. A false sense of safety can lead to complacency and a decrease in vigilance. When drivers rely too heavily on automated systems, they may become less attentive or engaged with the task of driving, increasing the risk of accidents. There can also be a psychological shift where individuals feel less responsible for their actions behind the wheel, attributing mistakes solely to the technology rather than taking personal accountability.

As a society, we need to carefully consider the role these systems play beyond the technical and also how we ought to permit auto makers to advertise them. Should these safety systems be considered a stop-gap on the road to true full self driving technology? To what extent are automakers truly interested in safety, and to what extent are advanced safety features being used as a trojan horse to acquire regulatory and social acceptance to land computers in cars? These questions are essential for policymakers, regulators, and consumers alike to ponder as we navigate the future of automotive technology. Automakers should be transparent about the limitations of their safety systems, as well as the level of autonomy they provide, and should be careful to evaluate the social and ethical impacts of each individual safety technology independently rather than painting them with the same large brush used to ponder full self-driving technology.

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