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# UX Challenges and Opportunities of Autonomous Vehicles regarding Driving Styles and Automation Levels

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## **Abstract**

Despite the prevalent general discussion and prospect of autonomous vehicles, little research has approached this issue with a focused theoretical background. However, discussion without a specific user or user group might become too abstract. Moreover, given that automation is not a unified concept, we can consider different levels of automation when we envision user experience (UX) of autonomous vehicles. To this end, the present paper explores UX challenges and opportunities of autonomous vehicles regarding driving styles and automation levels. This paper brings up some argumentative points, compared to traditional Human Factors view and is expected to promote lively discussions at the workshop.

## **Author Keywords**

Automation Levels; Driving Style; User eXperience

## **ACM Classification Keywords**

H.5.2. [Information interfaces and presentation (e.g., HCI)]: User Interfaces; J.4 [Computer Application]: Social and Behavioral Sciences–Psychology

## **Introduction**

The number of road accidents and death rate have consistently decreased, but still the absolute number is very high [e.g., 1, 2]. The connected vehicles paradigm

is one of the strategies to solve this issue and many projects are on-going in a collaboration with government, industry, and academia [e.g., 3]. However, this is an intermediate step to get to the ultimate goal, autonomous driving. With the advance of sensing technologies and computing powers, the era of autonomous vehicles are fast approaching. The present paper attempts to re-explore user eXperience (UX) challenges and opportunities of autonomous vehicles regarding driving styles and automation levels. By doing so, we will be able to posit more concrete future of driver UX in autonomous vehicles.

### **Pros and Cons of Autonomous Vehicles from Traditional Human Factors Perspective**

From the traditional Human Factors perspective, advantages and downsides of the autonomous vehicle have been identified [4]. There are clear incentives. Safety is the primary motivation. If every car is fully automated, it might reach the goal of zero accident on the road. It can also improve mobility of older adults and people with disabilities. Not just mobility disabilities, but other types of disabilities can be overcome, such as visually impaired people or people with cognitive impairments. It can also enhance fuel efficiency by optimizing the route and speed. On the other hand, research has also listed some weak points of the autonomous vehicle. One of the most important issues in automation is trust. If users do not trust (i.e., disuse) the automation, then, it is going to be a problem. Likewise, if the users trust the system too much (i.e., misuse), it can also be a problem [5]. Here, complacency issue arises. If the users get to be overly reliant on the system, they would overestimate what the system can do. Then, users will disengage themselves from the system and their situation

awareness will decrease. Thus, when drivers have to take over the control, it will become slower and problematic. As Parasuraman pointed out [5], automation without taking users into account (i.e., abuse) will be a disaster. Therefore, Lee [6] suggests designing “appropriate” trust, not simply greater trust. Of course, it should be “appropriateness” for users and their goals. Another concern is information overload because of increased monitoring tasks. It is the different side of the same coin because high operator workload will also result in complacency [7]. As an approach of considering users and their environment, the present paper focuses on drivers’ specific driving styles and automation levels.

### **Driving Styles**

There are a number of driving style measures. Van Huysduynen [8] and colleagues have recently validated the multidimensional driving style inventory (MDSI) [9]. In their study, they found that five factors they extracted from participants in Netherlands and Belgium are more stable compared to eight factors from the original study with Israel participants. The five factors include Angry driving, Anxious driving, Dissociative driving, Distress-reduction driving, and Careful driving. Depending on different driving styles, UX designers can use different approaches and strategies.

### **Levels of Autonomous Driving**

Gasser and Westhoff [10] proposed five levels of autonomous driving: manual driving, driver assistance, partially automated driving, highly automated driving, and fully automated driving. The current advanced driver assistance systems (ADAS) [11] has already shown the levels three and four: automated parking, lane-keeping systems, adaptive cruise control, forward

collision warning, speed regulation systems, curve speed warning, and blind spot monitoring. Some issues regarding autonomous vehicles seem to be resolved by adopting a different level of autonomous vehicles. Also, drivers with different driving styles might require different levels of autonomous vehicles.

### **UX Challenges and Opportunities of Autonomous Vehicles**

**Angry driving** or road rage has become a more and more critical issue on road [12]. Even with autonomous vehicles, angry driving can exist. For example, with partially automated driving or highly automated driving [10], anger can still be induced by other drivers' intentional behaviors (e.g., tailgating) or by applying different social norms. Even with fully automated vehicles, drivers can still swear or do small actions. To counteract this serious phenomena, emotional driving research has rapidly increasing in the community. A certain emotion could be detected in an unobtrusive way and mitigated by several psychological strategies, including social interactions with vehicle agents [12].

**Risky driving** is often addressed as one of the caveats of autonomous vehicles [4]. For example, if drivers sufficiently trust vehicles, some drivers will likely follow the front car closely or drive faster than usual. It could be a big issue with partially or highly automated vehicles. However, once fully automated vehicles are pervasive (and secure high level safety), this can be a good mode for some drivers who have a risk seeking tendency. This could be a converse statement from the safety perspective of traditional Human Factors, but this could better fulfil specific population's needs from the UX perspective.

Some people have an **anxious driving** style. To better understand this anxious drivers, we need to look at the plausible sources of anxiety regarding autonomous vehicles. Again, it seems related to trust. On one hand, people can be anxious about their poor driving skill. Fully automated vehicles can solve this issue. On the other hand, people can be anxious about not being able to control over something. In this case, a designer can design the interface so that drivers can feel more controllability and vehicle systems serve as a driver assistance.

**Dissociated driving** includes errors and mistakes (e.g., errors in gear shift or lights). If this stems from poor (or inexperienced) driving, again fully autonomous vehicles can solve this issue. Drivers do not need to differentiate gear shifts or calculate route themselves. If it is a type of bodily *slip* (with good intention), brain-computer interfaces can be a good alternative. The vehicle can directly read information from the driver's brain. In the case where drivers still want to control over fully automated vehicles, there might need some negotiation process between the driver and the vehicle for better UX.

**Careful driving** is referred to "better safe than sorry". To fulfil this type of drivers' motivation with any type of autonomous vehicles, we can provide more effective and robust monitoring interfaces rather than providing a number of distracting tasks. This type of people will likely want to have higher situation awareness and will be satisfied with the more completed monitoring mechanisms.

Van Huysduynen et al. [8] confirmed these five factors, but their first two factor analyses also include the sixth

factor, **distress-reduction driving style**, which is closely related to driver UX in autonomous vehicles. This might be a core element of autonomous vehicles we need to ponder more. To provide "relax" in fully autonomous vehicles, we can design a vehicle space for sleeping, cooking, massage, music, movies, games, contemplation, even light yoga, etc.

### Conclusion

In the present paper I explored various aspects of autonomous vehicles regarding driving styles and automation levels. Some prospect will trigger arguments. However, this will serve as a good starting point about how to embrace individual differences in autonomous vehicles to secure better UX. As shown here, some issues can be naturally resolved by the introduction of fully automated vehicles. Depending on driver styles, some aspects that were previously identified as an issue might serve as a good opportunity for specific people. I do not assert different levels of autonomous vehicles should exist together for different people. That might be more dangerous and more problematic. Instead, even with fully automated vehicles, designers can emphasize or strengthen a certain aspect of different levels of automation. In conclusion, the investigation of autonomous vehicles regarding different driving styles and automation levels seems to be promising. The present paper only slightly touches each driving style, whereas more in-depth scenario making and empirical research should be followed. Then, we will figure out more concrete strategies and directions for autonomous vehicle design.

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