# Multitasking in Autonomous Vehicles: Ready to Go?

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## Abstract
Autonomous cars can take over tasks from the driver and thereby have the potential to free cognitive resources that humans normally allocate to vehicle control. Theoretically, this can create opportunities for the driver to spend time on other tasks such as reading email or making a phone call. However, what happens in situations where the car makes a fatal error? How well does the driver notice this? And how quickly do they respond? In this paper we take the position that a better understanding is needed of the consequences of autonomous vehicles for the human operator.

## Author Keywords
Autonomous Driving; Driver Safety; Human Factors, Cognitive Workload; Situational Awareness; Multitasking; Driver Distraction

## ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

## Introduction: Frequent (in-car) multitasking
Multitasking is a ubiquitous phenomenon that occurs in many settings [8]. For example, recent research suggests that about 80% of the Dutch population uses at least one form of media (e.g., internet, TV, radio) while performing another general activity (e.g.,

shopping, studying) for on average 3.5 hours a day [14]. This includes media use on the road (e.g., while commuting by bus, or while driving a car).

Multitasking has indeed been observed in driving situations [10]. The negative consequences of this behavior have been well documented (e.g., for meta-analyses see [2, 4]). For example, holding a conversation with a remote person can deteriorate driving performance (e.g., [5, 9, 11]). One hypothesis is that even thinking can distract from driving [13]. If so, then many forms of distraction or multitasking while driving can be dangerous.

## The promise of the autonomous car

One promise of the (semi-) autonomous car in this regard is that it can take care of (some of the) regular task demands that are normally imposed on the driver. For example, the car can help to maintain a central lane position and can facilitate a timely brake response to avoid a crash. Situations in which inattention of the driver (e.g., due to multitasking) might have lead to an accident might then be avoided altogether. As the level of autonomy of the car increases [12], increasingly less input by the driver is required for the driving task.

## Challenges

The above scenario presumes a perfect autonomous system, which in practice is not always the case. For example, the Google Autonomous car was involved in 11 minor crashes in the 6 years since the autonomous car project started [15]. Although in these cases the system itself was technically not to blame (e.g., they were due to other traffic), they do illustrate the need for added supervision on the autonomous system. The efficacy of such supervised autonomy will to a large extent be the responsibility of the human supervisor, in particular in lower levels of driver automation (i.e. levels 1-3 in standard [12]).

The challenge is that a redesign of the system will not only change the system but also of the human operator - as has been found in automation research [1]. Although human behavior might be understood in the situation preceding automation, it is not guaranteed that their tasks and behavior is similar in the automated environment.

The transition from man-controlled driving to autonomous driving changes the driver's task from "operating" a vehicle to "monitoring" vehicle operation. One challenge that might arise here is that due to the monotony of the monitoring task, drivers might distract themselves even more (e.g., glance away from the road for longer periods of time). For example, because they see the control of driving safety as being of lower importance [6, 7]. That is, in-car multitasking might *increase* in autonomous cars. We speculate that this is particularly the case in cars with a high level of automation, but not full automation (i.e. level 4 in standard [12]). There is a need how distraction in these cases affects safety and performance.

## Conclusion: Research Opportunities

Little is known about the effects of automation on human distraction in autonomous vehicles at various levels of automated driving and this creates research opportunities. We take the position that the chances for distraction are particularly high with an increase in automation level (e.g., levels 3 and 4 in [12]). Human behavior needs to be better studied in these situations as human behavior might change with a change in

automation [1]. Specific research questions are for example how easily are drivers distracted by other tasks if they only need to monitor an autonomous car (i.e., at SAE level 4)? Do drivers notice unexpected events that the autonomous vehicle might miss (e.g., a kid suddenly crossing the street)? And how quickly do they respond to situations that require action by the human operator (e.g., task-switching costs are known to be persistent in human performance and may be fatal with split-second emergencies [3])? If people are easily distracted, how do we maintain their situational awareness and how is their attention grabbed when it is needed? These and other questions need to be answered before the mass introduction of completely autonomous systems.

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