Engaging in Activities while in an Automated Car Increases the Willingness to Tolerate Longer Travel Times

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SHORT SUMMARY

Automated driving can enable drivers to engage in various recreational or productive activities while the car is driving in automated mode. The current study used survey data, where the respondents rated their intention to use conditionally automated (SAE level 3) passenger cars, what activities they would engage in during the automated mode, and how much additional travel time they might accept if the car could drive in an automated mode. Engaging in recreational activities was the strongest predictor of accepting additional travel time. Resting and relaxing did not influence the accepted extra travel times. Those who accepted the longest extra travel time also considered working in a car. The cost of travel time with automated cars is influenced by recreational activities. The ability to work is important for users, who are the willing to tolerate the longest additional travel times.

Keywords: Acceptance; Automated and connected driving; Non-driving related activities; Value of travel time savings.

1. INTRODUCTION

Automated driving systems in passenger cars intend to reduce or even completely remove the driver's involvement in the driving task. This is projected to make travelling by car more safe and comfortable, and to enable repurposing the travel time for productive or recreational activities (Soteropoulos et al., 2019). Consequently, the perceived cost of travel time may decrease (Cornet et al., 2022; Lehtonen et al., 2022). Decreased cost of travel time in passenger cars is likely to increase the mode share of passenger cars and the vehicle kilometres travelled, which is problematic for the sustainability of the transport system (Hardman et al., 2022; Sonnleitner et al., 2022). To better understand the changes due to the decreased cost of travel time, it is valuable to understand, which activities drivers envision themselves to engage in during automated driving.

Previous studies have found that people typically project themselves engaging in different sorts of recreational activities during automated driving (Nordhoff et al., 2020; Pudāne et al., 2019). Respondents less often envision themselves working in an automated car. On the other hand, a possibility to engage in work-related activities e.g, during a commute could possibly provide some additional free hours if the commute could be counted as a work time.

The current paper is based on a survey, which investigated the activities that people would like to engage in while travelling in an automated passenger car, their willingness to use automated cars,

and how much extra travel time they could accept on-board an automated car if they did not need to drive themselves compared to driving manually. The accepted extra travel time can then be interpreted to reflect the changes in the perceived cost of travel time (Lehtonen et al., 2022). We analysed if the self-projected willingness to engage in recreational or working activities predicts a higher willingness to accept longer travel times after controlling for the general willingness to use.

2. METHODOLOGY

Data

We used L3Pilot project's Impact Assessment Survey data (Bjorvatn et al., 2021). The survey focused on conditionally automated (SAE level 3) passenger cars. Respondents were provided a textual description of the capabilities of the cars. The description stated that while activated, the driver does not need to keep their hands on the wheel or eyes on the road and can focus on other tasks. However, the respondents were told that the car may ask the driver to take back the control when it is leaving its operational design domain, e.g. when the lane markings are not visible or the weather conditions are poor.

The data was collected in eight European countries (Germany, Italy, Netherlands, UK, Poland, Romania, Sweden, Spain) in January 2021 with a total of 8,432 responses. Data was filtered for respondents who exhibited straight-line responding. This resulted in 7,769 respondents.

The current analysis utilized questions on the intention to use automated cars, how much longer travel time they could accept if the car could drive in an automated mode, and which activities they would engage while the car is driving in an automated mode.

Measures

Intention to use was calculated by averaging the responses to three statements:

- I intend to use a conditionally automated car in the future.
- I plan to buy a conditionally automated car when it is available.
- If I were driving a conditionally automated car, I would very likely activate the automated driving function.

The responses to the statements were given on a five-point scale (Strongly disagree, Disagree, Neutral, Agree, Strongly agree).

The participants answered if they would like to engage in different activities while the car is driving in an automated mode. Twelve activities were listed, and the responses were given on a six-point scale (Always, Very often, Sometimes, Rarely, Never, Not relevant for me) (Table 1). For regression analysis, five activity scores were calculated by converting the response into numeric values. Never / Not relevant for me = 1, Rarely = 2, Sometimes = 3, Very often = 4, Always = 5).

Table 1. Activities during automated driving and activity scores.

Activity score	Activities
Listening and observing	Listening to music, radio and audiobooks Observing the landscape and road ahead
Active recreation	Eating or drinking Spending time with fellow passengers Messaging/calling friends or family Using digital media Entertaining/taking care of children Reading a book or magazine
Resting	Relaxing and/or resting
Working	Working
Not included	Monitoring how the car is functioning
Not included	Sleeping

Activity score *Listening and observing* was calculated as an average of two corresponding activities (Table 1). Listening and observing are rather passive activities where the user is not engaged to anything what a driver could not do while steering the car. *Active recreation* was an average of different hands-off-the-wheel and/or eyes-of-the-road activities which are not work related. *Working* was included separately. *Resting and relaxing* was also taken as a separate activity, because even though it is a recreational activity, it is different in the sense that the user is not actively doing anything. Monitoring was not included in the activity scores, because intention to monitor the car might reflect mistrust toward a novel system. Constant monitoring of the car is also not required in conditionally automated cars. It is likely that the users of automated cars would either soon start to trust the system or stop using it. Sleeping was not included in the activity scores, because that would not be allowed in conditionally automated cars.

The participants were asked in four scenarios how much additional travel time they could accept if the car would be driving in automated mode compared to driving manually. There were two types of scenarios, *Longer route* and *Congestion*. Longer route scenario suggested that the automated driving would be available, but only if the user is willing to use a longer route:

Imagine that you are travelling by car. There is an alternative route that is somewhat longer, but on which the automated driving system would be available. How much additional time would you be willing to accept if the car could drive by itself and you could engage in other activities?

Congestion scenario asked if the respondents would be ready to drive during the peak-hours instead if they could use an automated car:

Imagine a car trip that you have scheduled to avoid the peak of congestion. A conditionally automated car could drive by itself in congested traffic. How much additional time would you be willing to accept in congested traffic if the car could drive by itself and you could engage in other activities?

The additional times accepted with automation were related to the trip duration in the manual mode (30-minutes or 120-minute), resulting in a percentage. Because the resulting distributions were limited between 0% and 100%, with a sizable proportion of zero answers, non-parametric quantile regression was used for the analysis.

Regression model

Quantile regression is a non-parametric regression method, which can be used to model the effect of the independent variables on the chosen quantile. Quantiles of 0.2, 0.5 and 0.8 were used. First, a mixed effect quantile regression model was calculated, which included the scenario type (Longer route vs. Congestion), manually driven duration (30-minute vs. 120-minute) and their interaction as fixed effects. A random intercept was used for the participants.

The mixed effect model was used to show that the differences between the Longer route and Congestion scenarios were small, but that there was an effect of the trip duration. Therefore, the accepted extra travel times for 30-minute scenarios were averaged. The average was used as the dependent variable when investigating the effect of the Intention to use and activities on the accepted extra travel time. This allowed using a (non-mixed) quantile regression model with the continuous covariates, which substantially reduced the computation time for the bootstrapped standard errors, confidence intervals and p-values.

3. RESULTS AND DISCUSSION

Activities

Responses to the activities the participants would perform while the car is in automated mode are shown in Figure 1. The two most common activities (listening to music, radio and audiobooks, observing the landscape and road ahead) are something that drivers can already do, because they do not require taking hands off the wheel or directing eyes off the road. The third common activity was monitoring how the car is functioning. In this activity, the users are still engaged to the driving task as a supervisor.

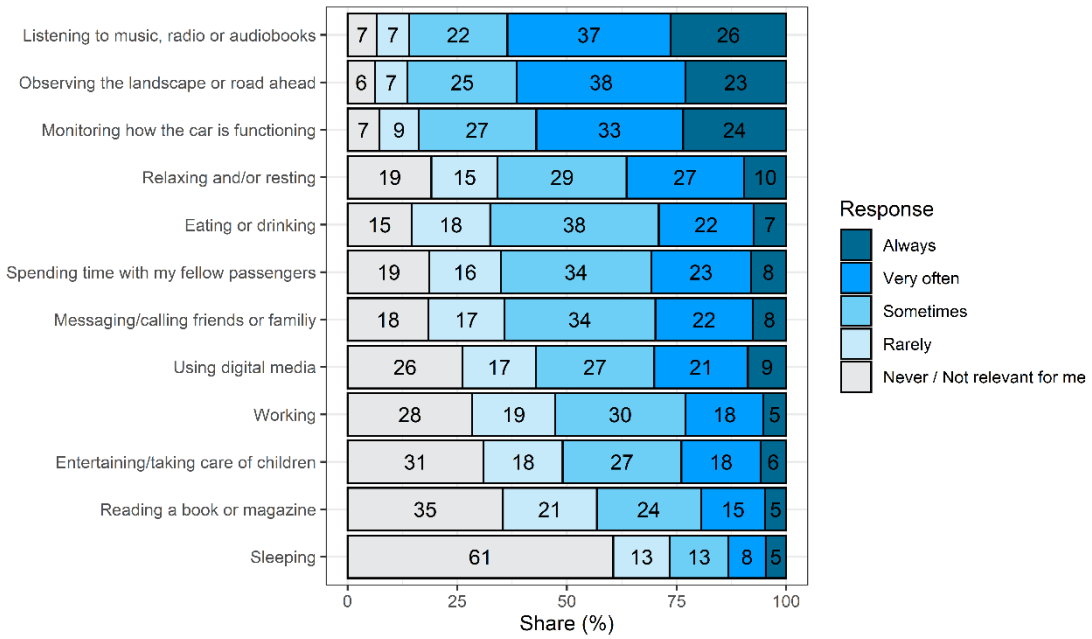

Figure 1. Activities to be performed while the car is in automated mode.

In the rest of the activities, the user disengages from the driving task and repurposes their travel time. Relaxing and/or resting is the fourth most common activity, followed by other recreational activities. Working comes as the ninth most common activity, but still half of the respondents would work at least sometimes.

Quantile regression models

For the 30-minute scenarios, the participants accepted 33% longer travel times in median. The accepted extra travel times did differ in the *Congestion* and *Longer route* scenarios. For the 0.2 and 0.8 quantiles, the *Congestion* scenario was statistically significantly different from *Longer route*, but the absolute difference was still less than one-tenth of the extra time in the *Longer route* scenario. The percentages of the extra time were smaller in the 120-minute compared to 30-minute scenario, with small but significant interaction with the scenario type.

Table 2: Mixed-effect quantile regression model for the extra travel time. Fixed effects shown for quantiles 0.2, 0.5, and 0.8 (tau).

Term	Estimate	SE	95% CI		p
			Lower	Upper	
tau = 0.2					
Intercept	18.53	1.58	15.36	21.71	<.001*
120 min[a]	-6.82	0.73	-8.29	-5.36	<.001*
Congestion[a]	-1.87	0.69	-3.26	-0.48	0.009*
120 min x Congestion	1.87	0.72	0.43	3.31	.012*
tau = 0.5					
Intercept	33.33	0.07	33.19	33.48	<.001*
120 min[a]	-12.14	1.19	-14.52	-9.75	<.001*
Congestion[a]	0.00	0.08	-0.15	0.15	1.000
120 min x Congestion	-0.56	0.47	-1.50	0.38	.234
tau = 0.8					
Intercept	46.00	2.65	40.67	51.32	<.001*
120 min[a]	-13.00	1.07	-15.16	-10.85	<.001*
Congestion[a]	4.03	0.93	2.17	5.90	<.001*
120 min x Congestion	-4.03	0.61	-5.26	-2.81	<.001*

[a] *Reference categories: 30-minute and Longer route. * $p < 0.05$*

The effect of the *Intention to use* and activities on the extra travel time were tested only for the averaged 30-minute scenarios. A higher intention to use predicted a longer extra travel time with all quantiles. The effects were larger for the 0.2 and 0.8 quantiles than for 0.5 quantile, but all the confidence intervals overlap.

Active recreation increased the accepted extra travel time at all quantiles. *Working* had a positive effect only for the highest 0.8 quantile, otherwise there was no effect. This suggests that those who would be ready to accept the longest extra time would also like to spend the time working. Working might be something where people want to have a long enough time to focus on.

Interestingly, *Resting and/or relaxing* did not have an effect on the accepted additional travel time. Even though 'doing nothing' or 'having time off' are recognized positive utilities of travel time (Pudāne et al., 2019; Singleton, 2019), they do not seem to be something that would make people accept extra travel time in automated cars.

Table 3: Quantile regression model for the average extra travel time in the 30-minute scenarios. Effects shown for quantiles 0.2, 0.5, and 0.8 (tau). Covariates were scaled before analysis: Intercepts correspond to the quantiles at the whole sample.

	Estimate	SE	95% CI		p
			Lower	Upper	
tau = 0.2					
Intercept	16.51	0.35	15.82	17.20	<0.001*
Intention to use	4.73	0.24	4.25	5.20	<0.001*
Resting	0.03	0.33	-0.64	0.69	0.940
Leisure	2.89	0.37	2.16	3.62	<0.001*
Working	0.49	0.31	-0.13	1.11	0.118
tau = 0.5					
Intercept	31.08	0.30	30.48	31.68	<0.001*
Intention to use	4.21	0.38	3.44	4.97	<0.001*
Resting	0.27	0.42	-0.57	1.10	0.530
Leisure	2.82	0.43	1.96	3.67	<0.001*
Working	0.69	0.38	-0.06	1.44	0.071
tau = 0.8					
Intercept	52.41	0.59	51.24	53.57	<0.001*
Intention to use	4.31	0.62	3.08	5.55	<0.001*
Resting	-0.99	0.70	-2.38	0.40	0.160
Leisure	5.72	0.80	4.14	7.30	<0.001*
Working	1.98	0.70	0.58	3.37	<0.006*

** $p < 0.05$*

4. CONCLUSIONS

Automated driving makes it possible to repurpose the driving time for other activities. The current study examined the activities that survey respondents envisioned engaging in while in an automated car and how these activities affected their willingness to tolerate longer travel times. Engaging in recreational activities predicted accepting additional travel time for most of the users. Those who accepted the longest extra travel times also considered working in a car. Resting and relaxing were commonly mentioned as in-car activities, but they did not influence the accepted extra travel times. The results suggest that in-car recreational activities decrease the perceived cost of travel time in automated driving. Working in an automated car may not be possible or attractive for all users, but for those who would like to work, are also most willing to tolerate additional travel time. In-car activities in an automated car are thus relevant for the sustainability of the transport system because the reduced cost of travel time may increase the use of cars. Policy measures to support the use of alternative travel modes, and to reduce the need for travelling are needed.

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