



Article

The Potential of Napping in Automated Driving and User Preferences for Wake-Up Concepts—An Online Study

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Abstract

In automated driving, drivers may sleep during rides, making it important to study napping preferences and wake-up scenarios for human-centered system design. We conducted an online study with 280 participants, balanced by age and gender, examining how often, when, and how long individuals would nap if given the opportunity. The study also explored preferred wake-up methods when the vehicle nears the end of its operational design domain. Using a mixed 2×2 design, participants were assigned to one of two travel purposes (“commuting” vs. “holiday trip”) and two minimal risk conditions (rest area vs. hard shoulder). The results showed that 40% intended to sleep during automated driving, highlighting a strong interest in in-car sleeping. Wake-up preferences varied by travel purpose and minimal risk condition, with many favoring awakening before the drive ended. Participants also anticipated sleep inertia and desired post-wake-up support. The findings allow suggestions for designing wake-up concepts that mitigate sleep inertia.

Keywords: automated driving; sleep; napping; sleep inertia; takeover

1. Introduction

Automated vehicles have the potential to increase comfort, decrease driver stress, reduce greenhouse gas emissions and improve overall road safety [1–3]. According to the classification of the Society of Automotive Engineers (SAE), automation can be divided into different levels [4]. Driving at Levels 0 to 2 implies that the driver still conducts some parts of the driving task. In contrast, at Level 3 to 5, the role of the driver changes to that of a passenger, as long as the automated system is activated. The user of the automation is not responsible for taking over any part of the driving task within the operational design domain (ODD). At Level 3, the driver has to be capable of resuming the driving task quickly on request. At Level 4, the driver may have the following choice. As soon as the vehicle leaves the ODD, the driver either takes over the driving task or a minimal-risk maneuver is initiated, meaning the vehicle automatically comes to a safe stop [4]. Hereby, the vehicle may stop on a nearby rest area, on the hard shoulder or on the curb of the road, depending on traffic conditions, the predictability of the ODD end and the availability of parking lots [5,6]. Hence, due to the higher predictability of the end of the ODD and the higher time budget for the transition of controls at Level 4 compared to Level 3, the role as passenger becomes even more pronounced.

This also becomes evident with regard to imaginable non-driving related tasks. At Level 3 and Level 4 automated driving, entertainment, work or relaxation are conceivable.



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However, using the extra time for sleeping is only possible in Level 4 and 5. Even short periods of sleep (i.e., naps) have positive effects on sleepiness and performance [7,8]. In the context of driving, taking a nap can reduce drowsiness, which has been identified as a major risk factor for safe driving [9–11]. Hence, the possibility to sleep during automated driving might reduce drowsiness during sections of manual driving because the driver can take over the driving task more rested.

Survey studies indicate that sleeping during automated driving is a very popular use case for automated driving [12,13]. According to Tomzig and Kaß [13], sleeping during the trip is particularly desired in the early morning and during nighttime. Corresponding and, hence, popular travel purposes include commuting to and from work, with driving durations of 30 to 45 min, and trips to a vacation destination, with driving durations of several hours.

While these results show the potential of sleeping during automated driving, sleep comes with a possible side effect after waking up, which is sleep inertia. Sleep inertia refers to the phenomenon of temporary disorientation and the decline in performance and mood after waking up from sleep [14]. Under sleep inertia, drivers exhibit impaired takeover performance and lane keeping, increased driving errors, reaction times and feelings of sleepiness, and decreased driving speed and motivation to continue driving [15–20]. Therefore, sleep inertia is a significant risk factor to be considered in the transition from automated to manual driving. For Level 4 automated driving, this is important because of the operational limitation of the automated vehicle. As soon as the vehicle leaves the ODD, the person in the driver's seat may be required to take control and drive manually again. During the transition of control from automated to manual driving, the responsible driver should be free of sleep inertia.

Because of this, sleep in automated driving creates an area of conflict: on the one hand, users should have the opportunity to sleep during automated driving to reduce drowsiness and increase the user experience of automated driving. On the other hand, system design should consider the possible occurrence of sleep inertia during the transition from automated to manual driving with a mitigation concept supporting the user during and after awakening.

The effects of sleep inertia diminish with the time spent awake, with noticeable improvements typically occurring within the first few minutes after awakening [14,15,21,22]. In aviation, where pilots may sleep under certain conditions in the cockpit, guidelines recommend a transition period of up to 20 min before resuming critical tasks [23–25]. Similar strategies are being discussed in the automotive context, such as waking the driver in advance or having the vehicle stop at a suitable location before requiring driver takeover [18,26].

Previous research has investigated various countermeasures against sleep inertia. Outside the driving context, studies have shown that music—particularly melodic music that aligns with personal preferences—can enhance alertness and performance after waking [27,28]. Studies on the use of bright or red light consistently report that this countermeasure reduces self-reported sleepiness [29–33]. However, findings regarding its effects on performance are inconclusive. One possible explanation is that the light may cause glare, which interferes with task execution [31]. Furthermore, it is hypothesized that the cooling of extremities could mitigate sleep inertia [34,35]. Although the potential of this measure has been proven with putting a hand in ice-cooled water [36], these conditions are hardly transferable to the vehicle context. To the best of the authors' knowledge, to date, only one study has tested a countermeasure against sleep inertia in the vehicle. In a driving simulator study by Wörle et al. [37], a reaction time game, as concept for cognitive stimulation, was able to temporarily increase the drivers' arousal but it could not increase

wellbeing and motivation. The measures of driving performance were not reported in the study.

So far, research on driver takeovers after sleep and the corresponding countermeasures has focused primarily on performance outcomes. There remains a gap in understanding user preferences which are considered important for a high user experience and acceptance for future in-vehicle napping. From a performance standpoint, it may be beneficial to delay takeover after sleep by stopping the vehicle. However, it is unclear whether users would accept this as they may prefer to continue their trip without delay. The acceptability of stopping on the roadside in the absence of parking spaces also remains uncertain. Furthermore, research on sleep inertia clearly shows that drivers need support to regain their fitness to drive after sleep [38] but user preferences remain yet unclear. The online study presented in this paper investigates user needs and preferences related to wake-up modalities, wake-up and takeover terms, and post-sleep support to mitigate sleep inertia. Hence, the study explicitly investigated edge cases at the boundary of the ODD, where driver readiness becomes relevant. We hypothesize that these user preferences vary depending on the travel purpose and the available possibilities to stop the vehicle. In detail, we assume that in a commuting use case, faster transitions from automated to manual driving are more acceptable or even desired than in vacation drives (i.e., stopping the vehicle is more accepted, the alarm is expected to be less urgent, and there should be a later expected readiness to continue driving manually in the vacation travel purpose compared to commuting). We also expect that achieving a minimal risk condition by stopping at a rest area is perceived as more acceptable than stopping on the hard shoulder. Further research questions, such as the desired wake-up modalities or the desired support after waking up, are exploratively investigated. The results aim to contribute to the user-centered design of in-vehicle awakening strategies.

2. Materials and Methods

The following chapter describes the applied methods in detail. This study represented an online experiment with a mixed study design. Participants were presented with future scenarios for sleeping during automated driving and asked for their preferences.

2.1. Experimental Design

To study potential users' napping desire in automated driving (Level 4) and preferences concerning aspects of the wake-up situation, four hypothetical situations were designed. The delineated situations differed regarding the general automated driving travel purpose and the minimal risk condition that followed the automated ride. The travel purpose was implemented as the between-subjects factor. According to the most popular travel purposes identified by Tomzig and Kaß [13], participants were either asked to imagine that they used the automated driving function during a commute ride in the morning or as part of an overnight journey while going on vacation. Furthermore, two minimal risk conditions were depicted for all participants, hence acting as the within-subjects factor. One minimal risk condition comprised stopping at a freeway rest area in case of an ODD limitation. In the other condition, it was depicted that the vehicle would stop on the hard shoulder as no nearby rest area was available [6]. So, in total, this design resulted in a 2×2 mixed factorial structure with participants being confronted with two situations each. The data was collected through an online questionnaire.

2.2. Sample

The sample consisted of $N = 280$ participants, which were recruited through the participant panel of the Würzburg Institute for Traffic Sciences (WIVW) and social media networks.

Participants had to be at least 18 years old. In total, $n = 141$ participants were female and $n = 148$ were male. One person identified as non-binary. The mean age was 46.3 years ($SD = 15.9$). The composition of the sample depending on the travel purpose is given in Table 1.

Table 1. Age and gender distribution across the sample.

Travel Purpose	Gender	N	Mean Age	SD Age
Commuting	female	70	46.3	14.1
	male	69	47.3	16.8
	non-binary	1	54.0	-
	subtotal	140	46.9	15.4
Vacation	female	71	46.3	16.8
	male	69	45.3	16.1
	non-binary	0	-	-
	subtotal	140	45.8	16.4
total		280	46.3	15.9

Note. Gender and age recorded by self-report. Age in years.

2.3. Procedure

In this study, the participants were presented with one of two depicted travel purposes for sleeping during automated driving and two different minimal risk maneuvers in the context of automated driving. At the beginning of the experiment, participants were informed about the general setting. It was explained that the ensuing questions would address automated driving and, therefore, information on an automated driving system was given. It was stated that this meant that their vehicle was completely self-driven by the system and that the vehicle performed all driving activities. Further, it was described that the person on the driver's seat was allowed to direct their attention away from the driving scene and delve into non-driving related tasks. Examples included reading, working or sleeping. In addition, they were told that the system would inform them in a timely manner about the potential need to take over manual driving, for example, when they reached the highway exit.

As mentioned, the participants were presented with two travel purposes—a commute and vacation drive—to investigate whether users' preferences regarding napping and awakening differed between these scenarios. The commute travel purpose was presented as follows: "You are commuting daily with your vehicle early in the morning. You are alone in your vehicle. Your drive lasts about 40 min. During the complete ride, you would have the possibility to activate the automation and could sleep".

The vacation travel purpose was introduced as follows: "You are going on holiday and are using your vehicle. You are alone in the vehicle. The drive lasts about six hours. You start your drive late in the evening and will reach your destination early in the morning. During the complete ride, you would have the possibility to activate the automation and could sleep".

Both minimal risk conditions were assessed in randomized order for all participants. The general introduction was read as follows: "Please imagine the following situation: You are getting near to the highway exit. After exiting the highway, you will have to drive the rest of your way to your destination. You will then again be responsible for your safety".

The following specific conditions then differed regarding the potential stopping place: on the hard shoulder (see Figure 1 left) or at a freeway rest area (see Figure 1 right).

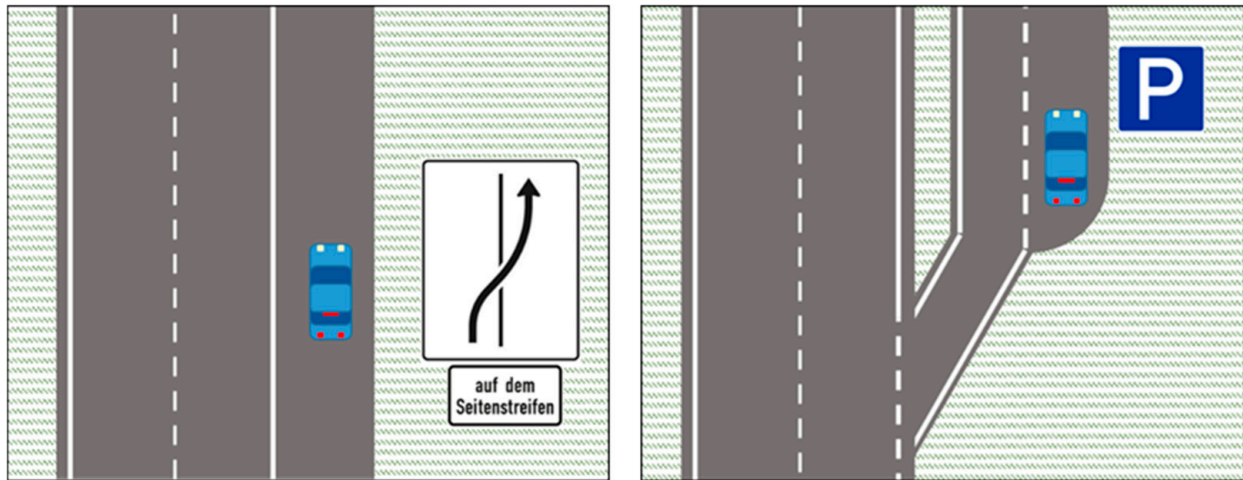


Figure 1. Presented minimal risk conditions: The vehicle either would stop on the hard shoulder (**left**) or on a freeway rest area (**right**).

2.4. Measures

The study was implemented with the software LimeSurvey Version 5.6.68+240625 (LimeSurvey GmbH, Hamburg, Germany) and conducted online. At first, participants were introduced to the scope of the study, agreed to the data privacy terms and gave their basic demographic information (gender and age). Then, questions on their sleeping behavior in everyday life and in vehicles as of today were administered. They covered the general tendency to sleep at a freeway rest area or as a passenger and the duration of such naps. After that, participants were assigned to one of the two travel purpose conditions and questions regarding their desire to sleep during an automated ride and their potential sleep duration followed. Thereafter, the minimal risk conditions were presented. Subsequently, after each minimal risk condition, participants were asked to indicate their preferred wake-up term: stopping and not being woken; stopping and woken up at the stoppage point; stopping and woken up before reaching the stoppage point; not stopping and woken up beforehand; or would not sleep under the given conditions. The participants who wanted to be woken prior to the end of the automated ride were then asked how far in advance this should occur. Furthermore, all the participants were asked to give their preferred wake-up modalities (e.g., alarm clock tones, music, sleep phase alarm clocks, etc.) and their preferred urgency (from 1—gently—to 7—directly). Finally, independent of the minimal risk conditions, the participants were asked to assess their anticipated sleep inertia, and, more specifically, the time until they expected to be fit to drive again, as well as their preference for certain measures to support them getting fitter more quickly (e.g., cool air, music, light, etc.).

All the survey questions are listed in Appendix A.1. Appendix A.2 contains a procedure chart showing the order in which participants answered the questions. Overall, the whole survey took approximately 5 to 10 min.

2.5. Data Analysis

Depending on the scale level of the dependent variable, we used different statistical tests to denote the significance of effects. We used Spearman correlations for ordinal scaled and Pearson correlations for interval scaled measures [39]. For pairwise comparisons, we used either Mann–Whitney U tests (for ordinal scaled variables) or *t*-tests (interval scaled). For comparisons comprising multiple factors, we either used cumulative link

models for ordinal scaled variables [40] or multilevel regression models for interval scaled variables [41].

In this paper, the interpretation of these regression models is similar to that of analyses of variance (ANOVA) for within-subjects designs. In contrast to ANOVAs, however, the regression models do not rely on complete cell occupancy and are therefore better suited for analyzing subsamples. The regression models were tested for their assumptions. The multilevel regression models were tested in terms of normality (Shapiro–Wilk tests) and homoscedasticity (Levene tests). In several models, there were indications for non-normal distributed residuals and for heteroscedasticity. Therefore, as a more robust approach, we applied bootstrapping with 2000 repetitions to compute the confidence intervals and p -values of the regression weights [42]. Furthermore, there were no indications for influential cases (all Cook's Distances < 1) [42]. Both cumulative link models and multilevel regression models were tested on multicollinearity. With all variance inflation factors < 10 , all the presented models fulfilled this assumption. We conducted the statistical analyses using the software R, version 4.1.2 [43].

3. Results

The following chapter summarizes the results. The significance level for statistical tests is $p < 0.05$ if not indicated differently.

3.1. Napping in the Vehicle

When asked how frequently participants sleep in cars (in a parking vehicle or as passenger), 1.1% of all participants indicated that they slept very often, 5.4% often, 21.4% occasionally, 25.4% rarely, and 46.8% never. Those participants who indicated they sleep at least rarely were asked how long their naps commonly take. In total, $n = 149$ participants indicated that their naps commonly take between 5 and 180 min, with 97.3% taking 60 min or less. The mean napping duration was 25.2 min (median = 20.0, $SD = 21.4$).

Across both travel purposes, approximately 42.5% of all participants intended to sleep during an automated drive if given the opportunity (“rather agree” to “strongly agree”; see Figure 2). A slight trend for a higher intention to sleep during automated driving was observed in the travel purpose “vacation”, though the difference to “commuting” was not significant (Mann–Whitney U test: $W = 8627$ and $p = 0.079$; see Figure 2). Across both travel purposes, the desire to sleep during automated driving was significantly higher in younger participants ($r(278) = -0.255$; $p < 0.001$), in those who frequently nap in a vehicle as a passenger nowadays ($r(278) = 0.227$; $p < 0.001$), and in those who generally desire to nap more often during the day ($r(278) = 0.161$; $p = 0.007$). In those participants with a positive intention to sleep during automated driving, the mean expected napping duration was 24 min for “commuting” (median = 25, min = 5, and max = 40) and 129 min for “vacation” (median = 60, min = 10, and max = 360). In total, $n = 7$ participants from “commuting” and $n = 1$ from “vacation” were excluded from the latter analysis because they indicated a desired napping duration that exceeded the maximum possible duration as given in the instruction (i.e., max. 40 min for the travel purpose commuting and max. 360 min for the vacation drive).

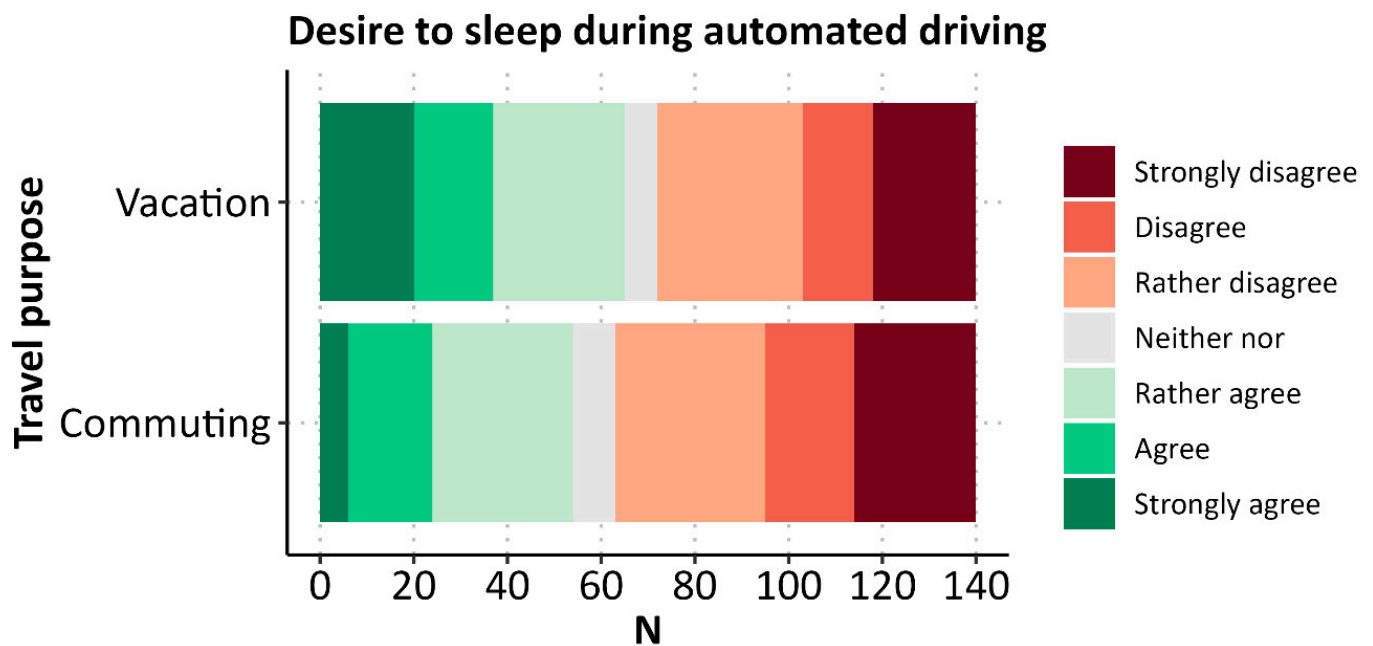


Figure 2. Desire to sleep during automated driving across travel purposes. The item in the questionnaire was as follows: “To what extent do you agree with the following statement? I would sleep during fully automated driving in the future if I had the opportunity to do so”.

3.2. Wake-Up Term and Waking Modalities

The participants were asked which wake-up term they would prefer if the ODD ended, implying they had to take over the driving task to continue driving. As tested with a cumulative link model, preferences significantly depended on the travel purpose and the minimal risk condition ($X^2(3, N = 280) = 71.5$ and $p < 0.001$; see Figure 3). The participants preferred to be awakened at an earlier point in the travel purpose “commuting” compared to “vacation” ($b = 1.06$, $SE = 0.52$, $z = 2.05$, and $p = 0.040$) and in the minimal risk condition “hard shoulder” vs. “rest area” ($b = 0.62$, $SE = 0.19$, $z = 3.23$, and $p = 0.001$). Both main effects reinforce each other as indicated by a significant interaction effect ($b = 1.01$, $SE = 0.29$, $z = 3.43$, and $p < 0.001$). Across all conditions, 11.3% of all participants wanted to stop but being awakened before the end of the ODD (category 3 in Figure 3). Furthermore, 40.0% of all participants did not want to stop (category 2 in Figure 3). Both subgroups were asked how many minutes they would like to be woken up beforehand. On average, these participants wanted to be woken up 7.7 min beforehand (median = 5.0, $SD = 6.4$, min = 1.0, and max = 45.0). As tested with a multilevel regression model, the preferred time differed significantly between conditions ($F(3, 184.5) = 4.73$, $p = 0.003$, and marginal $R^2 = 0.035$). There was a significant effect of the travel purpose with a longer desired waking time in the travel purpose “vacation” compared to “commuting” ($b = 2.35$, 95% CI [0.36–4.43], $\beta = 0.37$, and $p = 0.019$). The waking time did not differ significantly between the minimal risk conditions ($b = 0.20$, 95% CI [−0.29–0.69], $\beta = 0.03$, and $p = 0.422$) but it differed significantly between the preferred scenario (i.e., categories “3: stop” vs. “2: do not stop”; $b = 1.17$, 95% CI [0.25–2.10], $\beta = 0.18$, and $p = 0.016$).

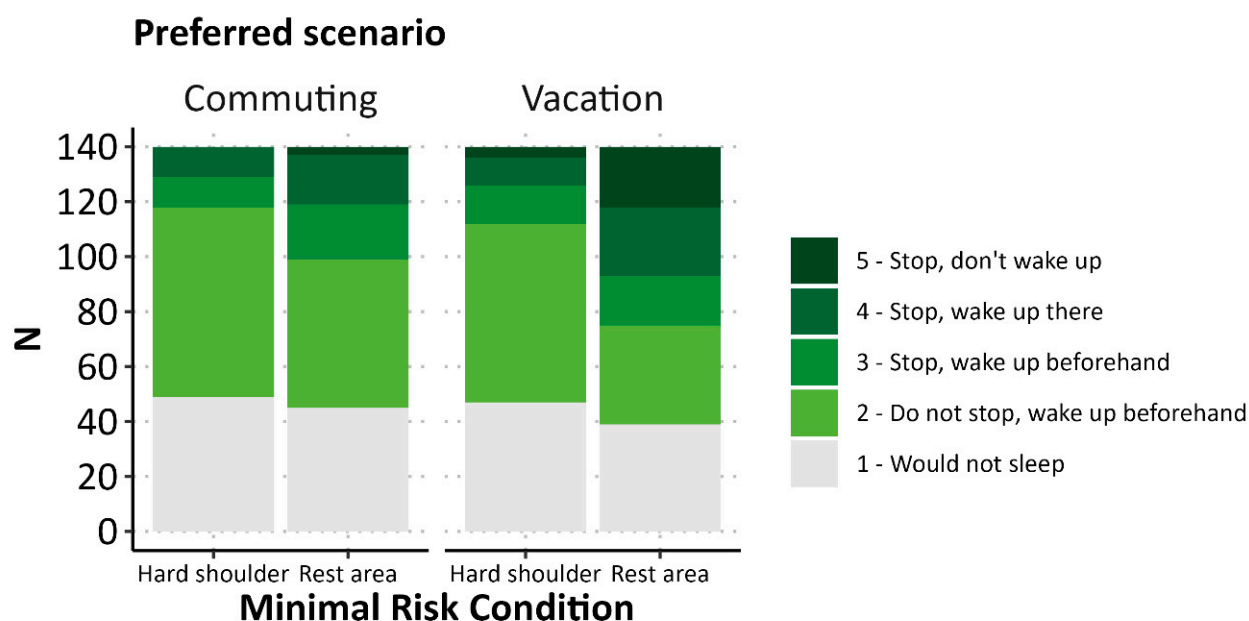


Figure 3. Preferred wake-up terms depending on the experimental conditions.

All participants were asked how they would like to be awakened at the end of an automated journey. Participants could select one or more of the modalities shown in Figure 4 and optionally indicate additional modalities. The distribution is shown in Figure 4. On average, the participants indicated 2.2 modalities ($SD = 1.2$, $\min = 1$, and $\max = 7$). Among “others”, the participants mentioned, for example, vibration in the seat, shaking of the belt, and natural sounds.

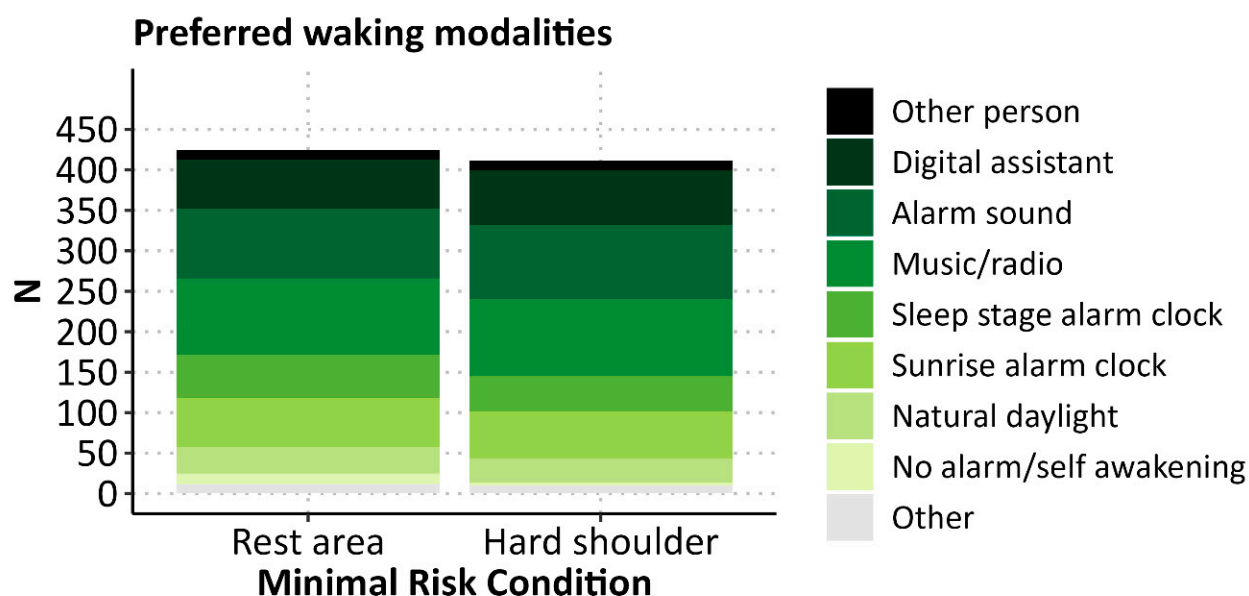


Figure 4. Preferred waking modalities across the two within-subjects conditions (i.e., minimal risk condition).

The participants were asked to what extent they preferred a gentle or an arousing wake-up alarm, depending on the experimental conditions. As shown in Figure 5, and tested with a multilevel regression model, the desired urgency significantly depended on the condition ($F(3, 238.4) = 15.8$, $p < 0.001$, and marginal $R^2 = 0.047$), with higher urgency levels observed for the travel purpose “commuting” compared to “vacation” ($b = 0.86$, 95% $CI [0.36–1.35]$, $\beta = 0.49$, and $p = 0.002$), and for the minimal risk condition “hard shoulder” compared to “rest area” ($b = 0.68$, 95% $CI [0.46–0.90]$, $\beta = 0.39$, and $p < 0.001$). There was a significant interaction effect, indicating that the difference between the travel

purposes is larger for the minimal risk condition “rest area” compared to “hard shoulder” ($b = -0.52$, 95% CI $[-0.52-0.82]$, $\beta = -0.29$, and $p = 0.001$).

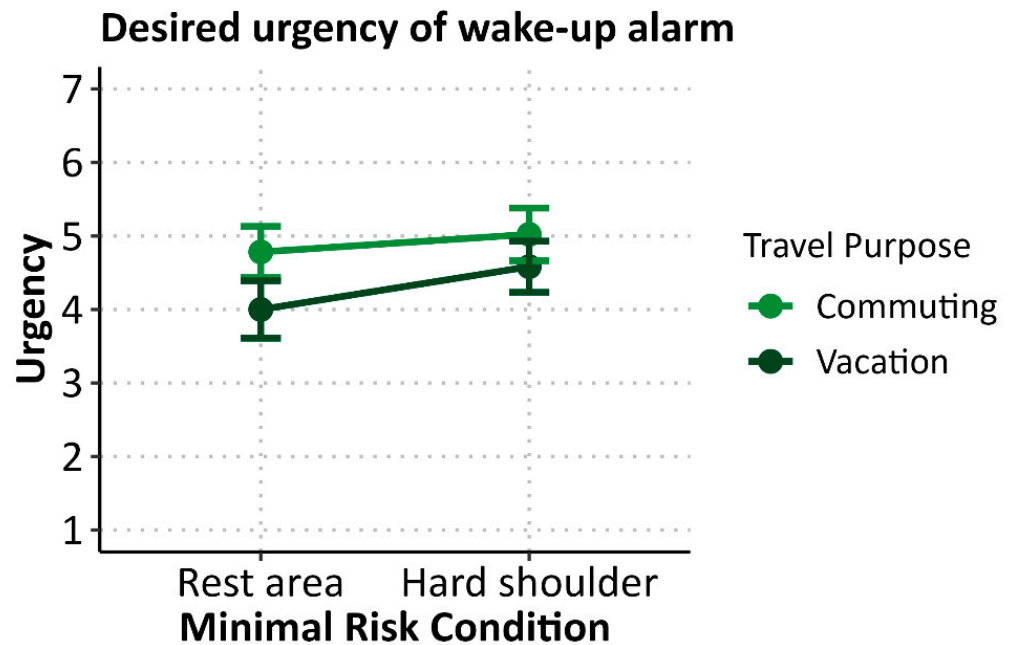


Figure 5. Desired urgency of wake-up alarm (1 = gentle; 7 = arousing) across the experimental conditions.

3.3. Sleep Inertia and Support

When commuting, the participants estimated that they would be fit to drive $M = 6.8$ min after awakening (median = 5.0, $SD = 7.0$, min = 0, and max = 30), and after $M = 11.1$ min (median = 5.0, $SD = 13.6$, min = 0, and max = 90) when on a vacation trip. The estimated duration was significantly higher in the vacation condition compared to commuting as tested by a one-sided t -test ($t(208.7) = -3.30$, and $p < 0.001$; see Figure 6). There was no significant correlation between the estimated duration and the desire to sleep during automated driving (Spearman $r(278) = -0.113$; $p = 0.058$). There was a significant positive correlation between the estimated duration and the desired time of waking up before the end of the automation (Pearson $r(170) = 0.668$; $p < 0.001$). For the subsample of participants, who intended to sleep during automated driving (at least “rather agree”; see Figure 2), Pearson correlations between the expected napping duration and the desired time of waking up before the end of the automation were computed. There was no significant correlation, neither for the commuting group ($r(45) = 0.122$; $p = 0.413$), nor for the vacation group ($r(62) = 0.014$; $p = 0.910$).

When asked for the desired means of support to increase alertness after awakening, most participants chose multiple options. Figure 7 summarizes that radio/music, cold air, movements, drinking water, drinking caffeine and light were the most popular. In the category “other”, participants named stretching, conversation with a specific person (e.g., partner), pain or that no support was necessary.

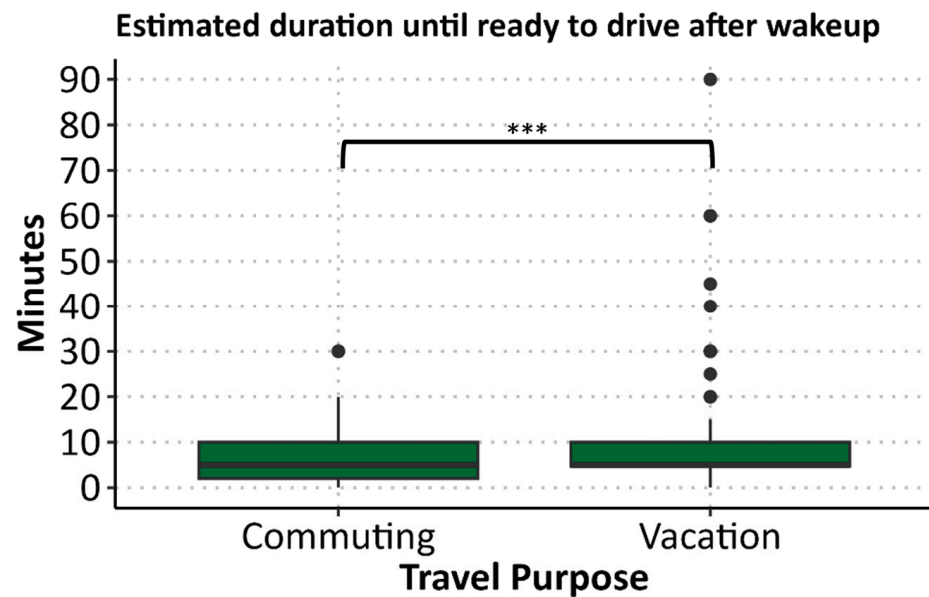


Figure 6. Estimated duration until participants feel fit to drive after awakening; *** $p < 0.001$. Dots indicate outliers in the data.

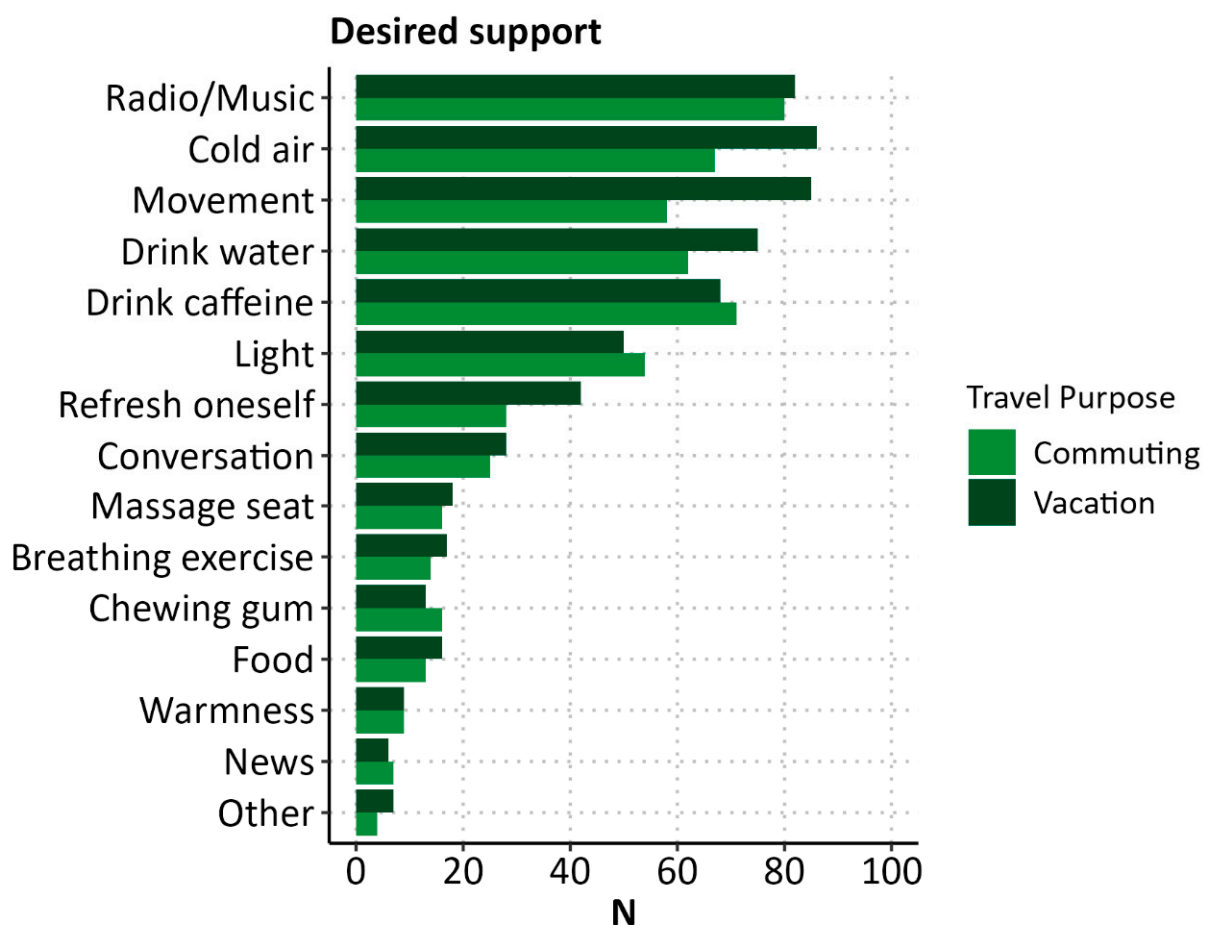


Figure 7. Desired means of support to increase alertness after awakening in the vehicle.

4. Discussion

The presented online study aimed to assess the user preferences for in-vehicle napping and wake-up concepts. The study hypothesized that variables like the purpose of travel and the possibility of stopping the vehicle at the end of the ODD may influence the user

preferences. A total of $N = 280$ participants, balanced by age and gender, were presented with one of two travel purpose scenarios (commuting vs. vacation trip) and two minimal risk conditions (stopping on hard shoulder vs. rest area). The participants indicated their willingness to sleep during automated driving and their preferred wake-up terms and modalities.

4.1. Popularity of Sleeping in the Vehicle and Expected Napping Durations

Approximately 42.5% of participants indicated a willingness to nap during automated driving. This finding is consistent with previous studies that reported similar approval rates of 46.6% [12] and 40.2%, respectively [13]. By replicating the approval rates, the presented study indicates a certain robustness of the quota. However, the willingness to nap depends on different factors. In the presented study, the preference was more pronounced amongst younger individuals and those who commonly nap. The study of Becker, Herrmann, Duwe, Stegmüller, Röckle and Unger [12] indicates that further factors, like the users' cultural background, may further influence the willingness to nap.

Surprisingly, the participants did not expect to utilize the entire duration of automated driving for napping. In the commuting travel purpose, the discrepancy may be explained by the fact that users expect to need time to properly wake up before taking over vehicle control. However, in the vacation travel purpose, the participants expected to sleep for much shorter duration than was realistically possible. Here, it should be noted that as the study was conducted online, the participant did not experience sleeping in an automated car in person. So, one possible explanation is that the participants did not read the instructions thoroughly. The instructions stated that the vacation travel purpose included an automated six-hour drive during the nighttime. Another explanation is that individuals, while generally open to sleeping, may be hesitant to sleep for extended periods within the vehicle. Users might be afraid of ergonomic limitations in the vehicle, i.e., sleeping in a lying position might not be possible [44,45], or they might expect a limited sleep quality and sleep duration due to the disruptive nature of a moving environment [38]. Furthermore, car sickness, which is a widespread phenomenon in manual driving as a passenger [46], could possibly contribute to participants not wanting to spend extensive time not watching the road. In the scope of longer automated drives, future research should clarify why drivers expect not to use the entire travel time to nap.

4.2. Wake-Up Preferences and Considerations for Sleep Inertia

The results demonstrate that, even after sleeping, many drivers do not want the vehicle to stop for a minimal risk maneuver but want to take over driving beforehand. Future systems could ask users about their individual preferences, but it is likely that many drivers will want to take over control while driving. This emphasizes the high relevance of considering the potential effects of sleep inertia in take over scenarios even in automated driving systems that can bring themselves to a state of minimal risk.

However, preferences vary depending on the scenario. In the commuting travel purpose, it was less popular to stop than in the vacation drive. This could be explained by the circumstance that people are likely to experience greater time constraints when commuting than when going on vacation. Further, it was less popular to stop on the hard shoulder than on a rest area. Hence, to meet user needs, it is important for the system to communicate at the beginning of the journey where and how the automated journey will end. This allows users to prepare accordingly and inform the system about their preferences if necessary. However, it is currently unclear to what extent the hard shoulder of the motorway can be used for such minimal risk maneuvers. Regulations may vary depending on the country and the type of road (e.g., country roads or motorways). In

Germany, for example, stopping on the hard shoulder of a motorway is only permitted in emergencies (e.g., in the event of a breakdown). At the same time, however, the German Ministry of Transport cites the hard shoulder as a possible stopping area for automated vehicles when system limits are reached [6]. In the future, legislators will need to determine the areas, purposes and durations for which automated vehicles may stop. They must be aware that taking over driving manually as quickly as possible is not always synonymous with safety, for example, if the person behind the wheel is still impaired by sleep inertia.

Participants generally desired a wake-up process that balanced gentle awakening with a necessary sense of urgency, with more urgent prompts preferred in the commuting travel purpose and in the scenario of a hard shoulder stopping. The participants indicated an optimal wake-up time of approximately 7–8 min prior to the end of the automated drive with earlier preferences in the vacation travel purpose compared to commuting. This preference is considered reasonable because sleep inertia tends to last longer after longer periods of sleep [47]. However, with approximately 2.5 min, the indicated time difference was relatively small on an absolute level. The desired wake-up time is likely to be strongly influenced by the expected duration of sleep inertia as suggested by the significant correlation between the desired wake-up time and the time people expect to need to be fit to drive again. The question arises whether 7–8 min is sufficient for sleep inertia to wear off. Previous research on the duration of sleep inertia in driving contexts indicates that the most severe impairments on lane keeping and physiological arousal disappear within the first two minutes after awakening [15,19,48]. However, some effects such as a reduced speed level, increased feelings of sleepiness or an elevated heart rate may persist for at least 20 to 30 min [16,37]. To the best of the authors' knowledge, there are no established standards for dealing with sleep inertia in vehicles. However, guidelines from aviation recommend a recovery phase of at least 20 min between waking up and resuming a task to let sleep inertia wear off [23,24]. In summary, it is considered beneficial that potential users are aware of the risk of sleep inertia and are requesting some minutes between awakening and taking over driving to recover from sleep inertia. However, the duration of sleep inertia expected by the participants was shorter than that indicated in the scientific literature [16,37]. The results therefore also suggest that drivers may underestimate the duration of sleep inertia. In order to mitigate potential risks and account for the considerable interindividual variability (see Figure 6), automated driving systems should therefore be capable of providing more time and be adaptive to individual preferences. Additionally, a future driver state detection could help the automated system to recognize sleep inertia in the driver [15,49]. In case of detected sleep inertia, the vehicle could then promote a safe stop instead of offering a driver take over.

Asked for their desired methods of support after awakening, most participants indicated multiple modalities. Future research should clarify whether this indicates a certain flexibility or a wish for a combination of modalities. Radio/music, cold air, movement, drinking water, drinking caffeine, and exposure to light were the most popular methods of support. Herein, it is considered that radio/music, cold air, and light are relatively easy to implement as countermeasures in the vehicle. As outlined in the Section 1, these measures have the potential to alleviate sleep inertia [27–33,36]. Future research should examine whether these measures are also effective in a vehicle context.

4.3. Limitations

The findings should be considered in light of some limitations. The design of an online study implies that the participants did not actually experience the presented scenarios. Further, as sleeping during automated driving is not yet a widespread use case, participants lacked experience with the presented scenarios. The results should therefore not be con-

sidered as an evaluation of the concepts. Instead, they reflect the expectations of potential users towards these future concepts. These expectations reveal the potential from users' perspectives and this knowledge can be used by the designers of future in-vehicle napping functions. After implementation, future research should assess the user evaluations in dedicated experiments in driving simulators or, preferably, in a real-world driving setting.

Finally, the study was conducted with mainly German participants. Future studies should look into different cultures as other studies have shown that the preference for actions of automated driving functions can vary between cultures [50].

5. Conclusions

In conclusion, this study demonstrates considerable interest in sleeping during automated drives. The results show a preference among users for being woken up 7–8 min before the end of the ODD and, if possible, not interrupting their journey with a stop. However, successful implementation will depend on considering the individual preferences that depend on the purpose of the trip and the available options for minimal risk maneuvers. Measures such as music, cold air or light could help drivers to quickly overcome sleep inertia.

Key challenges remain in developing technical capabilities to accurately assess the driver's readiness and to establish automotive standards on appropriate recovery times. The finding that a large portion of drivers do not want to stop indicates that a critical issue may emerge on how to prevent drivers from taking control before sleep inertia has fully subsided.

6. Outlook

The presented online experiment is part of the "SALSA" research project and is the first in a series of studies. In the further course of the project, concepts for waking up and measures against sleep inertia in the automated driving context will be developed. The concepts will be evaluated in experiments in driving simulators and in prototype vehicles on test tracks.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki [51]. The study was reviewed and approved by the institutional ethics officer of the WIVW (Approval No. 656). As the survey represented a non-interventional study, further approval of an external ethics committee was not required.

Informed Consent Statement: Participants were informed about the purpose and procedure of the study before starting the questionnaire. They were also told that participation was voluntary and that they could withdraw at any time. Informed consent was obtained from all participants involved in the study.

Data Availability Statement: The original data presented in the study are openly available in PsychArchives at <https://doi.org/10.23668/psycharchives.21464> (accessed on 22 January 2026).

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Appendix A.

Appendix A.1. List of Survey Questions (English Translation from German Original)

1. How old are you?

_____ years

2. Which gender do you identify with the most? [Single choice]

- ☐ Female
 - ☐ Male
 - ☐ Diverse
-

People are described as “morning types” or “evening types”

3. Which of the following types do you consider yourself to be? [Single choice]

- ☐ Definitely a “morning type”
- ☐ Rather more a “morning” than an “evening type”
- ☐ Neither
- ☐ Rather more an “evening” than a “morning type”
- ☐ Definitely an “evening type”

More information:

Morning types (colloquially known as “larks”) tend to get up early and go to bed early. They feel most energetic early in the day.

Evening types (colloquially known as “owls”) tend to get up late and go to bed late. They feel most energetic late in the day.

4. If it were solely based on your own well-being and you had sufficient time, how often would you take a nap during the day? [Single choice]

- ☐ Daily or almost daily
 - ☐ 1–3 times per week
 - ☐ 1–3 times per month
 - ☐ Less frequently/only in exceptional cases
 - ☐ Never
-

[if response to question 4 was not “never”]

5. How long would the nap usually last?

_____ minutes

[if response to question 4 was not “never”]

6. What time would you start your nap?

_____ o'clock

7. How alert or sleepy do you feel in the first few minutes after taking a nap? [Single choice]

- ☐ Very sleepy, great effort to keep awake
- ☐ Sleepy, but some effort to keep awake
- ☐ Sleepy, but no effort to keep awake
- ☐ Some signs of sleepiness
- ☐ Neither alert nor sleepy
- ☐ Rather alert
- ☐ Alert
- ☐ Very alert
- ☐ Extremely alert
- ☐ I do not know/cannot say.

8. How often do you take a nap in a car, e.g., at a rest area or as a passenger? [Single choice]

- ☐ Very often, on (almost) every car trip
- ☐ Often, on many car trips
- ☐ Occasionally, on some car trips
- ☐ Rarely, only in exceptional cases
- ☐ (Almost) never

[if response to question 8 was not “(Almost) never”]

9. How long does your nap in the vehicle typically last?

_____ minutes

The questions on the following pages relate to automated driving. This means that the vehicle drives completely autonomously on the highway and takes over all driving functions. You may turn your attention away from the traffic and engage in other activities, such as reading, working, or sleeping.

The system can inform you in advance when you need to take back control of the steering wheel, e.g., when you are approaching a highway exit.

Please imagine the following situation:

[travel purpose condition “commuting”]

You are commuting daily with your vehicle early in the morning. You are alone in your vehicle. Your drive lasts about 40 min. During the complete ride, you would have the possibility to activate the automation and could sleep.

[or travel purpose condition “vacation trip”]

You are going on holiday and are using your vehicle. You are alone in the vehicle. The drive lasts about six hours. You start your drive late in the evening and will reach your destination early in the morning. During the complete ride, you would have the possibility to activate the automation and could sleep.

10. To what extent do you agree with the following statement?

“In the future, I would sleep during fully automated driving if I had the opportunity to do so.” [Single choice]

- ☐ Strongly disagree
 - ☐ Disagree
 - ☐ Somewhat disagree
 - ☐ Neither agree nor disagree
 - ☐ Somewhat agree
 - ☐ Agree
 - ☐ Strongly agree
-

[if response to question 10 was at least “somewhat agree”]

11. How long would you want to sleep in that situation?

_____ minutes

Please imagine the following situation: You are getting near to the highway exit. After exiting the highway, you will have to drive the rest of your way to your destination. You will then again be responsible for your safety.

[minimal risk condition “hard shoulder”]

There is no rest area before the highway exit. However, the vehicle could stop on its own on the hard shoulder before the exit.

We assume that stopping on the hard shoulder would be permitted in this case.

[Presentation of Figure 1 left]

[or minimal risk condition “rest area”]

Shortly before the highway exit, there is a rest area where the vehicle could park itself.

[Presentation of Figure 1 right]

12. Which of the following options would you prefer? [Single choice]

- ☐ The system should stop at the hard shoulder/nearest rest area and let me sleep until I wake up on my own. [5]
- ☐ The system should stop at the hard shoulder/nearest rest area and wake me up as soon as we have stopped there. [4]
- ☐ The system should stop at the hard shoulder/nearest rest area and wake me up before we arrive there. [3]
- ☐ I do not want to stop at the hard shoulder/rest area. The system should wake me up beforehand so that I can take over driving again in good time. [2]
- ☐ None of the options, because I would not sleep in this situation. [1]

[if response to question 12 was category 2 or 3]

13. How many minutes before the end of the automated journey would you like to be woken up?

_____ minutes

[if response to question 12 was not category 1]

14. How would you like to be woken up in the scenario selected above? [multiple choice; options presented in randomized order]

- ☐ Sleep phase alarm clock
 - ☐ Digital assistant
 - ☐ Music/radio alarm clock
 - ☐ Natural daylight
 - ☐ Classic alarm tone
 - ☐ Light alarm clock/sunrise simulation
 - ☐ Another person
 - ☐ I would not need an alarm clock because I want to/would wake up on my own.
 - ☐ Other: _____
-

15. In this situation, it is important to me that an alarm clock would awake me... [single choice]

- ☐ 1—gently
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7—directly/immediately

16. Regardless of whether you stop on the hard shoulder or at a rest area, and regardless of whether you would actually sleep: How long do you think it would take before you feel ready to drive again after taking a nap in your vehicle?

_____ minutes

17. What support would you like to receive after waking up to help you feel fit again as quickly as possible so that you can drive yourself? [multiple choice; options presented in randomized order]

- ☐ A caffeinated drink (e.g., coffee or tea)
 - ☐ The opportunity to move around
 - ☐ Doing breathing exercises
 - ☐ Cool air
 - ☐ Eating something
 - ☐ Seat massage
 - ☐ Warmth
 - ☐ Chewing gum
 - ☐ Light
 - ☐ Reading the news
 - ☐ Drinking water
 - ☐ Listening to the radio/music
 - ☐ Having a conversation
 - ☐ Freshening up, e.g., washing your face
 - ☐ Other: _____
-

Appendix A.2. Procedure Chart

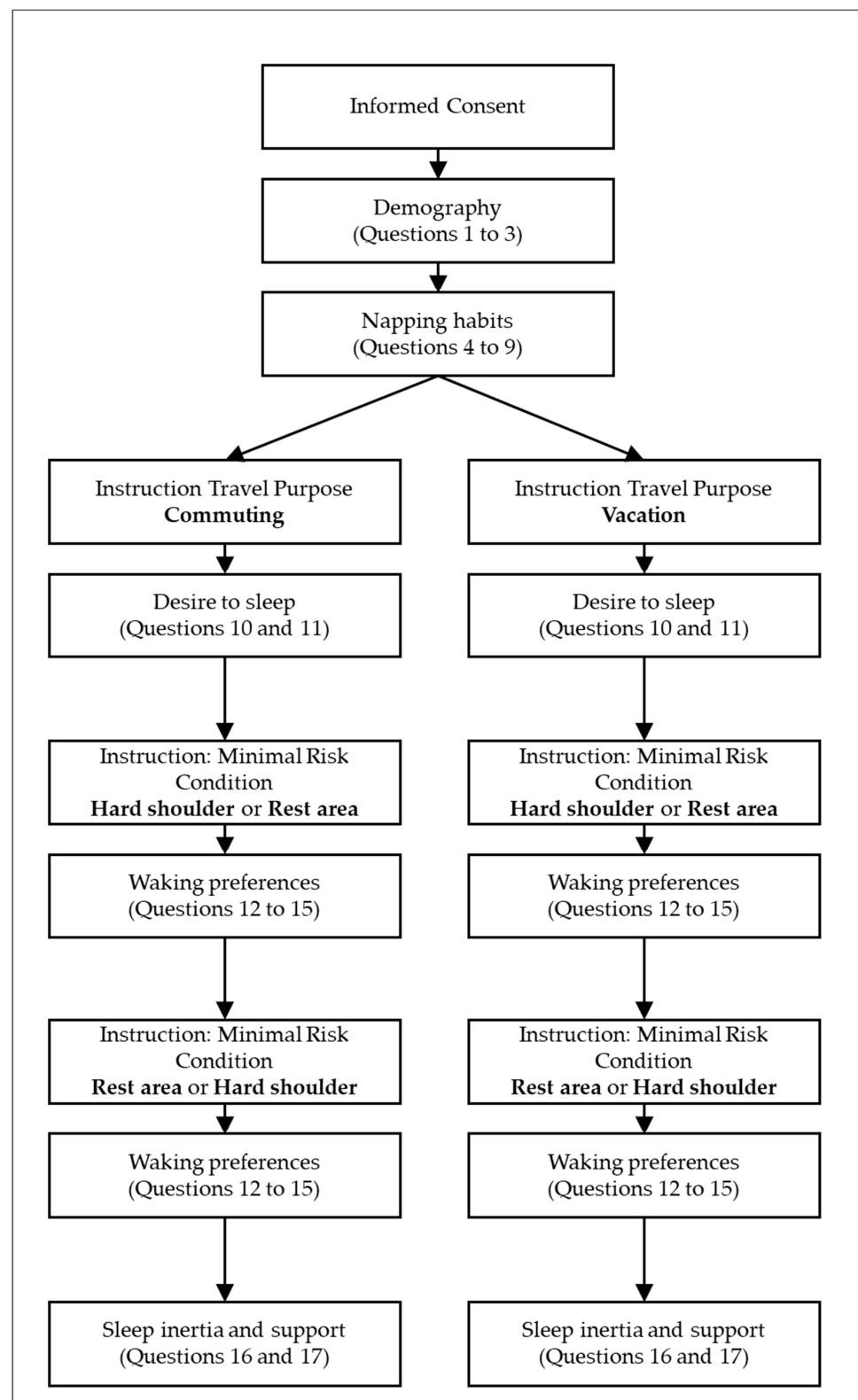


Figure A1. Question numbers refer to the list of survey questions as presented in Appendix A.1.

References

1. Jamson, H.; Merat, N.; Carsten, O.M.J.; Lai, F.C.H. Fully-Automated Driving: The Road to Future Vehicles. *Driv. Assess. Conf. Arch.* **2011**, *6*, 2–9.
2. Massar, M.; Reza, I.; Rahman, S.M.; Abdullah, S.M.H.; Jamal, A.; Al-Ismael, F.S. Impacts of Autonomous Vehicles on Greenhouse Gas Emissions—Positive or Negative? *Int. J. Environ. Res. Public Health* **2021**, *18*, 5567. [\[CrossRef\]](#) [\[PubMed\]](#)
3. Kitajima, S.; Shimono, K.; Tajima, J.; Antona-Makoshi, J.; Uchida, N. Multi-agent traffic simulations to estimate the impact of automated technologies on safety. *Traffic Inj. Prev.* **2019**, *20*, S58–S64. [\[CrossRef\]](#) [\[PubMed\]](#)
4. SAE. *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*; SAE International: Warrendale, PA, USA, 2021; Volume J3016.
5. Gyllenhammar, M.; Brännström, M.; Johansson, R.; Sandblom, F.; Ursing, S.; Warg, F. Minimal risk condition for safety assurance of automated driving systems. In Proceedings of the CARS: 6th International Workshop on Critical Automotive Applications: Robustness & Safety, Online, 13 September 2021.
6. German Federal Ministry of Transport. Germany Will Be the World Leader in Autonomous Driving. Available online: <https://www.bmv.de/SharedDocs/EN/Articles/DG/act-on-autonomous-driving.html> (accessed on 29 September 2025).
7. Hartzler, B.M. Fatigue on the flight deck: The consequences of sleep loss and the benefits of napping. *Accid. Anal. Prev.* **2014**, *62*, 309–318. [\[CrossRef\]](#)
8. Tietzel, A.J.; Lack, L.C. The short-term benefits of brief and long naps following nocturnal sleep restriction. *Sleep* **2001**, *24*, 293–300. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Anund, A.; Kecklund, G.; Peters, B.; Forsman, Å.; Lowden, A.; Åkerstedt, T. Driver impairment at night and its relation to physiological sleepiness. *Scand. J. Work Environ. Health* **2008**, *34*, 142–150. [\[CrossRef\]](#)
10. Åkerstedt, T.; Peters, B.; Anund, A.; Kecklund, G. Impaired alertness and performance driving home from the night shift: A driving simulator study. *J. Sleep Res.* **2005**, *14*, 17–20. [\[CrossRef\]](#)
11. Connor, J.L. The role of driver sleepiness in car crashes: A review of the epidemiological evidence. In *Drugs, Driving and Traffic Safety*; Birkhauser: Basel, Switzerland, 2009; pp. 187–205. [\[CrossRef\]](#)
12. Becker, T.; Herrmann, F.; Duwe, D.; Stegmüller, S.; Röckle, F.; Unger, N. *Enabling the Value of Time. Implications for the Interior Design of Autonomous Vehicles*; Horváth & Partners: Stuttgart, Germany, 2018.
13. Tomzig, M.; Kaß, C. Sleeping during highly automated driving—target groups and relevant use cases of an in-car sleeping function. In Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2022 Annual Conference, Torino, Italy, 20–22 April 2022; pp. 87–100.
14. Tassi, P.; Muzet, A. Sleep inertia. *Sleep Med. Rev.* **2000**, *4*, 341–353. [\[CrossRef\]](#)
15. Wörle, J.; Metz, B.; Steinborn, M.B.; Huestegge, L.; Baumann, M. Differential effects of driver sleepiness and sleep inertia on driving behavior. *Transp. Res. Part F Traffic Psychol. Behav.* **2021**, *82*, 111–120. [\[CrossRef\]](#)
16. Tomzig, M.; Wörle, J.; Kremer, C.; Baumann, M. Sleep in automated driving—Effects of time of day and chronotype on sleepiness and sleep inertia. *Transp. Res. Part F Traffic Psychol. Behav.* **2024**, *102*, 16–31. [\[CrossRef\]](#)
17. Tomzig, M.; Wörle, J.; Kremer, C.; Baumann, M.; Neukum, A. Is the NASA nap the solution for sleep inertia in automated driving? Unveiling effects of deep sleep on driving behavior, vigilance and subjective experience. *Transp. Res. Interdiscip. Perspect.* **2025**, *31*, 101472. [\[CrossRef\]](#)
18. Tomzig, M.; Wörle, J.; Gary, S.; Baumann, M.; Neukum, A. Strategic naps in automated driving—Sleep architecture predicts sleep inertia better than nap duration. *Accid. Anal. Prev.* **2025**, *209*, 107811. [\[CrossRef\]](#)
19. Wörle, J.; Metz, B.; Baumann, M. Sleep inertia in automated driving: Post-sleep take-over and driving performance. *Accid. Anal. Prev.* **2021**, *150*, 105918. [\[CrossRef\]](#)
20. Wörle, J.; Metz, B.; Othersen, I.; Baumann, M. Sleep in highly automated driving: Takeover performance after waking up. *Accid. Anal. Prev.* **2020**, *144*, 105617. [\[CrossRef\]](#)
21. Ferrara, M.; De Gennaro, L.; Bertini, M. Time-course of sleep inertia upon waking from nighttime sleep with different sleep homeostasis conditions. *Aviat. Space Environ. Med.* **2000**, *71*, 225–229. [\[PubMed\]](#)
22. Signal, T.L.; van den Berg, M.J.; Mulrine, H.M.; Gander, P.H. Duration of sleep inertia after napping during simulated night work and in extended operations. *Chronobiol. Int.* **2012**, *29*, 769–779. [\[CrossRef\]](#)
23. Rosekind, M.R.; Smith, R.M.; Miller, D.L.; Co, E.L.; Gregory, K.B.; Webbon, L.L.; Gander, P.H.; Lebacqz, J.V. Alertness management: Strategic naps in operational settings. *J. Sleep Res.* **1995**, *4*, 62–66. [\[CrossRef\]](#) [\[PubMed\]](#)
24. ICAO; IATA; IFALPA. *Fatigue Management Guide for Airline Operators*; International Civil Aviation Organization (ICAO): Montreal, QC, Canada; International Air Transport Association (IATA): Montreal, QC, Canada; International Federation of Airline Pilots' Associations (IFALPA): Montreal, QC, Canada, 2015.

25. CASA. *Safety Behaviours, Human Factors: Resource Guide for Engineers*; Australian Government Civil Aviation Safety Authority: Canberra, Australia, 2013.
26. Hirsch, M.; Diederichs, F.; Widloither, H.; Graf, R.; Bischoff, S. Sleep and take-over in automated driving. *Int. J. Transp. Sci. Technol.* **2020**, *9*, 42–51. [\[CrossRef\]](#)
27. Hayashi, M.; Uchida, C.; Shoji, T.; Hori, T. The effects of the preference for music on sleep inertia after a short daytime nap. *Sleep Biol. Rhythm.* **2004**, *2*, 184–191. [\[CrossRef\]](#)
28. McFarlane, S.J.; Garcia, J.E.; Verhagen, D.S.; Dyer, A.G. Alarm tones, voice warnings, and musical treatments: A systematic review of auditory countermeasures for sleep inertia in abrupt and casual awakenings. *Clocks Sleep* **2020**, *2*, 416–433. [\[CrossRef\]](#)
29. Hayashi, M.; Masuda, A.; Hori, T. The alerting effects of caffeine, bright light and face washing after a short daytime nap. *Clin. Neurophysiol.* **2003**, *114*, 2268–2278. [\[CrossRef\]](#)
30. Hilditch, C.J.; Wong, L.R.; Bathurst, N.G.; Feick, N.H.; Pradhan, S.; Santamaria, A.; Shattuck, N.L.; Flynn-Evans, E.E. Rise and shine: The use of polychromatic short-wavelength-enriched light to mitigate sleep inertia at night following awakening from slow-wave sleep. *J. Sleep Res.* **2022**, *31*, e13558. [\[CrossRef\]](#)
31. Hilditch, C.J.; Pradhan, S.; Costedoat, G.; Bathurst, N.G.; Glaros, Z.; Gregory, K.B.; Shattuck, N.L.; Flynn-Evans, E.E. An at-home evaluation of a light intervention to mitigate sleep inertia symptoms. *Sleep Health* **2024**, *10*, S121–S129. [\[CrossRef\]](#) [\[PubMed\]](#)
32. Santhi, N.; Groeger, J.A.; Archer, S.N.; Gimenez, M.; Schlangen, L.J.; Dijk, D.J. Morning sleep inertia in alertness and performance: Effect of cognitive domain and white light conditions. *PLoS ONE* **2013**, *8*, e79688. [\[CrossRef\]](#) [\[PubMed\]](#)
33. Figueiro, M.G.; Sahin, L.; Roohan, C.; Kalsher, M.; Plitnick, B.; Rea, M.S. Effects of red light on sleep inertia. *Nat. Sci. Sleep* **2019**, *11*, 45. [\[CrossRef\]](#) [\[PubMed\]](#)
34. Kräuchi, K.; Cajochen, C.; Wirz-Justice, A. Waking up properly: Is there a role of thermoregulation in sleep inertia? *J. Sleep Res.* **2004**, *13*, 121–127. [\[CrossRef\]](#)
35. Kräuchi, K.; Knoblauch, V.; Wirz-Justice, A.; Cajochen, C. Challenging the sleep homeostat does not influence the thermoregulatory system in men: Evidence from a nap vs. sleep-deprivation study. *Am. J. Physiol.-Regul. Integr. Comp. Physiol.* **2006**, *290*, R1052–R1061. [\[CrossRef\]](#)
36. Adkins, M.; Cox, R.; Axelsson, J.; Wright, K. Impact of cold-water hand immersion on cognitive performance and sleepiness during sleep inertia. *Sleep* **2023**, *46*, A73. [\[CrossRef\]](#)
37. Wörle, J.; Kenntner-Mabiala, R.; Metz, B.; Fritzsche, S.; Purucker, C.; Befelein, D.; Prill, A. Sleep Inertia Countermeasures in Automated Driving: A Concept of Cognitive Stimulation. *Information* **2020**, *11*, 342. [\[CrossRef\]](#)
38. Wörle, J. Sleep in Automated Driving: Post-Sleep Driver Performance in Transitions of Control—The Effects of Sleep Inertia. Ph.D. Thesis, Ulm University, Ulm, Germany, 2023.
39. Bortz, J.; Schuster, C. *Statistik für Human- und Sozialwissenschaftler*, 7th ed.; Springer: Berlin/Heidelberg, Germany, 2011.
40. Christensen, R.H.B. Analysis of Ordinal Data with Cumulative Link Models—Estimation with the R-Package Rrdinal. R-Package Version 2011, 28, 406. Available online: <https://www.semanticscholar.org/paper/Analysis-of-ordinal-data-with-cumulative-link-%E2%80%94the-Haubo-Christensen/8e4b2336496b3a17594da1fdc929b1ef131a2654> (accessed on 29 September 2025).
41. Hox, J.; Moerbeek, M.; Van de Schoot, R. *Multilevel Analysis: Techniques and Applications*; Routledge: Abingdon-on-Thames, UK, 2017.
42. Field, A.; Miles, J.; Field, Z. *Discovering Statistics Using R*; SAGE Publications: Thousand Oaks, CA, USA, 2012.
43. R Core Team. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2021.
44. Parida, S.; Mallavarapu, S.; Abanteriba, S.; Franz, M.; Gruener, W. User-Centered-Design Approach to Evaluate the User Acceptance of Seating Postures for Autonomous Driving Secondary Activities in a Passenger Vehicle. In Proceedings of the International Conference on Human Systems Engineering and Design: Future Trends and Applications, Munich, Germany, 16–18 September 2019; Springer: Cham, Switzerland, 2019; pp. 28–33.
45. Roach, G.D.; Matthews, R.; Naweed, A.; Kontou, T.G.; Sargent, C. Flat-out napping: The quantity and quality of sleep obtained in a seat during the daytime increase as the angle of recline of the seat increases. *Chronobiol. Int.* **2018**, *35*, 872–883. [\[CrossRef\]](#)
46. Metzulat, M.; Metz, B.; Landau, A.; Neukum, A.; Kunde, W. Does the visual input matter? Influence of non-driving related tasks on car sickness in an open road setting. *Transp. Res. Part F Traffic Psychol. Behav.* **2024**, *104*, 234–248. [\[CrossRef\]](#)
47. Lovato, N.; Lack, L. The effects of napping on cognitive functioning. *Prog. Brain Res.* **2010**, *185*, 155–166. [\[CrossRef\]](#)
48. Tomzig, M.; Wörle, J.; Neukum, A.; Baumann, M. The arousal paradox in critical task performance in automated driving during sleep inertia using a quasi experimental approach. *Sci. Rep.* **2025**, *15*, 20338. [\[CrossRef\]](#) [\[PubMed\]](#)
49. Hild, J.; Lerch, D.J.; Diederichs, F. A Model of Driver Readiness After Sleep. In Proceedings of the International Conference on Human-Computer Interaction, New York, NY, USA, 1–3 January 2026; Springer: Cham, Switzerland, 2026; pp. 358–371.

50. Edelmann, A.; Stümper, S.; Petzoldt, T. Cross-cultural differences in the acceptance of decisions of automated vehicles. *Appl. Ergon.* **2021**, *92*, 103346. [[CrossRef](#)] [[PubMed](#)]
51. Goodyear, M.D.E.; Krleza-Jeric, K.; Lemmens, T. The Declaration of Helsinki. *BMJ* **2007**, *335*, 624–625. [[CrossRef](#)] [[PubMed](#)]

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