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# Next-Day Effects of Social Drinking on Driver Fatigue and Driving Performance

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**Abstract.** Binge drinking of alcohol leads to worsened driving performance the following morning, even when the blood alcohol concentration (BAC) has returned to or is close to zero. The objective of this study was to investigate the effects of social drinking (BAC = 0.05%) on next-day driver fatigue and driving performance. A homogenous sample of 32 experienced male drivers drove for 35 min on rural and urban roads in a driving simulator, both the day after drinking alcohol and the day after a sober evening. The main effects on next-day performance were ambiguous, where self-assessments showed lower next-day performance and higher subjective sleepiness after drinking alcohol in the evening, whereas variability in lateral position, heart rate variability and attention showed worse next-day performance in the control condition. Overall, the effect sizes were small. The results indicate that a BAC level of 0.05% does not influence next-day performance after a full night's sleep to any greater extent. Further studies including a placebo condition are needed to verify this result, also considering more BAC levels, long-term effects of habitual drinking, and longer driving times.

**Keywords:** Alcohol · intoxication · next-day performance · driver fatigue

## 1 Introduction

Alcohol impairs performance and has a clear negative impact on traffic safety [1, 2]. Beyond the direct effects of alcohol there are also next-day hangover effects with performance impairments for several tasks related to short- and long-term memory, psychomotor speed, and sustained attention [3].

It has been hypothesized that alcohol induced impairments in sleep quality/duration, in combination with subsequent daytime sleepiness, is a contributing factor to the next-day effects on cognitive performance [4]. In a driving setting, post-alcohol and next-day effects of larger amounts of alcohol have been established in several studies [5–8], however, next-day effects of low or moderate amounts of alcohol on driver fatigue are largely unknown.


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The purpose of the present study was to investigate next-day effects of alcohol in the evening on subjective and objective indicators of fatigue and driving performance. The underlying hypothesis was that alcohol in the evening would affect night-time sleep which in turn would lead to increased fatigue levels and impaired driving performance the following day. A study was thus set up to compare the development of driver fatigue while driving in a simulator both the morning after drinking alcohol (target BAC = 0.05%) and when driving on a morning with no alcohol in the evening.

## 2 Methods

A homogenous sample of 32 experienced male drivers aged 25–60 years, with a body mass index $< 35$, and with moderate drinking habits with an Alcohol Use Disorders Identification Test [AUDIT; 9] score $\leq 7$, were recruited for the study. All participants gave their informed consent. The study was approved by the Swedish Ethical Review Authority (Dnr 2021–05701-01).

The study had a within-subject $2 \times 2$ design with a factor for next-day effects (after alcohol in the evening vs a control condition with no alcohol in the evening) and a factor for drive time (morning/forenoon). Next-day effects data were collected on two separate occasions in counterbalanced order. Before the next-day alcohol condition, the participant came to the lab in the evening, made a baseline drive, drank alcohol, made an intoxicated drive, and then went home to sleep. Alcohol doses were determined based on Hume–Weyers formula [10]. The targeted BAC level was 0.05% which corresponds to "social drinking". The achieved mean BAC level was $0.055 \pm 0.009\%$, as measured with a Dräger 6820 breathalyser (Drägerwerk AG & Co, Lübeck, Germany).

The tests were conducted in a fixed-base driving simulator with a vehicle mock-up and three computer screens with a visual angle of about 150 degrees. The simulated route consisted of two parts, a rural road that took about 25 min to drive followed by an urban scenario that took about 10 min to drive. The rural road had a speed limit of 70 km/h and was intended to be monotonous and fatigue-inducing. There was no traffic in the own lane and only scarce traffic in the oncoming lane. The urban scenario was more active, requiring planning ahead for smooth progress. Other road users were present, including pedestrians and bicyclists. Several changes in the speed limit occurred (the main speed limit was 50 km/h, with 3 temporary changes to 30 km/h and 1 change to 70 km/h). The goal was to create a scenario that required the driver to attend to numerous targets in several directions, but without any unpredictable critical incidents. The driving simulator was equipped with a 4-camera eye tracking system (Smart Eye Embedded Tracking SDK v12.0, Smart Eye AB, Gothenburg, Sweden). An electrocardiogram (ECG, lead II) and a vertical electrooculogram (EOG) were recorded with a Vitaport 3 bio-amplifier (Temec Instruments BV, the Netherlands). A 3-min psychomotor vigilance task [PVT; 11] was performed before and after each drive in the simulator.

Several indicators targeting driving performance in general, and fatigue in particular, were calculated. Sleep quality the night before the experiment was assessed via a sleep diary where the participants logged when falling asleep and waking up. They also rated their sleepiness level when waking up on the subjective 9-level Karolinska Sleepiness Scale [KSS; 12], and assessed if it had been difficult falling asleep(1 – very difficult, 5 – not at all), if they had gotten enough sleep during the night (1 – not at all, 5 – definitely), if they felt rested (1 – not at all, 5 – definitely), and how many times they had woken up during the night (0, 1, 2, 3 or more).

Results from the PVT tests were quantified as the mean reaction time and the number of lapses ($\geq$355 ms). Before the PVT test started, they rated their sleepiness level on the KSS scale, how they believed that alcohol would affect their driving (scale 0–10), and how well they would likely drive (scale 0–10). The two latter questions were rephrased in the post-drive assessments to reflect how well they had performed during the drive.

Performance indicators were calculated in 3 km segments during the rural drives. The shorter urban route was treated as one segment. KSS was rated every fifth minute during the drives and the nearest rating in each segment was used throughout the drives. Driving performance was assessed as the standard deviation of lateral position (SDLP), as the proportion of the drive exceeding the speed limit weighted by the amount of speeding (speeding index), and as the number of times that the time headway (THW) was $\leq$ 2 s. SDLP was only assessed on the rural road since the road geometry had a large impact on the indicator in the urban scenario, and THW was only used in the urban analyses since there were no other traffic in the own lane on the rural road. Blink duration and peak eyelid closing velocity were extracted from the EOG, heart rate and the normalize low and high frequency components (LF and HF) of the heart beat signal were extracted from the ECG, and the pupil diameter and attention level [13] were extracted from the eye tracking data.

The performance indicators were analysed with mixed-model analyses of variance (ANOVA), using fixed factors for *next-day* effects (after alcohol in the evening versus a control condition with no alcohol in the evening), *drive time* (morning/forenoon), before versus after each drive (before/after), distance driven (10 segments from 0 – 30 km). Participant (1–32) was included as a random factor. The significance level was set to 0.05. Bonferroni correction was used to compensate for multiple comparisons. Data preparation and statistical analyses were performed in MATLAB 9.9 (The Mathworks Inc., Natick, MA, USA).

## 3 Results

The subjective sleep diaries after the night with alcohol in the evening versus the control night showed no significant differences in total sleep time, KSS, difficulty falling asleep, and feeling well rested in the morning. The participants woke up more often after drinking alcohol in the evening (mean $\pm$ standard error alcohol vs control, 4.22 $\pm$ 0.14 vs 3.56 $\pm$ 0.13, $F_{(1,54)} = 10.55$, $p = 0.003$), and provided lower ratings on the question whether they had slept enough during the night (1.09 $\pm$ 0.15 vs 1.78 $\pm$ 0.15, $F_{(1,54)} = 10.74$, $p = 0.003$).

The PVT measurements indicated slower reaction times and more frequent lapses after the sober evening, but these differences were not significant. The self-ratings done in connection with the PVT showed slightly higher KSS ratings the day after drinking alcohol compared to after a sober evening (4.41 $\pm$ 0.06 vs 3.79 $\pm$ 0.06, $F_{(1,184)} = 20.41$, $p < 0.001$). They also felt more affected by alcohol (0.58 $\pm$ 0.06 vs 0.00 $\pm$ 0.00, $F_{(1,183)} = 52.50$, $p < 0.001$) and believed that their driving quality was better (7.23 $\pm$ 0.09 vs 7.56 $\pm$ 0.09, $F_{(1,183)} = 6.26$, $p = 0.01$).

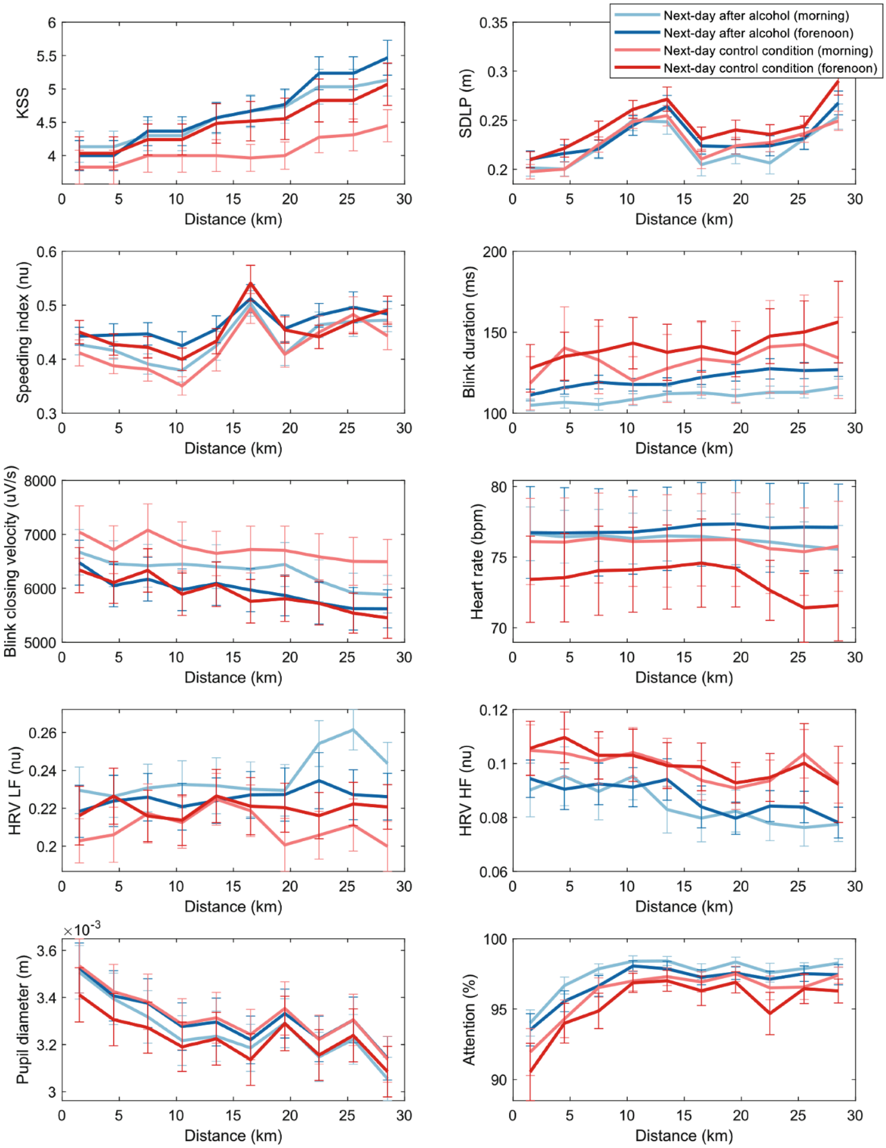


**Fig. 1.** The mean values of each performance indicator computed on the rural road for each of the 10 segments (distance driven), separated by the next-day condition (after alcohol vs control) and by the two driving sessions (morning, forenoon). The error bars represent standard error of mean.

When driving on the rural road stretch, the participants rated themselves as more fatigued the day after drinking alcohol (4.63 ± 0.03 vs 4.28 ± 0.03, $F_{(1,1138)} = 51.48$, $p < 0.001$), while SDLP was larger (0.228 ± 0.001 vs 0.234 ± 0.001, $F_{(1,1138)} = 7.40$, $p = 0.007$) and blink durations were longer (114.37 ± 2.48 vs 135.78 ± 2.58, $F_{(1,1048)} =$

35.32, $p < 0.001$) in the control condition,. Elevated HRV LF (0.21 ± 0.002 vs 0.23 ± 0.002, $F_{(1,1041)} = 25.81$, $p < 0.001$) and higher attention levels (96.84 ± 0.12 vs 95.86 ± 0.13, $F_{(1,1058)} = 28.50$, $p < 0.001$) in the alcohol condition indicates that the participants try to compensate in order to perform well. Significant effects were also found for HRV HF (0.098 ± 0.001 vs 0.087 ± 0.001, $F_{(1,1041)} = 33.62$, $p < 0.001$) and pupil diameter (3.33 ± 0.006 vs 3.28 ± 0.006, $F_{(1,1048)} = 39.41$, $p < 0.001$). Note that all differences in next-day performance, even though significant, are small (fractions of a KSS unit, centimetres of SDLP, a few milliseconds of blink durations, etc.), see also Fig. 1. Like the PVT results and pre/post drive ratings, the subjective and objective ratings go in different directions in terms of fatigue. For the other factors in the analyses, there were expected and clear time on task effects in most indicators. Performance and fatigue were also worse/higher in the morning drive compared to the forenoon drive, regardless of alcohol.

For the urban road stretch, no significant next-day differences were found except for KSS ($F_{(1,321)} = 34.01$, $p < 0.001$) and attention level ($F_{(1,296)} = 8.42$, $p < 0.001$), which can both be explained as carryover effects from the rural scenario. Note that a different set of performance indicators were used for the urban scenario, aiming to bring out possible next-day differences in visual perception and anticipatory driving.

## 4 Conclusions

Taken together, our results indicate that a low amount of alcohol in the evening (BAC $\leq$ 0.05%) does not affect driver fatigue, driving performance or sustained attention after a normal night's sleep. Subjectively rated performance measures indicated higher fatigue levels the next day, while objective measures went in the other direction or were insignificant. Overall, detected differences in performance were small when comparing next-day performance after drinking alcohol compared to a control condition with no alcohol in the evening. There might still be a next-day risk of long-term fatigue on longer drives, especially if drivers are over-compensating and thus risk becoming fatigued due to overload. Further studies including a placebo condition are needed to verify the results, also considering longer driving times and more BAC levels.

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## References

1. Garrisson, H., Scholey, A., Ogden, E., Benson, S.: The effects of alcohol intoxication on cognitive functions critical for driving: a systematic review. Accid. Anal. Prev. **154**, 106052 (2021)
2. Ahlström, C., Zemblys, R., Finér, S., Kircher, K.: Alcohol impairs driver attention and prevents compensatory strategies. Accid. Anal. Prev. **184**, 107010 (2023)
3. Gunn, C., Mackus, M., Griffin, C., Munafò, M.R., Adams, S.: A systematic review of the next-day effects of heavy alcohol consumption on cognitive performance. Addiction (Abingdon, England) **113**, 2182–2193 (2018)

4. Verster, J.C.: The alcohol hangover–a puzzling phenomenon. Alcohol Alcohol. **43**, 124–126 (2008)
5. Liu, Y.-C., Ho, C.H.: Effects of different blood alcohol concentrations and post-alcohol impairment on driving behavior and task performance. Traffic Inj. Prev. **11**, 334–341 (2010)
6. Törnros, J., Laurell, H.: Acute and hang-over effects of alcohol on simulated driving performance. Blutalkohol **28**, 24–30 (1991)
7. Alford, C., et al.: The impact of alcohol hangover on simulated driving performance during a 'commute to work'-zero and residual alcohol effects compared. J. Clin. Med. **9**, 1435 (2020)
8. Verster, J.C., et al.: Effects of alcohol hangover on simulated highway driving performance. Psychopharmacology (Berlin, Ger.) **231**, 2999–3008 (2014)
9. Saunders, J.B., Aasland, O.G., Babor, T.F., De La Fuente, J.R., Grant, M.: Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. Addiction **88**, 791–804 (1993)
10. Hume, R., Weyers, E.: Relationship between total body water and surface area in normal and obese subjects. J. Clin. Pathol. **24**, 234–238 (1971)
11. Basner, M., Rubinstein, J.: Fitness for duty: A 3 minute version of the psychomotor vigilance test predicts fatigue related declines in luggage screening performance. J. Occup. Environ. Med./Am. College Occup. Environ. Med. **53**, 1146 (2011)
12. Åkerstedt, T., Gillberg, M.: Subjective and objective sleepiness in the active individual. Int. J. Neurosci. **52**, 29–37 (1990)
13. Ahlstrom, C., Kircher, K., Kircher, A.: A gaze-based driver distraction warning system and its effect on visual behavior. IEEE Trans. Intell. Transp. Syst. **14**, 965–973 (2013)