# Tenth International Conference on Managing Fatigue: Abstract for Review

**The impact of eating at night on time on task impairments during simulated driving**

Miss Charlotte C Gupta **, University of South Australia, charlotte.gupta@mymail.unisa.edu.au
Assoc. Prof Jillian Dorrian, University of South Australia, Jill.Dorrian@unisa.edu.au
Miss. Crystal L Grant, University of South Australia, Crystal.Grant@unisa.edu.au
Miss. Maja Pajcin, University of South Australia, Maja.Pajcin@unisa.edu.au
Assoc. Prof Alison M Coates, University of South Australia, Alison.Coates@unisa.edu.au
Prof David J Kennaway, University of Adelaide, David.Kennaway@adelaide.edu.au
Prof Gary A Wittert, University of Adelaide, Gary.Wittert@adelaide.edu.au
Assoc. Prof Leonie K Heilbronn, University of Adelaide and South Australia Medical Research Institute (SAHMRI), Leonie.Heilbronn@adelaide.edu.au
Dr. Chris B Della Vedova, University of South Australia, Chris.DellaVedova@unisa.edu.au
Assoc. Prof Siobhan Banks, University of South Australia, Siobhan.Banks@unisa.edu.au

**Please note corresponding author

**Problem** [100 words]
There are an increasing number of shiftworkers eating during the nightshift, a time when performance is already impaired due to greater sleep propensity. We have previously found that eating a large meal during the nightshift impacts driving performance and increases sleepiness. To further understand this post-prandial effect at night, time on task impairments should be explored. This is important for understanding the impairments of shiftworkers driving for different amounts of time, for example a taxi driver may drive for shorter periods of time during the night compared to a truck driver.

**Method** [250 words]
This study explored the effect of eating a meal during the nightshift on time on task. Healthy, non-shiftworking males aged 18-35y participated in a laboratory based study. Participants underwent 4 simulated nightshifts from 2000h to 0600h and had a 6-hour sleep opportunity during the day, from 1000h to 1600h.

Total 24-hour energy intake was isocaloric and macronutrient balanced across conditions, and all meal content was consistent with the average Australian diet and comprised 40% carbohydrate, 33% fat, 17% protein and 23g fibre. The difference between conditions was in the timing of the meals. The eating at night condition ate a large meal (30% of 24-hour energy intake) during the nightshift at 0130h. The no eating at night condition did not eat during the nightshift (from 2000h to 0600h).

Performance assessments occurred at 1730h, 2030h and 0300h and consisted of several tasks: 40-minute simulated drive on a York driving simulator, 10-point rating scale of subjective sleepiness and 3-minute Psychomotor Vigilance Task (PVT-B). The sleepiness scale and PVT-B were performed both before and after the simulated drive. Participants were allocated to an eating at night (*n*=5) or a no

eating at night ($n$=5) condition. Variables analysed from the driving simulator included time spent in the safe zone (percentage of time spent within 10km/h of the speed limit and 0.8metres of the centre of the lane), speed variability (km/h) and lane variability (m). The driving simulator was binned into eight 5-minute bins to allow for analysis of time on task. From the PVT-B, reciprocal of the mean reaction time (Mean RRT) and number of lapses (reaction time>355ms) were analysed.

As a methodological check of sleep quality differences between conditions, standard polysomnography (PSG) measures were taken for the 8h baseline sleep, 6h day sleep on day 4, and the 8h recovery sleep. Mixed effects regression models were conducted for total sleep time, wake after sleep onset, sleep efficiency, sleep onset latency and the total time in minutes of rapid eye movement, stage 1, stage 2, stage 3 and stage 4 sleep. No differences were found between the eating and no eating conditions.

**Results** [250 words]
For all variables, mixed effects ANOVA models were conducted. As only the 0300h drive was performed after the nightshift meal, only data from this drive was used in the current analyses. Group differences were tested for the 1730h and 2030h drive and no significant differences were found. A significant main effect of time on task was found for time spent in the safe zone ($p$<0.001), speed variability ($p$<0.001) and lane variability ($p$<0.001), with driving performance worsening during the drive. The main effect of eating condition was also significant for time spent in the safe zone ($p$<0.001), speed variability ($p$<.001) and lane variability ($p$<0.01), with worse performance in the eating at night condition (**Table 1**).

**Table 1. The effect of time on task and eating condition during the simulated drive.** Mixed effects ANOVA model results for the driving simulator variables: time spent in the safe zone (percentage of time spent within 10km/h of the speed limit and 0.8 metres of the centre of the lane), speed variability (km/h) and lane variability (m). The main effects of time on task and eating condition (eating at night or no eating at night) are shown, and the interaction between time on task and eating condition. The mixed effects ANOVA models had fixed effects of time on task, eating condition and time on task*eating condition and a random effect of participant ID.

| | Time on Task | | Eating Condition | | Time on Task*Eating condition | |
|---|---|---|---|---|---|---|
| | F (df) | *p* | F (df) | *p* | F (df) | *p* |
| Time spent in the safe zone (%) | 6.17 (1,303) | <0.001 | 69.65 (1,303) | <0.001 | 1.76 (1,303) | 0.1 |
| Speed Variability (km/h) | 4.25 (1,303) | <0.001 | 62.70 (1,303) | <0.001 | 1.01 (1,303) | 0.42 |
| Lane Variability (m) | 6.887 (1,303) | <0.001 | 10.11 (1,303) | 0.002 | 0.71 (1,303) | 0.67 |

The interaction between time on task and eating condition was not significant for any of the driving variables. However, the pattern of results seen in **Figure 1** shows the eating at night condition performing worse across the drive compared to the no eating at night condition.

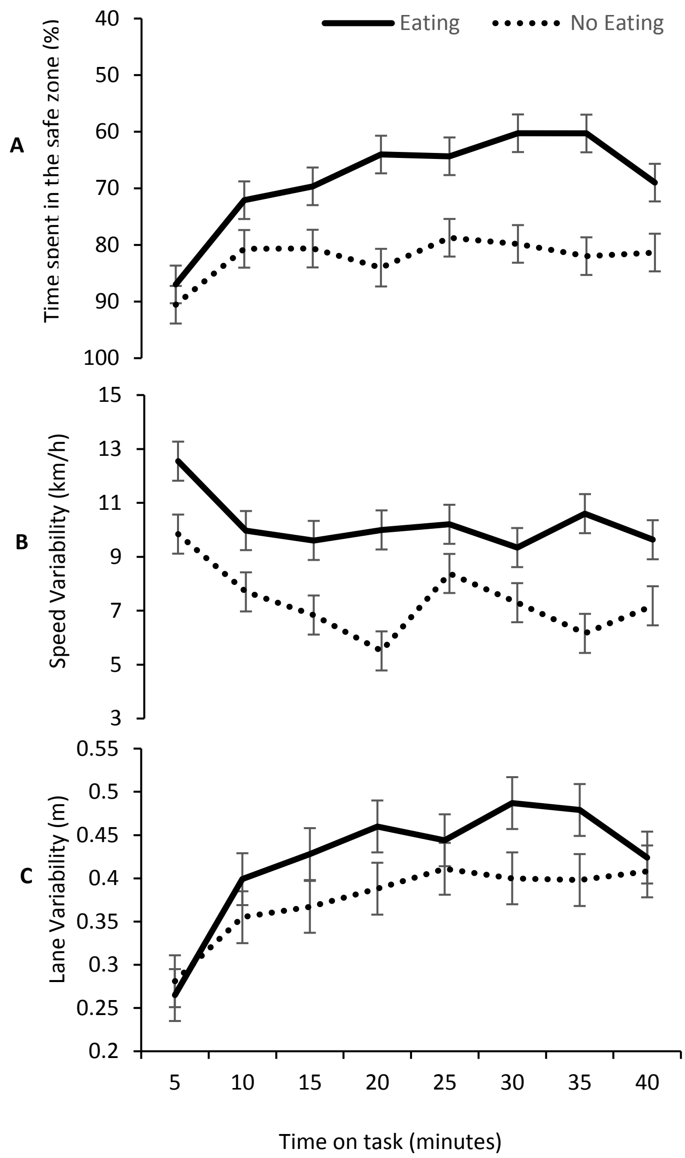


**Figure 1. Time on task impairments across the 40-minute simulated drive for each of the driving variables by eating condition (*n*=10).** The x-axis shows the 40-minute drive split into eight 5-minute bins (time on task). The interaction between time on task and eating condition is shown for time spent in the safe zone (%; Panel A), speed variability (km/h; Panel B) and lane variability (m; Panel C). Upwards on the y-axis indicates worse driving performance. The y-axis for time spent in the safe zone (Panel A) has been reversed. Error bars indicate standard error. Data shown for all participants (eating at night condition *n*=5, no eating at night condition *n*=5).

There was a main effect of time (task performed before and after the driving task) for Mean RRT ($p$=0.01), number of lapses ($p$=0.02) and subjective sleepiness ($p$=0.04), with worse PVT-B performance and increased sleepiness after the drive compared to before (**Table 2, Fig. 2**).

**Table 2. Effect of time on task and eating condition on Psychomotor Vigilance Task (PVT-B) performance and subjective sleepiness.** Mixed effects ANOVA model results for each of the PVT-B variables, reciprocal of the mean reaction time (Mean RRT), mean number of lapses (lapse is defined as a reaction time>355ms) and subjective sleepiness. The main effects of time (before or after the drive) and eating condition (eating at night or no eating at night), are shown and the interaction between time and eating condition. The mixed effects ANOVA models had fixed effects of time, eating condition and time on task*eating condition and a random effect of participant ID.

| | Time (before or after 0300h drive) | | Eating Condition | | Time*Eating condition | |
|---|---|---|---|---|---|---|
| | F (df) | *p* | F (df) | *p* | F (df) | *p* |
| Mean RRT | 7.77 (1,76) | 0.01 | 1.00 (1,76) | 0.32 | 0.17 (1,76) | 0.68 |
| Number of Lapses | 6.11 (1,76) | 0.02 | 1.60 (1,76) | 0.21 | 0.09 (1,76) | 0.76 |
| Subjective Sleepiness | 4.38 (1,76) | 0.04 | 3.24 (1,76) | 0.08 | 0.06 (1,76) | 0.81 |

The main effect of eating condition was not significant for PVT-B or subjective sleepiness and a significant interaction between time and condition was not found.

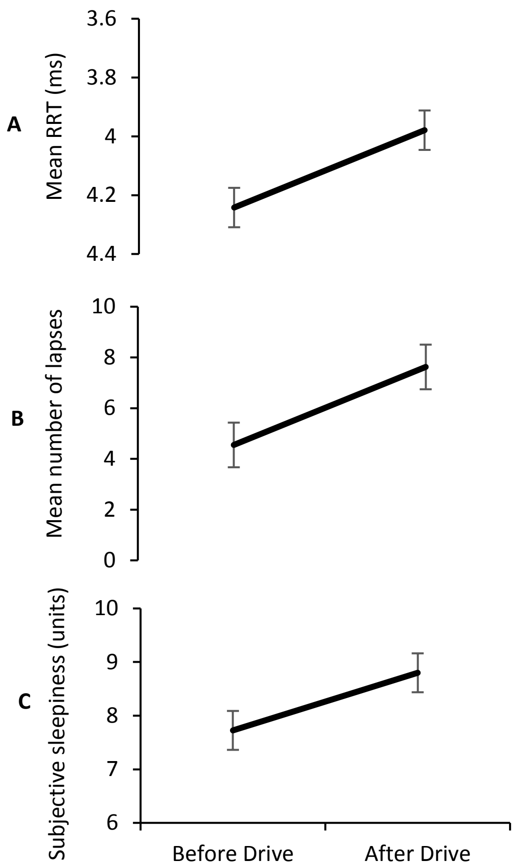


**Figure 2. Psychomotor Vigilance Task performance and subjective sleepiness before and after the driving simulation (*n*=10).** The two time points, before the 40-minute driving simulation and after the driving simulation, are shown on the x-axis. Results shown are for the reciprocal of the mean reaction time (Mean RRT; Panel A), mean number of lapses (lapse defined as a response time>355ms; Panel B) and subjective sleepiness (Panel C). Upwards on the y-axis indicates worse PVT-B performance and greater subjective sleepiness. The y-axis for Mean RRT (Panel A) has been reversed. Error bars indicate standard error. Data shown for all participants (eating condition *n*=5, no eating condition *n*=5).

**Discussion [250 words]**

This study builds on our previous findings demonstrating a negative effect of eating at night on overall driving performance and sleepiness during the nightshift. In the current study, the time on task effect was investigated to further understand the impact of eating at night on performance. A clear time on task effect was seen, with driving impairments, measured by less time driving safely and greater speed and lane deviation, increasing across the drive. Further, attention was impaired after the drive and there was greater sleepiness compared to before the drive. This demonstrates that performance was impaired with time on task.

The interaction between time on task and condition was not significant for the driving variables, attention variables or subjective sleepiness. However, as can be seen in **Figure 2**, there is a pattern of the eating at night condition performing worse across the drive compared to the no eating at night condition. There was no impact of condition on attention and sleepiness after the drive compared to before. Taken together, this suggests that time on task impairs performance at 0300h but eating at night does not appear to differentially impact this effect.

To further these results, future research should explore different meal options, including snacks and meals of different macronutrient content, in a larger sample. Additionally, this study was conducted with healthy, non-shiftworking individuals, limiting generalisability given real-world shiftworkers include women, smokers, and those with health issues. However this non-shiftworking sample allowed for greater internal validity through the control over these factors. Further, by recruiting non-shiftworkers we controlled for any sleep debt and circadian disruption which is experienced by many shiftworkers and may also adversely influence results.

**Summary [150 words]**

This study has added further evidence to the findings that, at night, shiftworkers perform worse with increasing time on task. Although not statistically significant, the results suggest that time on task is potentially exacerbated by eating at night and this should be further explored in future studies. This study is a step towards understanding the impact of eating at night on the performance of shiftworkers. This is important as recommendations can be made to shiftworkers about limiting meals during the night to not only improve health, but also performance and safety.