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Behaviour patterns and effects of napping during night-time driving

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Abstract

Sleepiness while driving is an underrated risk. Between 1.2% (USA) and 8.4% (France) of road crashes have been directly related to falling asleep behind the wheel. The actual incidence of it being compounding factor in accidents is certainly higher. To this, age, extent of sleep deprivation, duration of drive and time of day can contribute to the actual risk for a sleep related vehicle accident (SRVA). In real situations drivers often employ countermeasures, such as self-stimulating behaviours or naps to alleviate the fatigue. In the present study, 21 participants were asked to drive two hours on a test track in the middle of the night (2 a.m. - 4:30 a.m; depending on condition). One group (n= 14) drove without interruption and the other group (n= 7) was allowed to rest or nap for half an hour after 90 minutes before driving another 30 minutes. Behaviours, not directly associated with driving (spontaneous behaviours) were analysed. In addition subjective sleepiness (Karolinska Sleepiness Scale: KSS) and objective assays on attention and concentration (Alphabetical Cross-out-test: AD-test) were conducted before and after the experiment. The results indicate that spontaneous behaviours increase with time on task and act as a self-stimulating countermeasure to sleepiness. Furthermore participants, who took a nap showed less behaviour after the break and rated themselves as less tired compared to the beginning and the non-nappers. On the level of attention and concentration (AD-test) the nappers performed worse than the non-nappers after the driving task. This indicates that a nap at 3:30 a.m. seems to have positive effects on subjective but not objective sleepiness and therefore may increase the risk of a SRVA.

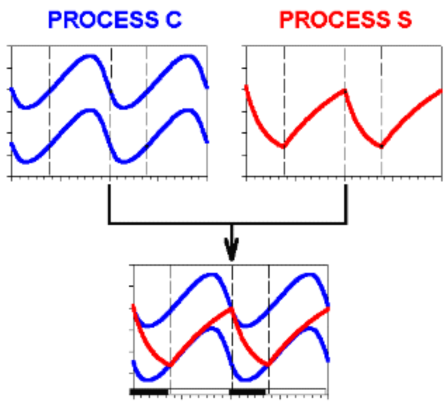
Introduction

Sleep and its Regulation

The medical dictionary definition of sleep is "a natural state of rest for the mind and body, in which the eyes usually close and consciousness is completely or partially lost, so that there is a decrease in bodily movement and responsiveness to external stimuli." This loss of consciousness is a phenomenon that has fascinated humans since antiquity. Even Greeks like Aristotle and Hippokrates searched for an answer to the question: "Why do we sleep"? Over generations, theories have been developed to explain the phenomena (Spork, 2007), like the existence of a poison, a "Hypnotoxin" (Pieron, 1913) that accumulated during wakefulness and needed to be decomposed during sleep. In the mid 20th century with the advance of neurophysiology, scientists began to develop new theories to explain the functions of sleep. Popular ideas were: Sleeping may simply function to save energy; It's important to import the impressions from the previous day into the long term memory; It strengthens the immune system (Bryant et al, 2004). At the same time researchers proposed that sleep may be essential for life. Experiments like those of Rechtschaffen et al. (1989) illustrated that sleep-deprived rats, could die within a period of two to three weeks. At the same time other studies showed that even small amounts of sleep deprivation were detrimental (Drummond et al, 2000; Killgore et al, 2006). In humans, sleep deprivation of 24 hours can result in reaction times comparable to blood alcohol levels of 1.0 per mill (Williamson & Feyer, 2000). These types of studies made the point quite clear that sleep may be necessary for both life and function.

The regulation of sleep is closely related to one's endogenous circadian clock (Aschoff, 1981). Biological clocks in our bodies, that are sensitive to light and a wide range of biological Zeitgebers, regulate our sleep behaviour and are responsible for the daily rhythm of sleeping and being awake. In this context, Borbély (2004) developed the so-called two-process model for sleep regulation. In it there are both circadian (C) and homeostatic processes (S). While the circadian component oscillates in a more or less constant rhythm of 24 hours, the homeostatic sleep pressure increases with time awake. After a certain amount of wake-time the product of the two processes reaches a threshold that induces sleep (Fig. 1). An example of how the processes function was shown in a study by Lavie (1999). In it subjects were asked to sleep for seven minutes and then stay awake for 12 minutes constantly over 24 hours. The tendency to fall asleep in the seven minute-intervals was high between 2 p.m. And 4 p.m. and most likely between 10 p.m. and 7 a.m. (Lavie, 1999). The conclusion is that if people try to work against their natural rhythm, with these processes it can lead to dangerous and uncontrollable situations.

Figure 1: The two-process model after Borbély (2004): This figure illustrates the patterns of circadian wakefulness (C) and the homeostatic (S) processes of sleep pressure after awakening and how they regulate sleep. Contact of the C and S leads to sleep (black bars). © www.pharma.uzh.ch



Sleepiness behind the wheel

Sleepiness while driving is an underrated risk. Depending on the country and study 1.2% – 3.2% (USA: Knipling & Wang, 1995; NHTSA, 1996), 2.5% (UK: Maycock, 1995) and 8.4% (France: Thomas & Attard, 1994) of the road accidents were the direct result of drowsiness. The real frequencies are much higher, because sleep related vehicle accidents (SRVA) are hard to prove and other factors like inattention may have caused the accident as well. It has been assumed by Horne & Reyner (1999) that when the point of run off had been seen by the driver several seconds before the crash, then the accident was not caused by a sleep episode. In contrast, a strong sign for a SRVA was running off the road, colliding with another vehicle or object without skid marks or other signs of braking. These features and this information are unfortunately rarely available in accident statistics.

A lot of different factors contribute to the risk of falling asleep while driving such as age (Horne & Reyer, 1999), extent of sleep deprivation (Arnedt et al, 2000), duration of the drive (Brown, 1999; Philip, 2005) and the time of day (Pack et al, 1995; Connor et al, 2002). Most accidents on the road occur between 2 – 6 a.m. and 2 – 4 p.m. Particularly 2 – 6 a.m. is a time of high sleep pressure for most people that along with the circadian process, can induce high levels of sleepiness. This is comparable to tiredness as a central nervous process, although tiredness is a psychological state, more dependent on stress. It appears mostly in monotonous situations (Weeß, n.d.). In 2002, Johns introduced the term 'Somnificity', in which posture characteristics, activity and environmental situations could be monitored as the capacity or propensity to sleep. If a person has to perform a monotonous task, like driving a car, in the middle of the night there is a high risk of falling asleep. This explains why most SRVAs happen on motorways between 2 – 6 a.m. A survey done by Maycock (1996), showed that of the 4,600 people asked, 29% admitted to having fallen asleep while driving at least once the past year.

Drivers' drowsiness is different than normal drowsiness because the driver is motivated to stay awake and fight off sleep (Liu et al, 2009). This allows one to pose the question of whether people are aware of their tiredness while driving. Awareness is particularly relevant because the transition form wakefulness to falling asleep is a gradual process and therefore poorly perceived by the subject (Nordbakke & Sagberg, 2007). A study, published by Jones et al. in 1979, claimed that the drivers had no foreknowledge of sleepiness before an accident. On the contrary, Horne (1998) showed that self-awareness of increased sleepiness starts about 40 minutes before the potential crash. A questionnaire in 2007 with more than 1,500 participants indicated that drivers were quite aware of both, the risk and the symptoms associated with falling asleep at the wheel (Nordbakke & Sagberg, 2007). Known symptoms are yawning, difficulties to keep one's eyes open, frequent eye blinks, difficulties in concentration and increased variation in speed (Nordbakke & Sagberg, 2007). On top of these Milosevic (1997) has proposed a general slowdown of activity before sleep. Although there seems extensive knowledge of the symptoms and the risks of falling asleep while driving, it has not been taken seriously by the public. People often overestimate their ability to fight the symptoms of sleepiness (Norbakke & Sagberg, 2007). To stay awake countermeasures have to be taken. A number of countermeasures are assumed to help here like: Opening the window, turning on the radio, taking a break, soliloquising and singing, drinking coffee or taking a nap. Hayashi et al. (1999) found, that a 20 min nap in the mid-afternoon would improve subjective sleepiness and performance levels. To investigate the effect of coffee or a nap in real life environments at night, Philip et al. (2006) asked young men to drive between 2 and 3:30 a.m. on a straight highway. The participants had to repeat the task three times. In one session they drank a coffee, another time a placebo and in the third condition they took a nap at 1 a.m., one hour before the test. A professional driving instructor went with them to control the driver and note lane crossings, an indication of sleep related accidents (65% of SRVAs occur after inappropriate line crossing; Sagberg, 1999). To control for individual differences, every participant had another driving session in the late afternoon (6 – 7:30 p.m.). The results showed that both napping and drinking a coffee reduced sleepiness, although the authors did report large inter-individual variability.

Reyner and Horne (1997) confirmed these assumptions and proposed that a combination of both countermeasures might be the best way to stay awake. However, in the long run it may be dangerous to rely on the effects of caffeine or a nap. It is possible that subjective and objective sleepiness drift apart from each other and that sleep may overcome a person in a rapid and unpredictable way. In a simulated night-shift study, Tremaine et al. (2010) found, that subjective sleepiness was less correlated with objective sleepiness when participants took a 30-minute night-nap. For these reasons scientists all over the world have been searching for reliable methods to document sleepiness, especially in situations, where falling asleep is extremely dangerous, such as driving a car.

Markers of sleepiness

There are subjective and objective methods to assess fatigue. One possibility to measure drowsiness is simply to ask drivers directly to rate their sleepiness on a scale from 0 to 10 (Moller et al, 2006). In most studies the Stanford Sleepiness Scale (SSS) or the Karolinska Sleepiness Scale (KSS) have been used. Both scales are based on individual verbal descriptions of their current state of drowsiness (Liu et al., 2009). Akerstedt and colleagues (2005) used the KSS to rate their participants sleepiness every five minutes during a driving task and compared these results with the drivers' lane departures. They found a positive correlation between the subjective KSS ratings and the risk of lane departures.

Computerised vigilance tests are often used as an objective method. These tests combine parameters of concentration, attention and alertness. Although it is not a simple reciprocal function to sleepiness, impaired cognitive functions and prolonged reaction time are consequences of reduced wakefulness and vigilance (Mathis & Hess, 2009). In simple reaction time tests stimuli are presented in irregular intervals. The subjects have to push a button when the stimuli are presented. Philip et al. (1999) illustrated, that in young drivers reaction time in these types of tests decreased with duration of driving. Another way of measuring attention and alertness is the Alphabetical Cross-out Test (AD-test), developed by Grünberger (1977). With a time limit of 20 seconds per row, subjects have to cross-out specific letters on a sheet, consisting of 20 rows with 40 letters each.

Finally electroencephalography (EEG) and electrooculography (EOG) are the most reliable markers for sleepiness. With EEG's one can precisely differentiate between wakefulness and sleep. Alpha-waves, frequencies between 8 and 12 Hz are an early sign of sleepiness and appear earlier in the wake-sleep transition than theta-waves with frequencies between 4 – 7 Hz. The comparison of alpha and theta power is a clear indictor of drowsiness. In a study by Otmani et al. (2005), EEG- activity changes in these two ranges increased with the driving duration. Hence, the more tired a person, the more theta-waves appear compared to alpha-waves. With EOG's it is possible to measure eye movements by transforming them into analysable electrical signals. Together with eye-blinks, eye movements provide information about the state of tiredness. While eye blinks reduce and eyelid closures extend, rapid eye movements (REM) disappear and slow eye movements (SEM) appear (Santamaria & Chiappa, 1987). The percentage of eyelid closure (PERCLOS) is the proportion of time in a specified time period, in which the participant's eyes are closed. A driver is considered to be drowsy with a PERCLOS over 80% (Wierwille &

Ellsworth, 1994). However, eye blinks and closures can also be affected by road lights and air temperature which probably makes them not sufficiently reliable for predictions of drivers' drowsiness in the field (Liu et al, 2009).

Driving behaviour and drowsiness

For the detection of drowsiness during driving in a motor vehicle, two methods have been used. The variability of driving speed is one. Fairclough and Graham (1999) reported, that sleep deprivation increases the variability of driving speed. Another approach has been to calculate the standard deviation of the lane position (SDLP) or the number of line crossings. Ingre et al. (2006) found that the SDLP was connected to the participant’s subjective sleepiness. The more tired they felt, the higher their SDLP. Another vehicle-based detection of drivers' drowsiness has been based on steering wheel movements (SWM). In a study by Fairclough and Graham (1999) sleep-deprived drivers were found to make more steering wheel reversals than rested drivers. In another publication, sleepy participants made fewer small but more large SWMs with time on task (Thiffault & Bergeron, 2003).

Non-driving behaviour

While objective methods mentioned like EEG, EOG and lane-departures have become a focus in many studies, analyses of the drivers' spontaneous behaviour have faded into the background. In 1994, Wierwille and Ellsworth published a study, in which trained personnel classified the drowsiness of drivers based on behavioural and eye parameters into five stages. Depending on gazing, eyelid closure and frequency, relaxing mimic and posture, the participants were rated as not, slightly, moderately, very or extremely drowsy (Wierwille & Ellsworth, 1994). Kolrep et al. (2005) developed a similar but slightly different method with nine rather than five stages and a discrimination between typical tired and wake behaviour. Based on the two mentioned publications, Dittrich et al. (2009) finally introduced the TUBS-Scale, an eight-point scale with a higher reliability and objectivity compared to the former studies. There are, nonetheless, still problems with this kind of assessment scale. Most of the studies were unfortunately carried out on driving simulators. None of them actually analysed spontaneous behaviours and their changes with regard to time on task. Furthermore these scales assumed, that the behaviour reported was a consequence of sleepiness and/or tiredness. The assumption that the absence of spontaneous behaviour is a result of sleepiness was not considered. In this thesis, spontaneous behaviour was therefore defined as behaviour of the driver, not directly associated with driving the car.

Goals of the study

This study examined individual spontaneous behaviours, which were not directly associated with driving and described their development with time on task during a 'real-life' night driving situation. The results may give a new insight in the prediction of falling asleep behind the wheel and its cause at the level of behaviour. Furthermore the influence of naps on these behaviours, subjective sleepiness, concentration and attention and a comparison between the sexes was investigated.

As a result the following questions served as a basis for the investigation:

1) How does spontaneous behaviour, which is not directly associated with driving a car, change with time on task?

2) Does a nap influence these behaviours?

3) Do naps influence subjective sleepiness, attention and concentration?

4) Are there differences in the appearance of spontaneous behaviour between tired and not-tired participants?

5) Do men and women differ in the expression of spontaneous behaviours?

Methods

Study design and subjects

The study was carried out in collaboration with the ISWF (Institut für Schlaf-Wach-Forschung), the ÖAMTC and the ASFINAG between September and November 2010 and took place on a test track in Teesdorf, Austria. The circuit is approximately 2.5 km long and features straight and winding road sections (Fig. 2).

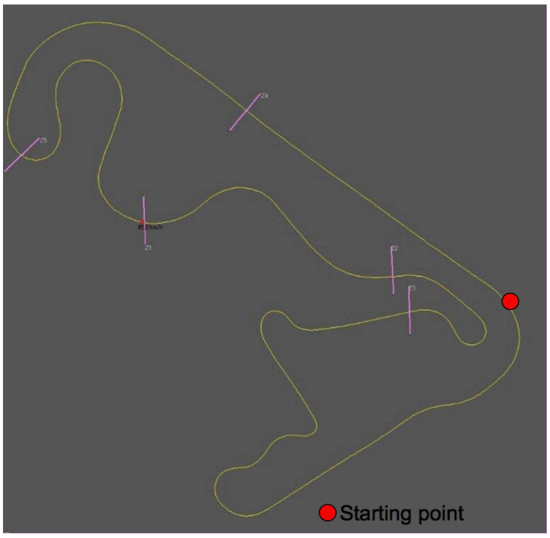


Figure 2: The test track with the starting point for the round-based analysis (left) and the whole test-area (right) at Teesdorf (© google maps)

To take part in the study, the participants had to have driven at least 7000 kilometres a year, without being professional drivers. Furthermore they had to fill out questionnaires about their sleep quality (Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale). People with chronic diseases were excluded. All drivers were informed about the experiment in advance. The study was conducted under consideration of the '*Guidelines for Good Clinical Practice*' and the '*Declaration of Helsinki*'.

All together 60 out of more than 200 applicants were chosen to participate, 26 female and 33 male drivers. (one driver was excluded because of technical problems). The average age of the women was 38.04 (SD: 6.26; 30 to 48 years) that of the men 43 years (SD: 6.91; 30 to 54 years). The male and female participants were randomly separated into two groups, a non-napping group (NNG) and a napping group (NG). Both groups had to drive two hours in the night. While the NNG drove continuously for two hours, the NG was allowed to take a break after 90 minutes of driving. After 30 minutes, they filled out a questionnaire (Karolinska Sleepiness Scale) and continued to drive for another 30 minutes. The method produced a total driving time of 120 minutes in both groups.

In the evening of the experiments, either Friday- or Saturday, the participants arrived at Teesdorf at 10 p.m. After a short introduction, they filled out several questionnaires (D-MEQ, KSS, sleep quality of the prior night). Moreover vigilance (computer test), attention and concentration (AD-test) was tested. In addition saliva samples were taken to measure levels of cortisol and alpha-amylase. This procedure was repeated at the end of the experiment. The driving part itself was carried out between 2 and 4:00 a.m. (or 4:30 a.m., depending on the condition). To simulate a situation of high but realistic sleep pressure, wakefulness of at least 15 hours was obligatory. Therefore the participants were allowed to sleep on the night before but not during the day of the test. During the experiment, chewing gums, listening to radio or stimulants like coffee or energy drinks were forbidden.

The participants were requested to drive at moderate speeds between 30 and 60 km per hour on the track. Overtaking other cars was forbidden and the drivers were instructed to stop their car when they saw the backlights of the car ahead. To assure safety, the experiment was observed by trained personnel, who were positioned across the track and had the possibility to communicate with the participants via Walkie-Talkies. Every driver was connected to an ambulant polygraphic system to record EOG and EEG signals. All participants drove their own cars. They were equipped with a GPS-system and three infrared cameras, of which one was directed towards the road. Two other cameras were placed in the car, directed towards the drivers' head and upper body, giving insight to the behaviour while driving.

Data collection and analysis

In this study, video recordings of 21 drivers were analysed, 14 of the NNG and seven of the NG. The sexes were balanced with ten male and 11 female drivers. With an inclusion limit of at least 20 analysable rounds (see below), the rest of the participants were excluded due to incomplete data sets. Causes here were technical problems in the system like switching off the engine that led to a shutdown of the cameras. Table 1 gives an overview of the age, sex, total number of rounds, number of rounds analysed, date of participation and condition of the drivers.

Table 1: The drivers analysed: Age, sex, driving condition, number of rounds driven/analysed and date of participation are listed. Differences between the number of total rounds and rounds analysed were caused by technical problems.

Study-ID	Age	Sex	Condition	Total Rounds	Rounds Analysed	Date
2004	41	F	NNG	31	29	30/10/10
2009	43	F	NNG	34	32	02/10/10
2012	49	M	NNG	30	30	13/11/10
2014	42	M	NNG	31	30	13/11/10
2016	40	F	NNG	38	31	22/10/10
2019	33	F	NNG	31	31	19/11/10
2023	30	F	NG	25	25	26/11/10
2024	41	F	NG	31	31	12/11/10
2026	40	M	NG	30	30	30/10/10
2029	31	M	NG	30	25	19/11/10
2030	54	M	NG	30	30	20/11/10
2032	30	F	NNG	29	29	12/11/10
2041	52	M	NNG	28	26	05/11/10
2042	35	F	NNG	30	26	29/10/10
2044	43	M	NNG	30	30	06/11/10
2048	44	M	NNG	30	25	20/11/10
2049	31	F	NG	31	31	06/11/10
2050	38	F	NNG	30	26	20/11/10
2056	37	M	NNG	35	35	02/10/10
2059	34	M	NNG	29	23	06/11/10
2066	42	F	NG	24	24	26/11/10

The beginning of the straight stretch was defined as the starting point of a round (Fig. 2). The time points of each onset were identified with '*Blackbox*'-software, a program, which shows the time of day and the localisation of the car on a map based on GPS positioning.

The video analysis was done with 'Solomon coder'. A bout interval of ten seconds was chosen. In each bout the presence or absence of a particular behaviour was noted on a 1/0 scale. When more than one category of behaviour was expressed, both were recorded. Behaviour that continued from one interval to the next was recorded for two bouts. When the driver stopped the car, the behaviours were not recorded. The number of bouts with given behaviours per round were used in the analysis. All shown behaviours in the ten seconds intervals were summed up for the individual rounds. There were generally 22 rounds before and seven rounds after the break. In the first rounds, trained personnel drove ahead of the group to help the drivers to get to know the track. These rounds were not included in the analysis. “Round 1” was the first circuit drive after the chaperones had left the track.

Behaviours

For behaviour-analysis, the in-car camera was used, showing the head and the upper body of the driver. The behaviours were defined and classified in two main categories: non driving and comfort or stretching behaviours. In these categories seven specific behaviours were registered.

<u>Non-driving behaviours were:</u>

- Yawning: Mouth opened wide with a deep inhalation and involuntary typical vocalisation
- Vocalisation: Acoustically perceived behaviours like singing, whistling or soliloquising
- Drinking: Intake of liquid via mouth (was monitored but it didn't occur and so was not included in the analysis)
- Auto- stimulative behaviour: All self-orientated movements and gesticulations, in which head or body were stimulated with one or both hands like hair crawling, eye-rolling or running fingers through one's hair

<u>Stretching behaviours (analysed separately) were:</u>

- Postural movement: Straighten of the upper body after having leaned backwards
- Shoulder movement: Lifting or circular movement of the shoulders
- Head (neck) movement: All head movements that were not directly associated with driving (vertical head movement, horizontal bending and rotary motion of more than 90 degrees)

Karolinska Sleepiness Scale (KSS)

Participants had to rate their sleepiness on a ten-point scale between, before and after the driving task. According to their KSS-scores, two groups of drivers were compared. The first group consisted of participants showing a decrease in the KSS-scores while the second group comprised those with increasing scores. Another post hoc approach was to compare individuals with KSS-scores less or more than five. One subject (2050) didn't fill out the KSS and had to be excluded from the analysis.

Alphabetical Cross-out Test (AD-test)

The AD-test was conducted before and after the driving session. The participants had to cross out four previously defined letters on a sheet consisting of 20 rows with 40 letters each. The time limit was set on 20 seconds per row. The total number of wrong crossed-out letters was subtracted from the total number of correct crossed-out letters. These parameters indicate attention, concentration and variability in concentration. A group comparison was done on behaviour patterns of drivers that had improved or declined in their test performance over the course of the experiment. One subject (2050) didn't participate in the AD-test and was excluded from the analysis.

Statistical analysis

Behavioural development with “time on task” was assessed with Pearson correlation statistics. Three time-periods were chosen to compare non-nappers and nappers, male and female drivers. They were a) the first five rounds (TP1), b) five rounds after one hour (TP2) and finally c) the last five rounds (TP3). In addition, the differences among the time periods, so-called delta values (DV) were calculated to examine differences in the patterns of behaviour with time on task. Here, the averages of the five rounds after one hour of driving (DV2) or the last five rounds (DV2) were compared to initial behavioural levels by subtracting the averages of the first five rounds. Furthermore, the average of five rounds after one hour of driving was subtracted from the last five rounds (DV3). These calculations were done for every driver separately.

All the graphs and statistical analysis were done with MS Excel (Microsoft Corp.), IBM SPSS 20.0 (IBM-Corp.) and Centurion StatGraphics. Depending on distribution and Variance, a t-test or Mann-Whitney U-test was used to calculate differences between nappers and non-nappers after night-time driving. For comparisons between the TPs a multifactorial test was used, either ANOVA or Kruskal-Wallis-test in the case of data that had no normal distribution. To find out how time-periods differed from one another, a Mann-Whitney U-test between TP1 & TP2, TP1 & TP3 and TP2 & TP3 was done separately. The confidence level was set at 95% for each test and results were interpreted as significant with a p-value $< 0,05$.

Results

All categories of spontaneous behaviour

The results of all expressed spontaneous behaviours, non driving and stretching, are shown in Fig. 3. The lowest level of behavioural expression was in the 1st round (mean: 3.75; SD: 3.38) and the highest value in the 21st round (mean: 7.16; SD: 7.09). This means that spontaneous behavioural expression increased and correlated significantly with time on task (Pearson correlation: r= 0,12; p< 0.05). In contrast to the overall analysis, there were no significant differences between the three TPs. The pattern of change was thus not consistent over individuals or too small to be documented in TP comparisons. The variability in the data was also documented in the number of individuals and measurements per round that were characterized by time-periods without movement, defined as 0-values in this thesis. For instance in the 3rd round the percentage of 0-values reached a maximum of 31.6% (3rd round) before it declined, staying below 25% until the break (Fig. 3). There was a significant, negative correlation between the percentage of 0-values and the time on task (Pearson correlation: r= -0.406; p< 0.05).

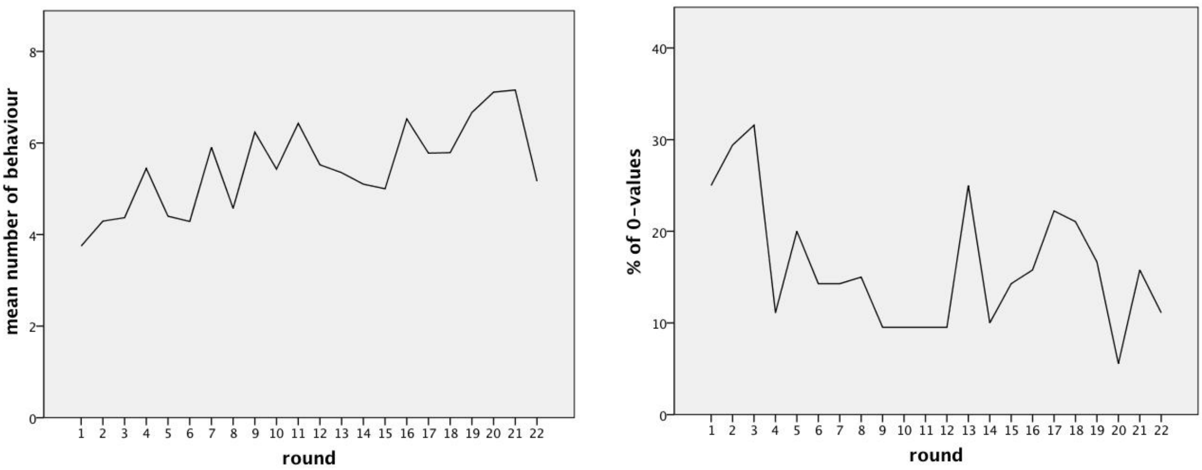


Figure 3: Left: Total number of all behaviours with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without spontaneous behaviour (0-values) decreased with time on task (n=21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

Non-driving behaviours (NDB)

Yawning

Yawning was not common. It was shown 0.06 times (SD: 0.25) in the 1st round. Nonetheless the maximum in the group means was found in the 17th round (mean: 0.72; SD: 1.13). Afterwards the behaviour declined and ended with a mean of 0.33 (SD: 0.57) (Fig. 4). In the figure one can also recognize the positive, significant correlation between yawning and time on task (Pearson correlation: r= 0.14; p< 0.01) (Fig. 4). With regard to the time-course, more yawning was shown at TP2 compared to TP1, the first five rounds (Kruskal-Wallis: p< 0.05). The percentage of time-periods without yawning decreased and significantly correlated with time on task (Pearson correlation: r= -0.688; p< 0.01) and remained on average over 57.1% after the 11th round for the duration of the study (Fig. 4).

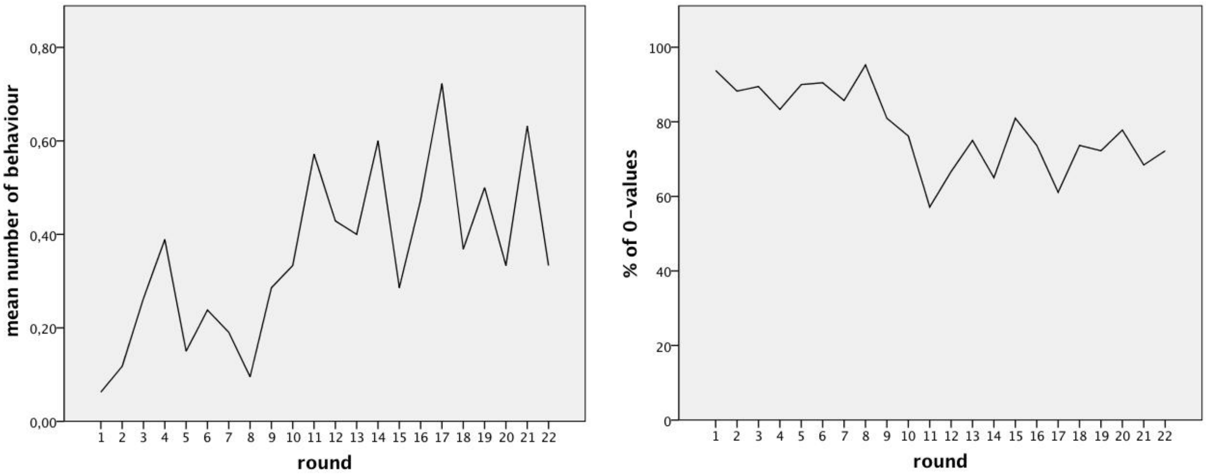


Figure 4: Left: Total number of yawning with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without yawning (0-values) decreased with time on task (n= 21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

Vocalisations

In Fig. 5 one can see that vocalisations were rare (below 1) during the first six rounds. The maximum in the group mean was found in round 21 (mean: 2.37; SD: 5.09). As a result there was a small but significant positive correlation with driving duration (Pearson correlation: r= 0.11; p< 0.5) (Fig. 5). On the basis of time periods, there were no significant differences. The percentages of periods without vocalisations decreased during the first rounds but then remained above 70% during the driving task. This negative correlation with time on task was significant (Pearson correlation: r= -0.469; p< 0.05).

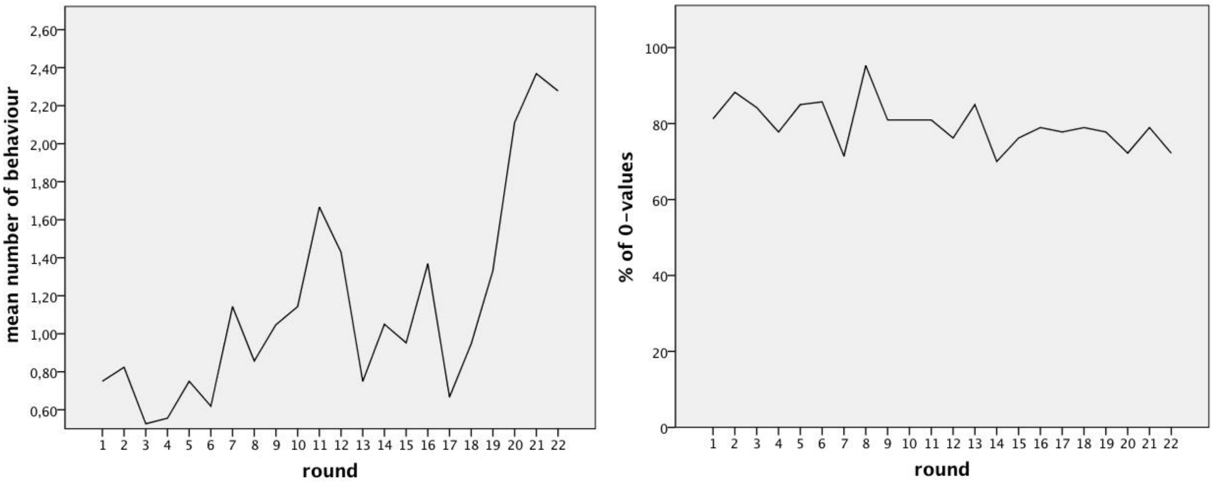


Figure.5: Left: Total number of vocalisations with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without vocalisations (0-values) with time on task (n= 21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

Auto-stimulative behaviour (ASB)

The range of ASB was rather high during the driving task. The lowest value was in the 1st round with a mean of 0.63 (SD: 0.96) and the highest in the 19th and 20th round with a mean of 1.83 (SD: 2.18 & 2.48). Although ASB increased with time on task, this trend was not statistically significant (Pearson correlation: r= 0.08; p= 0.08) (Fig. 6). Similarly, the differences between the TPs were not significant. In the figure the percentage of 0-values are also shown. Here one can recognize a significant, negative correlation with driving duration (Pearson correlation: r= -0.587; p< 0.01), the minimum of 27.8% was in the 20th round (Fig. 6).

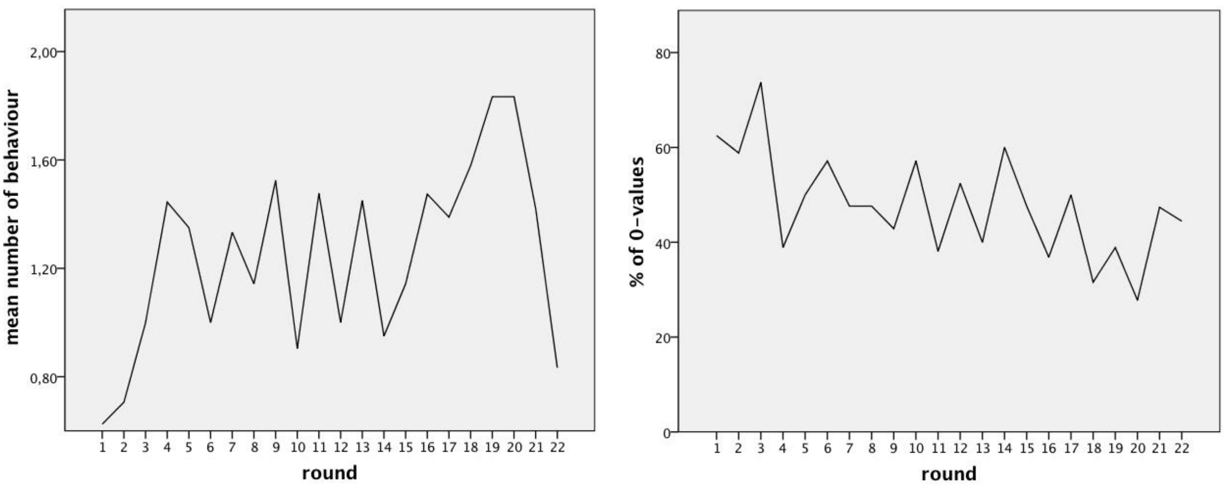


Figure 6: Left: Total number of auto-stimulative behaviours (ASB) with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without ASB (0-values) decreased continuously with time on task (n= 21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

All NDB (yawning + vocalisation + auto-stimulative behaviour)

The sum of yawning, vocalisation and auto-stimulative behaviour (indicated as NDB) at the onset of the drive was 1.44 (mean, SD: 2.85). In the course of the night, the total number of NDB increased continuously and reached a mean of 3.44 in the last round. The maximum was observed in the 21st round (mean: 4.42; SD: 5.38) (Fig. 5) and correlated significantly with time on task (Pearson Correlation: r= 0.16; p< 0.01). Nonetheless, the changes were so slight that in contrast to the overall analysis, there were no significant differences among the three TPs. In contrast, there was a pronounced, significant pattern in the absence of NDB (Pearson correlation: r= -0.748; p< 0.01). The percentage of periods without NDB declined from 62.5% (1st round) to 11.1% during round 20.

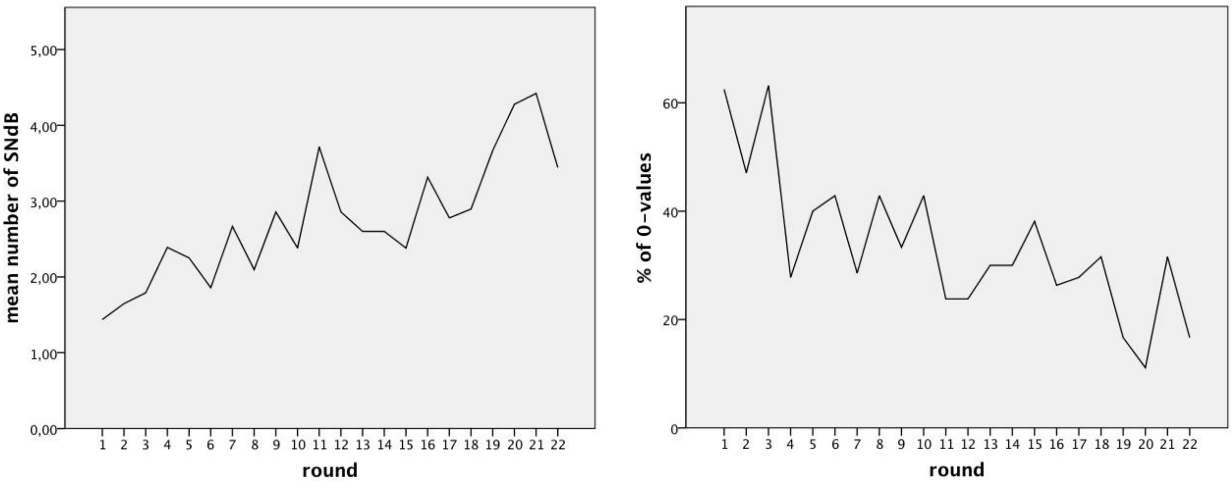


Figure 7: Left: Total number of NdBs with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without NDB (0-values) decreased continuously with time on task (n= 21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

Stretching and comfort behaviours

Postural movements

Along with the NDB, nearly all subjects regularly performed behaviour associated with comfort. In Fig. 8 one can see that the postural movements declined (Pearson correlation: r= -0.09; p= 0.06) during the experiment, with the highest values at the beginning (mean: 0.63; SD: 1.03). Thereafter, the mean number decreased continuously (below 0.40) till the end of the task. The percentages of periods without postural movements slightly increased with time on task (Pearson correlation: r= 0.085; p= 0.708) and remained above 68.4% for the duration of the drive (Fig. 8). There were no significant differences among the TPs.

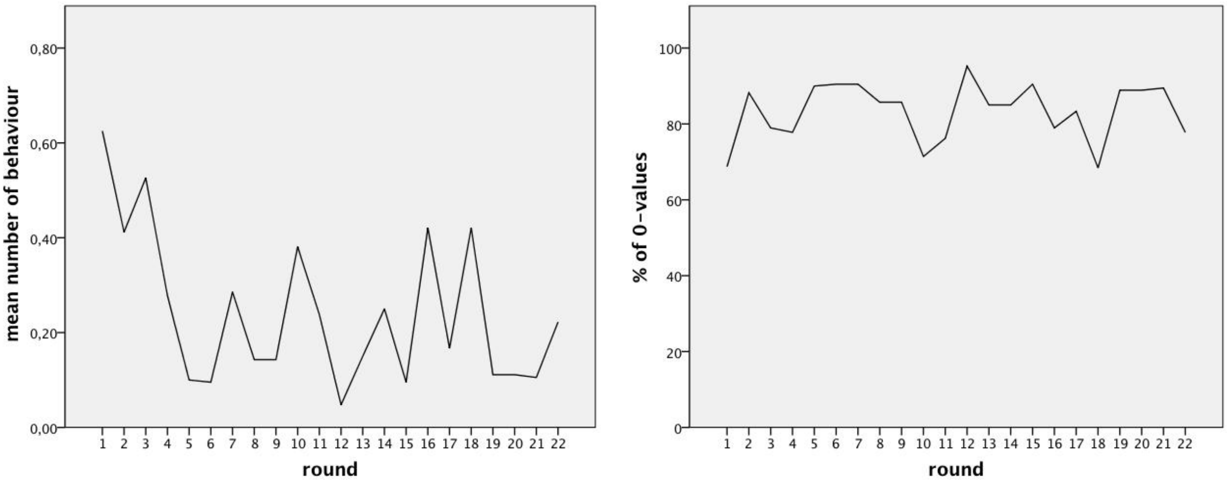


Figure 8: Left: Total number of postural movements with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without postural movement (0-values) with time on task remained unchanged (n= 21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

Head movements

Maxima in head movement were shown in the 7th, 10th and 12th round with a mean number between 1 and 1.1. Thereafter, the average number of head movements decreased, resulting in a negative correlation with time on task (Pearson correlation: r= -0.08; p= 0.11). This trend was observed in all drivers (Fig. 9). Comparisons among the TPs did not produce any significant results. The percentage of periods without head movements showed a high variability with a maximum of 80% in the 5th round. In the following round 6 it was 42.9% and thereafter fluctuated between 38.1% (10th round) and 73.7% (16th round) until the end of the drive. The temporal patterns were not significant (Pearson correlation: r= 0.259; p= 0.245).

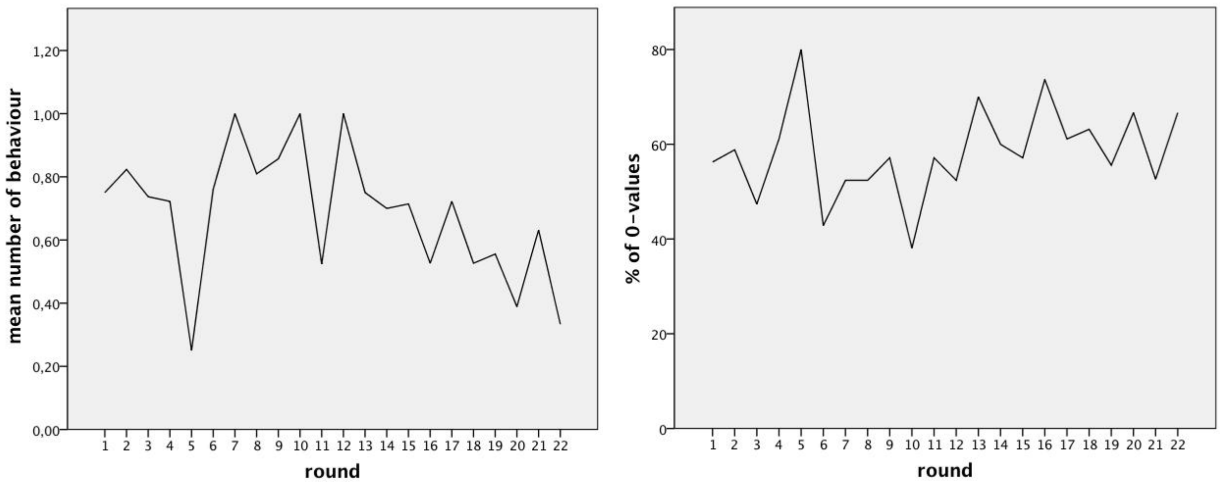


Figure 9: Left: Total number of head movements with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without head movement (0-values) with time on task showed a high variability (n= 21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

Shoulder movements

No shoulder movements were observed in the 1st, 11th and 22nd round. The most frequent expression of the movements was in the 4th round (mean: 0.33; SD: 0.69). Shoulder movement changes with time on task were far from being significant (Pearson Correlation: r= -0.021; p= 0.66) (Fig. 10). On the individual level this behaviour was shown maximally two times per round and the percentage of periods without shoulder movements remained very high (> 76.2%) all the time. There were no differences in the TPs and no observable patterns in the 0-values (Pearson correlation: r=0,011; p=0,962).

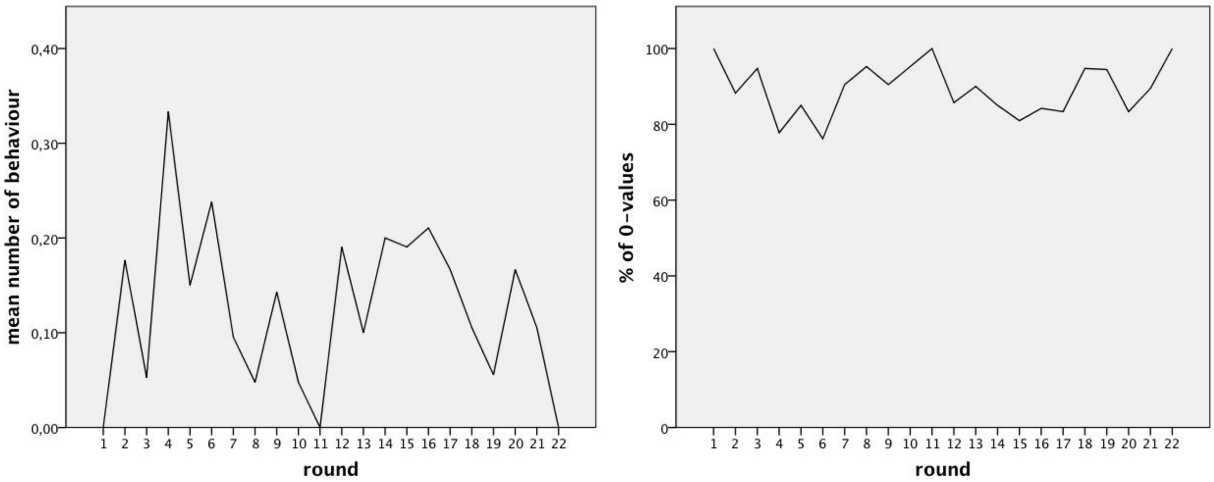


Figure 10: Left: Total number of Shoulder movements with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without shoulder behaviour (0-values) with time on task remained unchanged (n= 21). Values represent % of the total sums of intervals measured in all drivers in a specific round.

All stretching (postural + head + shoulder)

The sum of all stretching behaviour ranged from 0.56 (22nd round; SD: 0.51) to 1.43 (9th round; SD: 1.36). Although there were no significant differences between the three TPs, the total number of stretching significantly declined with time on task (Pearson correlation: r= -0.105; p< 0.05) (Fig. 11). Surprisingly, although this pattern was present in expression, the percentage of periods without stretching behaviour showed no distinct temporal pattern (Pearson correlation: r= 0.035; p= 0.878).

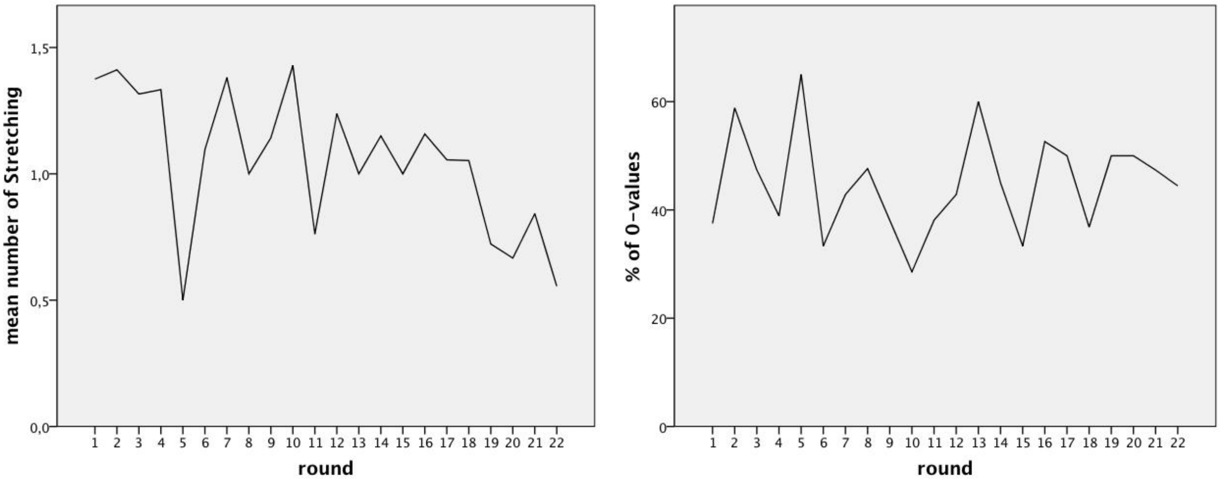


Figure 11: Left: Mean number of stretching behaviour with time on task (rounds) (means of individual measurements per round) Right: Percentage of periods without stretching behaviour (0-values) with time on task remained unchanged (n=21).Values represent % of the total sums of intervals measured in all drivers in a specific round.

Sex differences

As illustrated in Fig. 12, male and female drivers showed similar variable patterns of spontaneous behaviour expression over the first 22 rounds. In detail, male participants showed nearly no body expression during the 1st round (mean: 2.57; SD: 2.64) and a maximum during the 9th (mean: 7.4; SD: 7.49) and 11th (mean: 7.4; SD: 8.04) round. Women showed the fewest behaviour in the 2nd round (mean: 2.67; SD: 2.12) and had a maximum of 8.33 (SD: 6.87) in the 21st round. (Fig. 12) Although the spontaneous behaviour of both sexes combined had been shown to be significantly correlated with time on task (Fig. 3), breaking the data down into sex groups changed the pattern. The distribution of all examined behavioural categories did not correlate significantly with time on task in males (Pearson correlation: $r= 0.02$; $p> 0.828$), whereas in female participants these changes were significant (Pearson correlation: $r= 0.20$; $p< 0.01$). The percentage of periods without spontaneous behaviour was 0% in males during the 5th, 11th and 17th round. Females in contrast showed more burst of spontaneous behaviour like in rounds 2, 3, 5, 13 and 17. (Fig. 12) With regard to specific behaviours, female drivers showed no yawning in the first five rounds. This resulted in significant differences in the distribution of yawning between the first five rounds as compared to either five rounds after one hour (Mann-Whitney U-test: $p< 0.01$) or to the last five rounds (Mann-Whitney U-test: $p< 0.05$). Outside of these differences, there were no significant differences comparing the TPs within the Sexes. Male drivers did show a negative DV1 in yawning. In contrast DV1 was positive in female participants and caused a significant difference between men and women (Mann-Whitney U-test: $p< 0,05$). DV3 also showed a significant difference (Mann-Whitney: $p< 0,05$) between the Sexes.

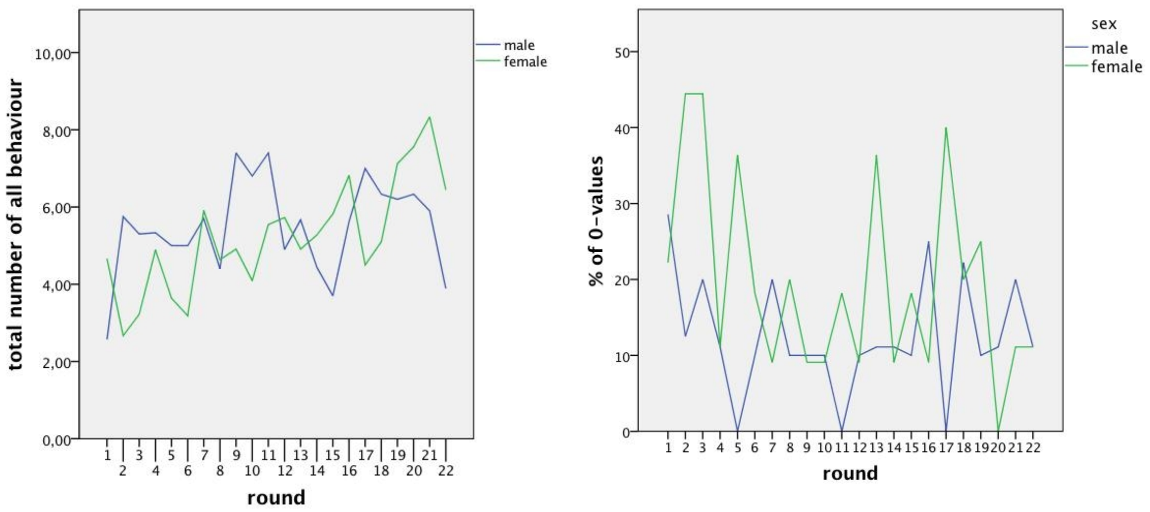


Figure 12: Left: The mean number of all analysed behaviour categories for males (n= 10) and females (n= 11) with time on task. (means of individual measurements per round) Right: The distribution of periods without any spontaneous behaviour (0-values) showed different time patterns in males and females.Values represent % of the total sums of intervals measured in all drivers in a specific round.

Comparison between nappers (NG) and non-nappers (NNG) – last five rounds

Comparisons between NG and NNG during the last five rounds revealed significant differences with less behaviour in the NG (Mann-Whitney U-test: $p < 0.01$). While the mean number of all behaviour categories in the NG remained low (between 1.00 in the 2^{nd} and 2.29 in the 5^{th} round), the NNG reached peak values shortly before the end in the 3^{rd} of the last five rounds (mean: 4.71; SD: 5.98). (Fig. 13)

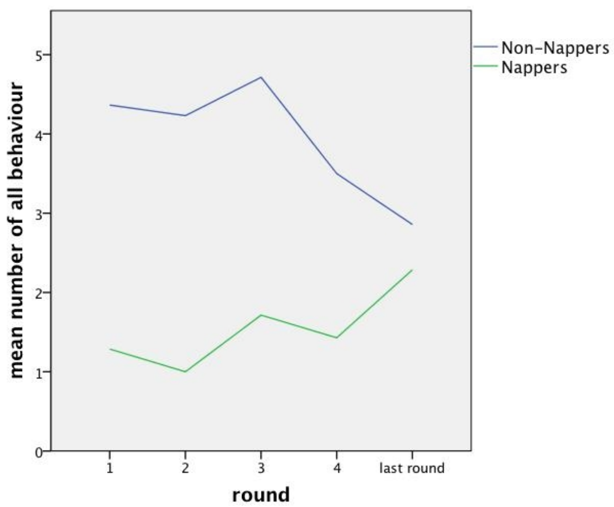


Figure 13: Comparison of all behavioural expressions between NG (n= 7) and NNG (n= 14) during the last five rounds. (means of individual measurements per round) Group differences are significant (Mann-Whitney U-test: $p < 0.01$).

Karolinska Sleepiness Scale

20 participants filled out the Karolinska- Sleepiness-Scale before and after the driving task. In eight subjects KSS-score improved after night-driving (Fig. 14). Among the NG, four participants rated themselves as being less tired at the end of the driving compared to the beginning, while three others had a higher KSS-score after driving. In the NNG, the ratio of participants who felt less and those who felt more tired at the end was 4:9. Before the driving task 17, after the task 13 participants rated themselves as not tired (KSS< 6) (Fig. 14).

Drivers with a KSS-score <6 showed significantly less behaviour in the last five rounds than the participants, who reported tiredness (KSS-scores between 6 and 9) (Mann-Whitney U-test: $p< 0.01$). The means in all behavioural categories during the last five rounds in subjects with low KSS-scores were always below the means of those with high KSS-scores. The analysis of the KSS development offers similar results. Fig. 14 illustrates that those participants, who had a higher KSS-score at the end of the driving task compared to the beginning showed significantly more behaviour than those drivers whose KSS-scores improved (the majority of the nappers, Mann-Whitney: $p< 0.01$).

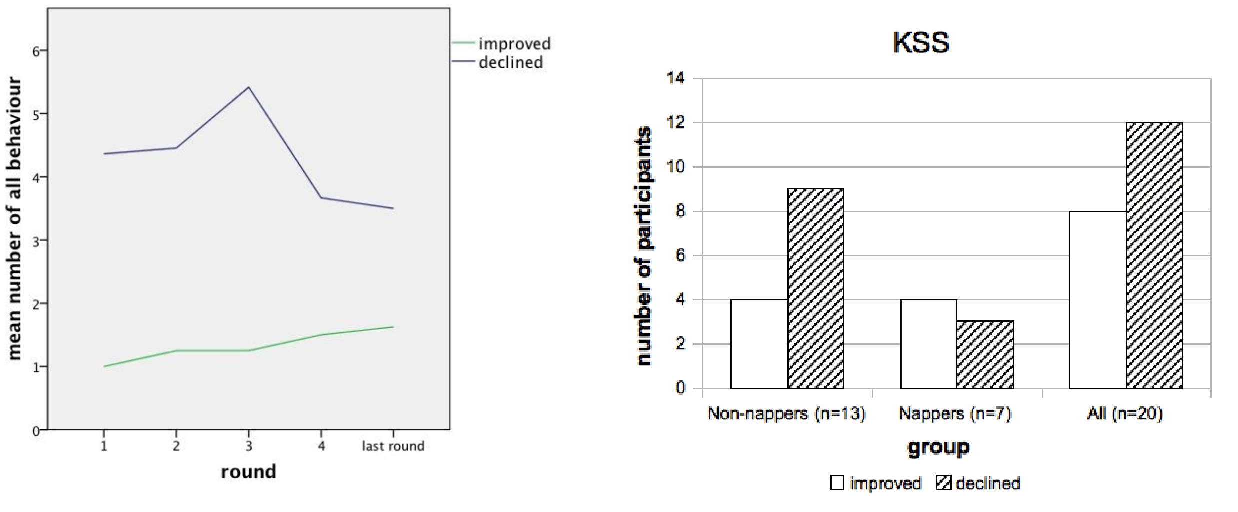


Figure 14: left: Comparison of the mean number of all examined behavioural categories during the last five rounds. The green line represents participants, who improved (n= 8) and the blue line illustrates participants, who declined their KSS-score (n= 12) (means of individual measurements per round). Drivers showing lower KSS-scores at the end of the task showed significant less behaviour (Mann-Whitney U-test: $p< 0.01$) Right: Distribution of the KSS-scores in the NNG (n= 13), NG (n= 7) and all drivers (n= 20). In the NNG more subjects rated their sleepiness higher after the driving task than before.

Alphabetical Cross-out Test (AD-test)

Comparing the results of the AD-test before and after the experiment, 11 out of 20 participants improved their performance, three in the NG and eight in the NNG. While more drivers without a break improved their performance in the AD-test (ratio 8:5), the ratio in the NG was only 3:4 (Fig. 15)

Subjects who improved their performance in the AD-test actually showed less behaviour during the last five rounds compared to those, without test-improvement. This result was, however simply a trend and not statistically significant (Mann-Whitney U-test: p= 0.456, Fig. 15).

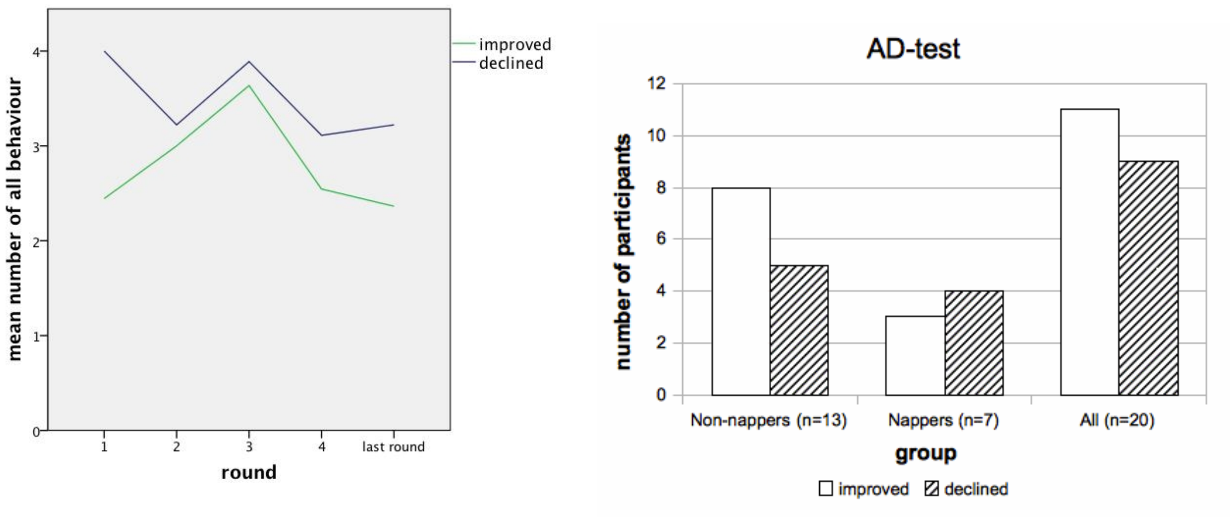


Figure 15: Left: Comparison of the mean numbers of all analysed behavioural categories during the last five rounds between drivers, who improved (n= 11) and declined performance in the AD-test (n= 9) (means of individual measurements per round). Right: Distributions of drivers with improved or declined AD-test performance in the NNG (n= 13), NG (n= 7) and NNG+NG (=All; n= 20). The test was conducted before and after the driving task.

Discussion

Behaviour, not directly associated with driving increased with time on task (Fig.3). Especially NdB's, individually (Fig. 4; Fig. 5; Fig. 6) or summed up (Fig. 7) showed a positive correlation with night-time driving. Yawning, a commonly known symptom of sleepiness, increased earlier than other behaviours like auto-stimulations or vocalisations, which may also serve as countermeasures to fight off sleep and stay alert (Nordbakke & Sagberg, 2007). In contrast to other NDB's, stretching did not increase during the experiment (Fig. 11). As shown in the results, postural-, head- and shoulder movement showed a negative correlation with time on task (Fig. 8; Fig. 9; Fig. 10). Moreover, all analysed behaviours varied during the experiment and did not decrease or increase continuously. A possible explanation for this is that tiredness behind the wheel is not a monotonous process. Hence, as already shown, drowsiness and performance varied over time (Hack et al, 2001). To distinguish between NDB and stretching has proven to be useful and may give a better insight in the development of spontaneous behaviour while driving. As head-, shoulder- and postural movements are often important for driving, the distinction between spontaneous and voluntary movements (as for driving a car) is not always clear. Therefor the quantification of movements without separating NDB and stretching behaviour may lead to imprecise results.

Typical driving behaviours (DB), such as steering wheel movements, large head movements or a change of posture and NDB (yawning, ASB, vocalisation) are randomly distributed during driving. If an individual gets tired, DBs decrease while NDBs such as vocalisations or ASBs increase to keep the body awake and stay alert (Fig. 16).

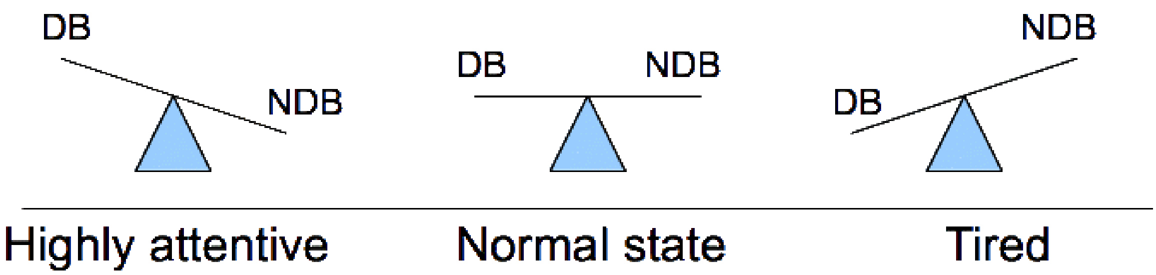


Figure 16: Behavioural model of being sleepy behind the wheel: In an alert state ("normal state") DB (necessary and directly associated with driving) and NDB (not directly associated with driving) are balanced. With increasing tiredness ("Tired"), DBs decrease and NDBs increase. The opposite happens in a state of high alertness ("Highly attentive").

Taking a nap in the middle of the night (3:30 a.m.) had a positive effect on subjective sleepiness (Fig. 14) and more drivers in the NG rated themselves as less tired after than before night-time driving (4 less: 3 more) compared to the NNG (4 less: 9 more). On the behavioural level, the NG moved significantly less after the break than the drivers without a break (Fig. 13). The same effect was observed with the KSS-scores (Fig. 14). Less spontaneous behaviour was detected in drivers, who rated themselves as not tired (KSS <6) or improved KSS-scores during the driving task compared to their 'tired' counterparts. Surprisingly, performance in the AD-test produced different results and puts a different perspective on the effects of napping. While more drivers in the NNG improved their performance in the AD-test (ratio 8:5), the opposite was found in the NG (ratio 3:4, Fig. 15). Recent findings indicate (e.g. Tremaine et al, 2010) that subjective and objective indicators of sleepiness may not always correspond and this mismatch may be enlarged by the inclusion of a night-nap. There is some evidence, that a nap at 3:30 a.m. only reduces subjective, not objective sleepiness. This might lead to dangerous situations of underestimating sleep pressure and a higher possibility of unexpected 'sleep-attacks'.

These findings contradict the traditional concepts of napping and recent studies, which claim a vigilance enhancing effect of a night-nap, coffee consumption or the combination of both (Philip et al, 2006; Menzin et al, 2001). Philip et al also reported that drivers, after taking a nap, performed better on a night-time highway driving task. Drivers were instructed to nap before, and not during the driving task. Moreover, a professional driving instructor was in the car and the driving performance was measured by the number of lane departures, which is claimed to be highly automatized behaviour (Tietze & Hargutt, 2001).

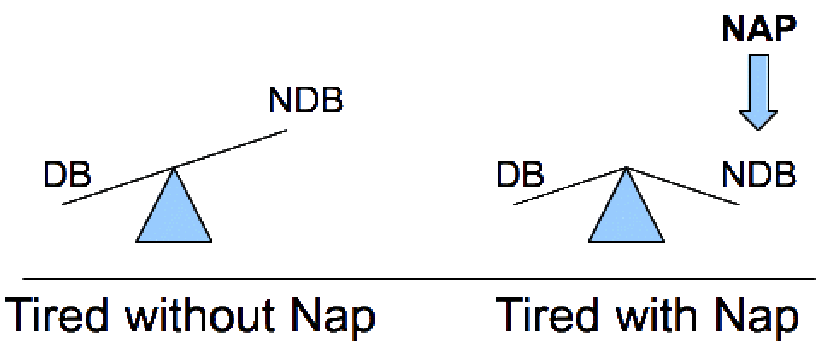


Figure17: Effect of a nap on drivers' behaviour and objective sleepiness. It is postulated that NDBs increase with tiredness. A nap reduces sleepiness subjectively and bears down the NDBs. This leads to an imbalance between DBs and NDBs as well as between subjective and objective sleepiness.

This thesis illustrates that a short sleep in the night may have negative effects on the awareness of sleepiness. It is postulated that a nap causes an imbalance between DB and NDB (Fig. 17). NDB, which probably is helpful to stay awake while driving is down-regulated after a nap, as well as subjective ratings of sleepiness.

Because of the high inter-individual variability the standard deviations within the groups were high and group comparisons did not show any significant results. As a matter of fact people behave differently, even more when they are sleepy. Therefor forming groups based on single or fixed criterions may not be effective, especially with drowsy drivers. (Liu et al, 2009). What works for one individual, may not automatically work for the other, especially on the level of behavioural compensation of drowsiness. While most participants showed more spontaneous behaviour during night-time driving, others didn't. A generalisation is desirable but not possible. Therefor, further investigations should take a more detailed look at each single individual and their behaviour. In addition, if every driver carried out the driving task two times, once in the afternoon with low sleep pressure, and once at night, with high sleep pressure, the interactions would be easier to generalize and interpret.

In this study, all participants were volunteers. It might be possible, that they didn't act like 'normal' drivers would in an everyday live-driving situation. Motivational aspects may have an essential role on driving behaviour or objective measures such as attention, concentration and reaction time (Horne & Burley, 2010). Also the foreknowledge of the driving condition (drivers knew in advance if they participate in the NNG/NG) may have influenced several parameters. To exclude these confounders, participants shouldn't be informed a priori about the driving condition.

It is claimed that various physiological measures only show poor associations with each other (Horne & Reyner, 1999) and therefor tiredness behind the wheel can't be described with one single measure. A combination of physiological-, subjective- and objective measures seems to be the best way to predict sleepiness behind the wheel (Liu et al, 2009). This study shows that quantifying spontaneous behaviour to describe the transition from being alert to falling asleep behind the wheel is entirely useful. The question of whether tiredness causes spontaneous behaviour or the absence of these behaviours leads to tiredness is an extremely important question which has to be addressed more detailed. There is evidence that the more tired a person is, the more spontaneous behaviour is shown. Taking a nap doesn't seem to mitigate the situation. While drivers feel less sleepy after a nap, their performance didn't improve objectively. In fact, more drivers in the NG were less attentive and concentrated during psychometric testing than those in the NNG (Fig. 15). The reason for this may be a down-regulation or decrease in spontaneous behaviour. The fact, that participants with lower KSS-scores (as compared to pre-test condition) showed significantly less spontaneous behaviour than drivers whose KSS-scores decreased during night-time driving (Fig. 14) strengthens the assumption that spontaneous behaviour is more associated with subjective than objective sleepiness. Further investigations should also examine the interaction between subjective and physiological/objective sleepiness, with and without a nap.

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Appendix

List of abbreviations

AD-test=Alphabetical Cross-out Test

ASB= Auto-stimulative behaviour

ASFINAG=Autobahnen- und Schnellstraßen-Finanzierungs-Aktiengesellschaft

DB=Driving behaviour

D-MEQ=Morningness-Eveningness-Questionnaire (German Version)

DV=Delta value

EEG=Electroencephalography

EOG=Electrooculography

F=Female participant(s)

ISWF=Institut für Schlaf-Wach-Forschung

KSS=Karolinska Sleepiness Scale

M=Male participant(s)

N=Napping group

NDB=Non-driving behaviour

NN=Non-napping group

NHTSA=National Highway Traffic Safety Administration

ÖAMTC=Österreichischer Automobil-, Motorrad- & Touring Club

PERCLOS=Percentage of eyelid closure

PVT=Psychomotor vigilance test

REM=Rapid eye movements

SEM=Slow eye movements

SRVA=Sleep related vehicle accident

SSS=Stanford Sleepiness Scale

SWM=Steering wheel movement

TP=Time-period

TUBS=Technical University of Berlin Scale

Karolinska Sleepiness Scale (KSS) - Questionnaire

ID Nr.:_______________________________ Uhrzeit _____________

Vor der Testung: ∑ Nach der Testung: ∑

SCHLÄFRIGKEITSSKALA (KSS)

Wie schätzen Sie Ihre Wachheit momentan ein? Markieren Sie bitte die entsprechende Zahl:

1. ***Äußerst wach***
2. ***Sehr wach***
3. ***Normal wach***
4. ***Ziemlich wach***
5. ***Weder wach noch schläfrig***
6. ***Etwas schläfrig***
7. ***Schläfrig, ohne Mühe wach zu bleiben***
8. ***Schläfrig, etwas Mühe wach zu bleiben***
9. ***Schläfrig, große Mühe wach zu bleiben***
10. ***Äußerst schläfrig, kann nicht wach bleiben***

Alphabetical Cross-out-Test (AC-Test)

ALPHABETISCHER DURCHSTREICHTEST (AD-Test)
(J. Grünberger)

ID.Nr.: __________ Datum: __________

1.Testung: 2.Testung:

Beispiele: A N E Y / O G A Y / E N R L / L O R G

Probe:

O E R G V N G A L P R N G O S L R R E H L Y A G T L N N Y K O E Y A B O Y E A Z

5 10 15 20 25 30 35 40

GM	
F	
GM-F	
SV	
F%	

	1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8 9 20 1 2 3 4 5 6 7 8 9 30 1 2 3 4 5 6 7 8 9 40	GM	F
1.	R N E Y P L R Y G V L G N G C L R O A Z O R Y Y W L E A E X A O N G T O E N A H		
2.	Y A O L U N R O O B N E R Y S E Y L A K O R G E D L A G A I G Y R G H N N L E F		
3.	E N G N X A L Y A H A Y G E B A O Y E V R L G O N R L Y R C O E F N Z L O G R T		
4.	O F A Y P O G R E H L R A O U G N R E W O G Y A S E N L R Z N L E L I A Y N Y F		
5.	Y N L O Z Y E G A X Y A E L S A G N R C R L Y N W O A E R U O G L G P N O R E D		
6.	N G L G K N O Y R H O E L G T R Y R E I N G L Y F N L E A H A O E R X A Y O A B		
7.	Y R O E D L Y A R I E N G A T N E L R Z G N A L X O Y E L W O O A N H Y G R G C		
8.	R L N E V R L A O U A Y Y G B L E A N H R G O E K N N G O S Y Y O A P G R E L F		
9.	G R E E P G O N O T G E A Y H O R Y E F N Y A G I L N A Y U R L L A C N L O R Z		
10.	L Y L A D N A A N H G Y O N K L R G N S Y G O O X E Y E O B R E O E W A L R R V		
11.	E G A O Z L R O R S Y A O L K N Y N R T Y O L G H A E N G P A E G L X R N E Y C		
12.	E O G R B Y E A A H G R E O V L N Y O I N Y L E U R N G O W G L A A F R L Y N D		
13.	Y N E A F G N A L C C R O O S R E L Y K G L R A P Y X G N K O E E N Y L A O R H		
14.	O O Y G D A O A R H A A N Y B R E N E T L R G R U N Z L L W E O G Y N E L G Y I		
15.	N E R N P G G O O X A L R N S Y Y R N C A L Y G H A A R E B Y E E O V L G L O D		
16.	G O O G I E E R E W L Y A R T L R O Y U R N E N F A G A O H L Y G N Z A Y N L K		
17.	R L G Y F A N Y R D E N R O W L Y G G P O R A O H Y E E E I G O N L U A L A N H		
18.	N E L O X R N A E Z L O Y G T O N Y R S Y L E Y K N A A G B O E R L C G G R A V		
19.	O R G E F L A O Y X N A O X H N G X G Z E R Y R H O N R E C A L E L U A L G N Y		
20.	A D E Y B G O A Y N N L G A I L E Y G K O O R N T Y R O A W L R E N S R L G E P		

Abstract

Sleepiness while driving is an underrated risk. Between 1.2% (USA) and 8.4% (France) of road crashes have been directly related to falling asleep behind the wheel. The actual incidence of it being compounding factor in accidents is certainly higher. To this, age, extent of sleep deprivation, duration of drive and time of day can contribute to the actual risk for a sleep related vehicle accident (SRVA). In real situations drivers often employ countermeasures, such as self-stimulating behaviours or naps to alleviate the fatigue. In the present study, 21 participants were asked to drive two hours on a test track in the middle of the night (2 a.m. - 4:30 a.m; depending on condition). One group (n= 14) drove without interruption and the other group (n= 7) was allowed to rest or nap for half an hour after 90 minutes before driving another 30 minutes. Behaviours, not directly associated with driving (spontaneous behaviours) were analysed. In addition subjective sleepiness (Karolinska Sleepiness Scale: KSS) and objective assays on attention and concentration (Alphabetical Cross-out-test: AD-test) were conducted before and after the experiment. The results indicate that spontaneous behaviours increase with time on task and act as a self-stimulating countermeasure to sleepiness. Furthermore participants, who took a nap showed less behaviour after the break and rated themselves as less tired compared to the beginning and the non-nappers. On the level of attention and concentration (AD-test) the nappers performed worse than the non-nappers after the driving task. This indicates that a nap at 3:30 a.m. seems to have positive effects on subjective but not objective sleepiness and therefore may increase the risk of a SRVA.

Zusammenfassung

Müdigkeit am Steuer ist ein ernst zu nehmendes und unterschätztes Risiko. Zwischen 1,2% (USA) und 8,4% (Frankreich) aller Verkehrsunfälle können direkt auf Müdigkeit zurückgeführt werden. Alter, Wachzeit, Dauer der Fahrt und Tageszeit spielen dabei eine wesentliche Rolle. Um aufmerksam und wach zu bleiben muss der aufkommenden Schläfrigkeit etwa durch selbst-stimulierendes Verhalten oder einer Pause mit kurzem Schlaf (Nap) entgegengewirkt werden. In der vorliegenden Studie wurden diese Gegenmaßnahmen untersucht, indem Versuchspersonen 2 Stunden auf einer Teststrecke zwischen 2Uhr und 4Uhr/4:30Uhr nachts fuhren. Während eine Gruppe (n=14) die gesamte Fahrzeit auf der Strecke blieb, musste eine zweite Gruppe (n=7) nach 90-minutiger Fahrt eine Pause mit Nap von 30 Minuten einlegen um die Fahrt anschließend weitere 30 Minuten fortzusetzen. Spontan auftretende Verhaltensweisen wurden anhand von Videoaufzeichnungen ausgewertet. Weiters wurden die Teilnehmer vor und nach der Fahrt gebeten, ihre momentane Müdigkeit (Karolinska Schläfrigkeits-Skala (KSS)) zu bewerten (subjektive Müdigkeit) und einen Test zur Bestimmung der objektiven Müdigkeit (Alphabetischer Durchstreich-Test (AD-Test)) durchzuführen. Auf Ebene der Verhaltensweisen kam es während der Fahrt zu einer Zunahme der gezeigten Verhaltensweisen. Weiters zeigten die Teilnehmer mit 'Schlafpause' im Vergleich zur Gruppe ohne Pause in den letzten sieben Runden weniger spontan auftretendes Verhalten und beurteilten ihre Müdigkeit als weniger stark ausgeprägt. Im AD-Test erzielten die Durchfahrer jedoch bessere Ergebnisse als die Napper. Diese Resultate deuten darauf hin, dass eine Unterbrechung mit Nap während einer Nachtfahrt einen positiven Einfluss auf die subjektive-, nicht jedoch auf die objektive Müdigkeit hat und dadurch adäquate Gegenmaßnahmen wie selbst-stimulatorische Verhaltensweisen unterdrückt werden.

Curriculum vitae

Personal information

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Education

Since 09/2008	Diploma study in Zoology at the University of Vienna
10/2006 – 09/2008	Diploma study in Biology at the University of Vienna
10/2005 – 10/2006	Civilian Service at the Austrian Red Cross
10/2004 – 10/2005	Diploma study in Communication sciences at the University of Salzburg
09/1996 – 06/2004	BRG Hamerlingstraße, 4020 Linz
09/1992 – 06/1996	VS Ennsdorf, 4482 Ennsdorf

Working Experience

2012	Employee at the Clever Dog Lab, VetMed Vienna for Video analysis
Summer 2011	Assistant in a study on the population of *Microtus bavaricus*
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September 2009	Employee at the Ars Electronica Festival 'Human Nature'

Skills

Languages:	German - native speaker
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	SPSS Statistics
	Solomon Coder
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