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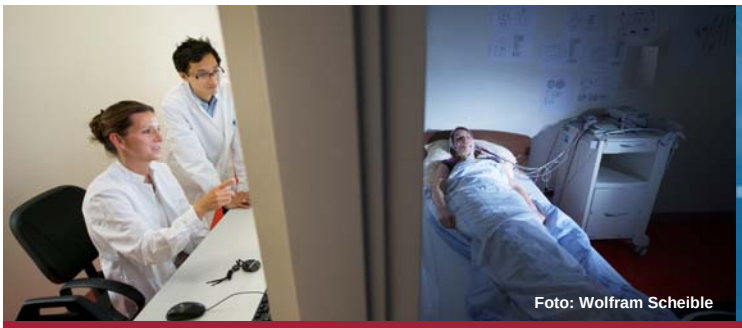

Memory & Consciousness:

Plasticity, Brain Rhythms and Sleep

ABSTRACTS

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The benefits of targeted memory reactivation are contingent on both the strength and type of newly-formed memories

Recent studies have suggested that memory consolidation can be enhanced by exposing individuals to auditory or olfactory memory cues during slow-wave sleep (SWS), a process known as targeted memory reactivation (TMR). Here, we examined the impact of auditory TMR for both visuo-spatial associations and paired associates, and whether such effects depend on memory strength at encoding. Participants learned 50 picture-word associations, before encoding a screen location and semantically-related sound for each of the pictures. During a subsequent nap, half of the sounds were replayed in SWS before participants carried out a final test phase. TMR reduced visuo-spatial memory decay between training and test, but only for picture-locations that were moderately well remembered prior to sleep ($p = 0.014$). Paired associates did not benefit from TMR, irrespective of pre-sleep performance. These findings suggest that the effects of TMR may be contingent on both memory type and strength prior to sleep.

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Emotional modulation of pain processing in dental phobia: Dissociation of somatosensory evoked potentials and subjective pain perception

Most people associate the visit to the dentist with discomfort or negative feelings. The recent study investigated the modulation of somatosensory pain perception by emotional sounds in patients with dental phobia and healthy controls. To this end, 24 dental phobic patients and 24 healthy controls were exposed to emotional sounds. Meanwhile, short painful electrical stimulation was administered. Electrophysiological results showed decreased somatosensory evoked potential (SEP) amplitudes regarding to the components N150 and P260 in dental phobic patients compared to healthy controls independent of the simultaneously presented sound. On subjective level, however, patients perceived electrical stimulation most painful whenever a phobia-related sound was presented. Conversely, healthy controls rated electrical stimulation on the same pain level whenever they listened to a negative or dental-related sound. The study emphasizes the influence of environmental stimuli on attention and pain perception in phobic patients and healthy participants.

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Sleep deprivation impairs and sleep supports the consolidation of fear extinction memories

Understanding how emotional memories are consolidated is crucial to improve treatment of several psychiatric disorders. Because sleep has an important role in learning and memory consolidation, we hypothesize that sleep also supports the consolidation of fear extinction memories. We subjected mice during their resting phase, to auditory fear conditioning and extinction. Mice with undisturbed sleep following the extinction training, presented good retrieval of fear extinction memory. On the other hand, mice, which were sleep deprived in the first 5 hours following extinction training, failed to show fear extinction retrieval. Moreover, animals trained during their active phase (spontaneous awake) show only a trend in reduced fear expression during extinction retrieval. These results suggest that sleep deprivation impairs, and sleep supports the consolidation of fear extinction memories. Next, we plan to correlate sleep time and patterns with efficacy of extinction memory retrieval, and investigate the underlying cellular mechanisms.

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Visual deprivation has local effects on EEG spectral power density during sleep

The synaptic homeostasis hypothesis provides an elegant model for how wake synaptic strengthening is balanced during sleep by slow wave activity (SWA) dependent downscaling, proposing that local differences in synaptic strengthening across the brain are reflected in local differences in SWA. To test this model, we blindfolded subjects for 12 hours and measured SWA during the following night. Our hypothesis was that total visual deprivation would decrease occipital SWA, since lowering of input to the visual cortex would locally minimize synaptic strengthening during wake and thus reduce SWA. Contrary to expectations, we found that depriving a sensory input increased SWA in the brain area receiving that sensory information, casting light on the complexity of brain function during sleep, and the difficulties in testing even the most elegant models.

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Cortisol synthesis suppression alters emotional and neutral memories

Suppressing cortisol synthesis inhibits memory retrieval, in particular for emotional material. We investigated the conditions of this retrieval impairment to occur and whether it persists over time. In a crossover study 18 men retrieved emotional and neutral texts and pictures (learned 3 days earlier) 30 min after morning awakening, when cortisol levels are naturally high, following administration of 1g of the cortisol synthesis inhibitor metyrapone or placebo. Metyrapone-induced cortisol suppression significantly impaired free recall of emotional, but not neutral texts. One week later, participants still showed decreased retrieval for emotional texts. In contrast, memory retrieval for pictures did not differ between the metyrapone vs. placebo condition and likewise was not different 1 week later. Of note, the retrieval of pictures took place one hour after memory retrieval of texts. At the time of retrieval of texts, cortisol and ACTH levels were more different between the metyrapone and placebo condition compared to the time of retrieval of pictures. These data suggest that cortisol levels need to be sufficiently suppressed for metyrapone to affect emotional memory retrieval and its reconsolidation.

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Memory systems interactions evolve over sleep

It has been suggested that beyond stabilization and enhancement, sleep also changes the quality of memory traces. We tested whether sleep influences performance and brain activity, indicating a transformation of memory in multi-item rule extraction. Participants learned a feedback-driven classification task and acquired explicit (item knowledge) and implicit memory (rule proficiency). After learning, participants either slept or stayed awake. Over sleep, the structure of memory changes, making explicit and implicit representations independent from each other. This change is reflected in better memory performance. This is related to stronger recruitment of implicit memory-associated structures, like the caudate nucleus, during an explicit item recognition memory task in sleepers. Stronger recruitment of the hippocampus, which is usually associated with explicit memory, is found in implicit rule memory transfer. In a cooperative task, using explicit item knowledge and implicit rule proficiency, the sleep group showed higher activation in both the hippocampus and the caudate nucleus and an increased connectivity between these structures. Sleep induces cooperation of explicit and implicit memory systems and changes the memory structure leading to improved performance.

Poster

A1

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Effects of D-cycloserine given during sleep on the consolidation and the learning of declarative memory

Sleep has beneficial effects on consolidation and subsequent learning of declarative memory. However, the neurochemical processes remain elusive. In the hippocampus, long term potentiation (LTP) is mediated by N-methyl-D-aspartate-receptors (NMDA) containing the NR2A subunit and long term depression (LTD) by receptors containing NR2B. The NMDA-receptor co-agonist D-cycloserine (DCS) preferentially acts through NR2A containing receptors favouring LTP over LTD. DCS aids sleep-dependent memory consolidation but may perturb subsequent new learning. In a double-blind, placebo-controlled, balanced crossover study participants learned two lists of word-pairs and then orally received DCS or placebo before sleeping 8 hours. The next evening, they learned two new lists of word-pairs, one list was composed of completely new word-pairs, the other of cues taken from one of the original lists which were paired with a new word (interference list). Afterwards, participants were asked to retrieve the original word pairs learned before sleep. Preliminarily results (n=8) will be presented.

A2

Barner C, Born J, Diekelmann S

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Can sleep improve memory consolidation for completed intentions?

Recent studies report that sleep enhances the consolidation of prospective memories (i.e. intentions for the future). Here, we ask whether completed intentions still benefit from sleep and, if not, whether they can be reinstated for sleep-dependent consolidation. In a first experiment, subjects encoded an intention which they had to execute 1.5 hours later while they were engaged in an ongoing task. After completing the intention they were allowed to sleep or stayed awake during the following night. When participants unexpectedly had to complete the task two days later again, the sleep and the wake group did not differ significantly in performance. In a second experiment, the instruction was reinstated after the first completion of the task. Surprisingly, this was not sufficient to make the intention become sensitive to sleep-dependent consolidation again. Further experiments are planned to reveal whether and under which conditions completed intentions can be reinstated for sleep-dependent consolidation.

A3

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Disentangling sleep, memory, and emotion

Emotional memories are preferentially consolidated during sleep. It remains unclear, however, whether or not sleep increases or decreases the emotional tone of a memory, and how memory strength relates to emotional tone. Our research aims to investigate these questions using a battery of methods measuring emotional response (self-report, skin conductance (SCR), heart rate (HRD), and evoked potentials (LPP)), the integration of which may be key to understanding the complex relationship between sleep and emotion. By using a delayed recall task with two separate recognition sessions (12 hours and 1 week), we hope to not only examine the acute effects of sleep on emotion and memory, but also long term effects. Preliminary skin conductance findings suggest sleep leads to a progressive decrease in emotional tone over time. Pilot heart rate data is being processed and will also be presented.

[* equal contributions]

A4

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The influence of music on memory consolidation and EEG signals

Music has been shown to have an influence on cognitive function, specifically in the realm of spatial memory performance (the "Mozart Effect"). It has additionally been shown that the replay of stimulus-associated auditory cues during a sleeping rest period following learning can facilitate memory consolidation. Here, using a non-spatial face-memory paradigm, we tested whether this effect exists with stimulus-associated music and a wakeful resting period. Additionally, EEG data was collected to investigate the influence of music on resting-state oscillatory rhythms. This work is part of a Master's thesis at the University of Bonn.

A5

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To sleep perchance, to dream; but will you remember? The role of vivid dreams and nightmares in the memory consolidation of an associative cognitive task

Understanding of why we dream still remains elusive in research. Our study aims to investigate whether participants who frequently experience vivid dreams or nightmares will perform better in an associative learning task than participants who seldom remember their dreams. We recruited 120 participants (half frequent and half infrequent dreamers) who completed and then repeated a Number Reduction Task over a 12 hour period, either with or without a bout of sleep during the interval, with random allocation to these conditions. Within the task is a “hidden rule” to allow for a speedy task completion. We hypothesize that of those who discover the hidden rule, a higher proportion of participants will have both slept and frequently experience vivid dreams. These observations would suggest that those who frequently experience vivid dreams and nightmares are more associative in nature and therefore more likely to identify common patterns when solving associative cognitive tasks.

A6

Dittrich L[1], Heiss JE[2], Warrier DR[2], Morairty SR[2], Kilduff T[2]

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Cortical nNOS/NK1 neurons as a neuronal substrate for homeostatic sleep regulation

Periods of prolonged wakefulness are followed by longer and/or deeper sleep, a phenomenon known as sleep homeostasis. We have found that cortical interneurons immunoreactive for neuronal nitric oxide (nNOS) and the neurokinin-1 receptor (NK1) express the activity marker Fos selectively during sleep. To test if these neurons are involved in sleep homeostasis, we systematically varied sleep pressure and -amount in rats, and quantified Fos expression. We found that the occurrence of sleep is necessary but not sufficient for the activation of nNOS/NK1 neurons. Rather, once the rat is asleep, these neurons are activated in proportion to the amount of sleep pressure that has accrued during the preceding wakefulness. To test if these neurons are causal for physiological processes occurring during recovery sleep, we studied nNOS-knockout mice. These mice showed a strongly attenuated sleep-homeostatic response. Our findings support the hypothesis that cortical nNOS/NK1 neurons translate sleep pressure into a homeostatic response.

A7

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Self-regulation of neuronal oscillations for brain-computer interfaces

We investigate the possibility of using self-regulation of neuronal oscillations for Brain-Computer Interfaces in order to enable basic communication for locked-in patients. For example, a volitional increase in the amplitude of neuronal oscillations may be used to communicate a “yes”, while a decrease may signal a “no” response to a question. In this work, we train ALS patient to self-regulate brain oscillations in gamma range (55-85 Hz) by means of individually adjusted online neurofeedback. For on-line decoding we use a linear support vector machine classifier, trained on all patient\'s electroencephalographic data. Off-line decoding accuracy is then estimated by linear classification of data in a leave-one-trial-out cross-validation procedure. However, there remains a question whether locked-in ALS patients remain conscious. We are going to address this question in the future work by monitoring changes in the coherence between dipoles forming Rest State Networks.

A8

Forcato C, Weber FD, Born J, Diekelmann S

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Reactivation during sleep stabilizes declarative memories independent of the type of reminder

Memory reactivation exerts different effects on declarative memories depending on whether reminders are presented during wakefulness or sleep. In the wake state reactivation labilizes memories requiring reconsolidation, whereas reactivation during sleep promotes memory stabilization. Here we tested whether only those reminders that induce labilization during wakefulness promote memory stabilization during sleep. In experiment 1, we show that only one of two different reminders labilizes memories during wakefulness. In experiment 2, both types of reminders were presented during slow wave sleep (SWS) within a 40-minute sleep period. Contrary to our hypothesis, during SWS both reminders produced memory stabilization compared to a no reminder condition. For the reminder that labilized memories during wakefulness, stabilization during sleep was associated with increased fast spindles. We propose that certain boundary conditions, which exist for memory labilization-reconsolidation during wakefulness, do not exist during sleep, suggesting that memory reactivation during wakefulness and sleep serves different adaptive functions.

A9

Hettich DT[1], Bolinger E[1], Matuz T[1], Birbaumer N[1,3], Bogdan M[1,2], Rosenstiel W[1]
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Classification of affective states in EEG during processing of emotional sounds in healthy individuals

To express and to understand emotions secures not just survival but also well-being in everyday life. Human communication and therefore decision-making strongly depends on emotions. Brain-computer interfaces (BCIs) provide disabled or paralysed individuals lacking oral communication with a communication channel that does not depend on muscle activity. The recent field of affective computing seeks to augment BCIs by integrating information about the users' affective states or workload contained in their physiological signals. Employing machine learning and an individual feature extraction method, this work describes the automatic classification of three affective states, i.e. unpleasant, neutral, and pleasant, in an auditory emotion induction paradigm of electroencephalogram (EEG) data in a healthy population. The data show that above chance classification is feasible in a two- (unpleasant, pleasant) and three-class (unpleasant, neutral, pleasant) problem using individual inter-hemispheric event-related de/synchronisation features in a support vector machine classifier.

A10

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Large-scale cortical correlation structure of spontaneous oscillatory activity

Little is known about the brain-wide correlation of electrophysiological signals. Here we show that spontaneous oscillatory neuronal activity exhibits frequency-specific spatial correlation structure in the human brain. We developed an analysis approach that discounts spurious correlation of signal power caused by the limited spatial resolution of electrophysiological measures. We applied this approach to source estimates of spontaneous neuronal activity reconstructed from magnetoencephalography (MEG). Overall, correlation of power across cortical regions was strongest in the alpha to beta frequency range (8-32 Hz) and correlation patterns depended on the underlying oscillation frequency. Global hubs resided in the medial temporal lobe in the theta frequency range (4-6 Hz), in lateral parietal areas in the alpha to beta frequency range (8-23 Hz), and in sensorimotor areas for higher frequencies (32-45 Hz). Our data suggest that interactions in various large-scale cortical networks may be reflected in frequency specific power-envelope correlations.

A11

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Sleep pattern in mice with suppressed interleukine-6 trans-signaling in the central nervous system or in the periphery

IL-6 is a cytokine implicated in the immune response. IL-6 can act on cells through two different pathways: classical, and trans-signaling. It is possible that both pathways have different roles in sleep regulation. The goal of this study was to characterize sleep in mice with suppressed IL-6 trans-signaling in periphery (PEPCK) or in the central nervous system (GFAP), compare them with wild type mice (WT), and thus to learn about the role of IL-6 trans-signaling in sleep regulation. Sleep parameters were characterized during 24-hour period of normal sleep/wake cycle. We found higher proportion of wake in the second part of light (inactive) period in PEPCK mice; higher proportion of slow wave sleep within sleep in the second part of light (inactive) period in PEPCK mice; delayed decrease of spindle density during dark (active) period in PEPCK mice; and increase in theta power in GFAP mice.

A12

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Early to bed, better to prescribe? Prospective memory performance in medical students after sleep extension or reduction

Remembering to execute a delayed action (e.g., to post a letter after work) is a cognitively challenging task and such prospective memory goals are often unsuccessful. Yet, there is surprisingly little consideration of the role of consolidation processes that underpin prospective memory. A positive role for sleep in prospective memory execution has been found (Scullin & McDaniel, 2012; Diekelmann et al, 2013). This is potentially important in clinical settings where sleep is often disrupted. An early (10pm) or late (2am) bedtime was manipulated with 40 medical students the night after encoding a prospective memory goal and the subsequent night. Participants monitored for names of familiar non-penicillin antibiotics during several ongoing cognitive tasks (lexical decision, semantic decision; living/non-living) simulating the cognitive demands of clinical settings. Penicillin containing semantic lures were also presented. Multiple linear regression revealed a significant positive relationship between amount of sleep and prospective memory performance. Those who went to bed early detected significantly more critical targets in all three tasks (all $p<.05$). However, erroneous key presses for 'lures' also increased ($p<.05$). Good sleep promoted target detection but the relationship between sleep and the ability to make fine-grained discriminations between categories (e.g., type of antibiotics) requires further exploration.

A13

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Tracking the time-course of novel word learning and lexical competition in adults and children: A visual world eye-tracking study

The integration of novel and existing word knowledge benefits from sleep in adults (Dumay & Gaskell, 2007) and children (Henderson et al., 2012). However, immediate lexical integration has been shown in adults when pictures were trained alongside phonology (Leach & Samuel, 2007). Here, a visual world paradigm was employed with 42 adults and 40 children (aged 7-8) with lexical integration for novel word-picture pairs (e.g., biscal) indexed by competition with their existing basewords (increased looks to biscal upon hearing biscuit). Pairings learned both immediately prior to testing and the previous day exhibited significant competition effects relative to untrained controls suggesting immediate integration. However children, not adults, demonstrated further enhancement for those learned prior to overnight sleep. In contrast, explicit memory benefitted significantly from overnight consolidation for both. The results concur with recent research suggesting sleep boosts some aspects of learning for children more than adults (Wilhelm et al., 2013).

A14

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Sleep mentation reflects memory reactivation

Sleep and its beneficial role for cognition have recently come into the focus of research. It has been shown that sleep benefits memory consolidation via a process of trace reactivation. Sleep mentation has been suggested to mark memory reactivation. This has so far only been discussed in the context of hypnagogic imagery during sleep onset. The aim of the present study was to investigate the influence of memory tasks on dreaming during more consolidated sleep. We hypothesized that task-related sleep mentation would occur also in deeper sleep stages, marking memory reactivation. 20 participants did a picture-learning task before falling asleep while listening to an audiobook. Subjects were awoken after each 90-min sleep cycle and questioned about their dreams. Dream reports could later be successfully matched with the corresponding task conditions (learning task, audiobook) by three blind and independent raters. This strongly supports that dreams reflect memory reprocessing during sleep.

A15

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Sleep facilitates declarative memory consolidation in infants

Human infants devote the majority of their time to sleeping. Yet, very little is known about the role of sleep in early memory processing. Here we test 6- and 12-month-old infants' declarative memory for novel actions after a 4-hour (Exp. 1) and 24-hour delay (Exp. 2). Infants in a nap condition took an extended nap (> 30 min.) within 4 hours after learning whereas infants in a no-nap condition did not. A comparison to age-matched control groups revealed that after both delays, only infants who had napped after learning remembered the target actions at the test. Additionally, after the 24-hour delay, memory performance of infants in the nap condition was significantly higher than that of infants in the no-nap condition. These results show that sleep has an enhancing role in the consolidation of declarative memories in the first year of life.

A16

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Sleep benefits children's episodic memory

A recent study in human adults indicated sleep's beneficial role for consolidating "what-where-when" episodic-like memories comparable with previous experiments in rats. Using the same paradigm we investigate, if advantages of deeper and longer sleep in school children (8-11 yrs.) further impacts episodic memory consolidation. Children experienced two short episodes one hour apart, each comprising four distinct female faces at different locations in a 3x3 grid on a PC screen. After encoding, children either slept overnight (n=10), or stayed awake during the day (n=6). Following a retention of ~10.5 h, episodic (-like) memory performance was tested by tracking eyes and explicit questionnaires. Like in adults, explicit "what-where-when" memory performance was more than twice as high in children that slept, while both groups had above chance performance. Likewise, separate explicit "what-when" memory was above chance only for the children that slept. Unlike adults, it seems that sleep's benefit in children was more evident in a higher performance for separate explicit memory components of "what" and "what-where". The implicit eye-tracking measures are less clear. However, our preliminary findings speak for minor differences between the benefits of children's vs. adults' sleep on explicit episodic memory, that might only be bared by comparing separate memory components or more sensitive eye-tracking measures.

A17

Niethard N, Inostroza M, Sato T, Born J

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Sleep dependent reorganization of neocortical microcircuits

The role of sleep in memory consolidation is a major question in neuroscience. In this context, the present study aims at exploring functional and morphological changes in motor cortex and prefrontal cortex cells related to inhibitory memory representations. Two-photon imaging offers a unique method to investigate these changes on a cellular level in vivo. However, it remains a challenge to train animals under head-restrained conditions. The present study reports techniques for training head-restrained mice to perform a Go-NoGo discrimination task in order to investigate functional and morphological changes of memory representations between pre-sleep learning and post-sleep retrieval. These methods offer the possibility to study spine formation and neuronal activity in the motor cortex and the prefrontal cortex during sleep. In the later course of this study this will be used to investigate task related changes in these brain areas.

B1

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Spindle activity during sleep slow oscillations

Sleep spindles are electrophysiological oscillations that occur in all mammalian species during Non-REM sleep. Spindles occur in the neocortex and hippocampus and have repeatedly been associated with memory consolidation. The timing of their occurrence can be biased by concurrent neocortical slow oscillations (wide-spread waves right below 1 Hz). In this study, we aim to investigate the spatial and temporal interplay of slow oscillations and sleep spindles. Slow oscillation events were algorithmically detected in the EEG of 12 subjects during Non-REM sleep. Time-frequency analysis centered around detected slow oscillation down peaks was performed on concurrent MEG recordings. Moreover, we used adaptive spatial filtering on the MEG data to localize cortical sources of spindle activity co-occurring with slow oscillation events. The grouping of spindle activity by slow oscillations shows remarkable resemblance to existing EEG literature. Concerning the sources of this spindle activity, we find highly variable localizations, both within and across subjects. Despite this variability, slower spindle activity (9-12 Hz) consistently occurred more frontally while fast spindle activity (12-15 Hz) was higher over central areas. A number of further analysis steps are ongoing to investigate cortical activity in other frequency bands.

B2

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The modulation of sleep continuity by periodical transcranial direct current stimulation

Background: Oscillating transcranial direct current stimulation (tDCS) at the prefrontal neocortex during sleep promotes a transient increase of slow wave sleep and boosts memory consolidation. We investigate whether periodical tDCS inducing prolonged stimulation effects before sleep can modulate whole night sleep continuity and sleep-dependent memory consolidation. **Methods:** We applied a standardized tDCS protocol (2 mA, 2x9 min cathodal, 2x13 min anodal, 2x11 min sham) bilaterally to the prefrontal neocortex of 18 healthy subjects (7 men, aged 40-65 years) in a randomized crossover design prior to polysomnographically monitored sleep. Memory tasks were conducted before and after sleep. **Results:** Total sleep time (TST) after anodal stimulation was 27.6 min less compared to TST after cathodal stimulation ($p < 0.01$). No effect in memory tasks. **Conclusion:** Periodical tDCS bilaterally at the prefrontal neocortex is a viable tool to modulate whole night sleep continuity. This finding might contribute to the development of novel treatment strategies for sleep disorders.

[* equal contributions]

B3

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The impact of post-learning sleep on false recognition memory of nonverbal visual stimuli

False memories have been shown to be enhanced after a normal night of sleep compared to wakefulness. However, in studies using the standard verbal Deese-Roediger-McDermott (DRM) paradigm, subjects are prone to use deliberate mnemonic strategies to memorize the learning material. This could affect both the correct retrieval of memories and the generation of false memories. Here, we employ a nonverbal version of the DRM paradigm introduced by Slotnick and Schacter (2004) to investigate whether the generation of visual false memories depends on sleep-dependent memory consolidation. We hypothesize that, analogous to the verbal DRM paradigm, sleep compared to wakefulness enhances nonverbal false memories in a recognition memory procedure. Our study will shed light on the development and sleep-dependency of false recognition memories without interference by deliberate mnemonic strategies.

B4

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Effects of mental fatigue and motivation in a long-lasting choice response task - An ERP study

Mental fatigue leads to problems in keeping attention focused and in consequence to a decrease in performance. To investigate the effects of mental fatigue on behaviour and event-related potentials (ERP) 16 healthy participants had to perform a monotonous choice response task for over three hours. For a detailed analysis of the time course the experiment was subdivided in three equal blocks by short breaks. Interestingly the performance - as measured by reaction times and error rates - showed a prominent decrease not until the last third of the experiment whereas the N2 and P3 amplitudes showed the most variation within the first block. Those results indicate that mental fatigue leads to a decrease in performance and action control. However the N2 and P3 components seem not affected by mental fatigue. Instead those changes in amplitudes may reflect the impact of practice in a long-lasting task.

B5

Nekovarova T[1], Englerova K[2], Galik M[2], Klement D[1], Rokyta R[2]

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Novel insight into object permanence in macaques

Object permanence is an ability to understand that an object can exist even if it is not directly accessible to one's senses. We can regard it as a base to create mental representations and to manipulate them. It is also considered to be one of the methods to test working memory. Object permanence is traditionally studied in human ontogeny. With increasing interest in animal cognition the question arose which animal species possess object permanence and to what degree. It was shown that among primates in great apes the highest stage 6 of object permanence occurs. However, the results in macaques are still ambiguous. We have shown that under some circumstances macaques have a capacity to reach stage 6. However, we have demonstrated that performance strongly relies on previous cognitive training and that object permanence can be trained as a cognitive ability; not just as a performance in a particular task.

B6

Paßmann S, Külzow N, Flöel A

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Effects of noninvasive brain stimulation during slow wave sleep on visual memory in younger and older adults

The application of a transcranial slow oscillatory electric current (tSOS) during NonREM within the frequency range of slow wave sleep enhanced sleep-associated memory consolidation in a word-pair associative task in healthy young adults. However, if there are comparable effects on other hippocampus-dependent declarative memory tasks have not been studied so far. Since memory functions and sleep architecture are strongly age dependent, it also remains unclear if similar effects occur in healthy older adults. Here, overnight performance in a visual-spatial task in 16 healthy young and 16 older adults was tested either with or without (sham) tSOS applied during nocturnal SWS. Younger adults remembered on average more pictures correctly after tSOS compared to sham. Older adults showed the reversed pattern. Thus, results extend previous findings in young healthy subjects and demonstrate beneficial effects of tSOS also for visual memory tasks. How these results are associated to age-related changes in sleep architecture is discussed.

B7

Purple R, Cosgrave J, Wulff K, Porcheret K

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Sleep and cognition during the prodromal phase of psychosis

Psychosis is a condition characterised by delusions and hallucinations, often applied to several mental health disorders including schizophrenia and bipolar. Common features of psychotic disorders include impaired cognition, affected mood, and disrupted sleep. This study aims to identify whether such features, with specific emphasis on sleep and circadian rhythm disruption, are present during the prodromal phase, prior to the onset of a psychotic disorder. This study follows a two-step process. Firstly, the general population is screened, using an online survey, to identify individuals at high psychosis risk based upon established risk factors. This targeted group are then profiled using an array of measures looking into sleep and circadian rhythms (polysomnography, actigraphy, and hormone collection), psychosocial factors (questionnaires) and various cognitive tests including two measures of sleep-dependent memory consolidation, which has shown abnormalities in patients with schizophrenia. This is an ongoing study with preliminary screening data acquired.

B8

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The recovery of semantic memory from interference after sleep

Sleep-associated memory consolidation has been found to enhance the integration of new information embedded in a semantic context (Tamminen, Payne, Stickgold, Wamsley, & Gaskell, 2010) and facilitate the recovery of recently learned information from Retroactive Interference (RI) (Drosopolous et al. 2007). We adapted the classic A-B, A-C list learning paradigm so that B-A-C word triplets were comprised of novel words ('A' items) that were either semantically congruent or incongruent with real word 'B' and 'C' list items. Memory for the congruent A-B list items manifested typical RI effects after both 20 minutes and 12 hours of wakefulness. However after 12 or 24 hour delays involving sleep RI effects dissipated for congruent A-B list memories. Conversely, memory performance for incongruent A-B list items remained at chance levels across all four time delays. These findings suggest that the semantic congruency of new information can influence the consolidation-associated recovery of memories from RI.

B9

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Modeling the sleeping thalamo-cortical system

The investigation of sleep's influence on memory consolidation is often driven by experimental studies that manipulate certain aspects of sleep or consolidation processes. Especially transcranial electric {Marshall2006} as well as sensory stimulation {Ngo2013} have shown great success in boosting the efficacy of memory consolidation. However, a detailed understanding of the thalamo-cortical interaction and the effect of stimulation on the sleeping brain is still lacking. Here population based models can give valuable insights into the underlying dynamics, both within specific brain regions as well as between different structures {Ursino2010, Sotero2007}. While those models have been highly successful in the reproduction of different brain rhythms of the awake brain, the drastic changes that arise during sleep have not been addressed sufficiently. Here we present an extended neural mass model of the thalamo-cortical system, that is able to reproduce the hallmarks of sleep namely slow oscillation as well as thalamic spindles. Furthermore, we investigate the effect of sensory stimulation on the sleeping brain similar to a study by {Ngo2013a}.

B10

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Improved visual memory by noninvasive brain stimulation during a daytime nap

Declarative verbal memory consolidation can be enhanced in young adults by applying transcranial slow oscillating stimulation (tSOS) during early nocturnal sleep. Based on the finding that a 90-minute daytime nap improves sleep-associated memory consolidation similarly as a whole night sleep, we investigated how tSOS during an afternoon nap affects the stabilization of declarative verbal as well as visual memory in healthy young and older adults. Using a within subject design, 14 young and 13 older subjects were tested on a verbal and visual-spatial memory task before and after a 90-minute nap either comprising tSOS at 0.75 Hz during non-REM sleep or sham stimulation. tSOS significantly improved picture recognition performance for young and older subjects, whereas verbal memory was not affected by stimulation during the nap. Our findings suggest that tSOS applied during a daytime nap is sufficient to improve consolidation of visual memory in young and older adults.

B11

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Grouping of MEG gamma oscillations by fast and slow sleep spindles

Sleep spindles are assumed to play an important role in memory consolidation. Cortical gamma (> 30Hz) oscillations are considered to reflect local cortical network processing. The temporal and regulatory relationships of spindle and gamma activity are therefore of particular importance for sleep related memory processing. We analyzed NonREM rich sleep periods and detected fast (12-15 Hz) and slow (9-12 Hz) spindles in simultaneous MEG and EEG recordings and their local and global co-occurrence and modulation with cortical gamma activity. As expected EEG and MEG spindles co-occurred and were correlated with power increases in the frequency band of the respective first harmonic (20-30 Hz), being most pronounced around their detection site. Cross-frequency coherence analyses indicated a power-to-phase-coupling of the MEG gamma band activity with the spindle rhythm that varied between subjects in cortical areas, as well as gamma and spindle frequencies. Taken together our findings support the idea that spindles provide a fine-tuned temporal frame for integrated cortical memory processing during sleep.

B12

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Effects of phase-independent auditory stimulation on sleep and memory

Sleep plays an active role in memory consolidation and especially slow wave sleep (SWS) seems to be important for the transfer of recently encoded memory representations into long-term stores. Consolidation of declarative memory relies on a dialog between neocortex and hippocampus, where cortical slow oscillations, thalamic spindles and hippocampal sharp wave ripples are thought to be key players. However, their individual contribution is not fully resolved. Recently, auditory closed-loop stimulation of slow oscillations has been shown to effectively enhance memory. In this study we investigated the effect of phase-independent acoustic stimulation on declarative memory consolidation. Subjects were continuously presented groups of three click sounds (pink noise of 50ms duration each) during slow wave sleep throughout the first half of the night. The first stimulus within a group served as a reset by triggering an individual slow oscillation event (K-complex). The second and third stimuli were delivered such that they concurred in time with the predicted up states of the induced slow oscillations (P900 components). Between stimulus groups there was a pause of 5-9s. Although the induced oscillations are comparable to the phase-dependent version reported by Ngo et al. (2013) stimulation was not effective in changing the performance of human subjects in a paired associate learning (PAL) task ($p=0.11$, $N=15$). Spindle power was significantly enhanced in response to the first click ($p<0.001$, $N=15$), but it was decreased across the entire stimulation period ($p<0.001$, $N=15$). The latter was most pronounced in the 5-9s interval between tones. Contrary to spindle activity, power in the SO band (0.5-1.1Hz) increased during the stimulation period ($p<0.05$, $N=15$). Our results indicate that auditory stimulation applied independent of the endogenous slow oscillation phase is not sufficient to enhance memory consolidation.

B13

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Is a run as good as a rest? Comparing the effects of exercise, wakeful-rest and interference on memory for newly learned words in adulthood

Memory for newly learned words benefits from overnight consolidation implicating sleep (Gaskell & Dumay, 2007). However, sleep may not be the only condition under which memory consolidation may occur. Human neuroimaging studies have reported increases in hippocampal blood volume after exercise associated with verbal memory improvements (Hillman, Erickson & Kramer, 2008) and vocabulary learning is boosted by exercise compared to a rest condition (Winter et al., 2007). Furthermore, verbal memory improves after a short unfilled break in young and older adults and amnesics suggesting 'wakeful rest' may aid memory consolidation by reducing post-learning interference (Dewar at al., 2012). Our study represents the first attempt to examine effects of exercise, wakeful-rest and verbal interference on word learning. By assessing integration of new words into the lexical network we examine whether wakeful rest and exercise can, like sleep, do more than simply strengthen memories. Eighty young healthy adults were trained on 20 aurally-presented novel words prior to one of four 30 minute intervals (wakeful rest – with/without verbal input; running on a treadmill – with/without verbal input). Explicit memory and implicit lexical integration were tested immediately, the following day and 1 week later enabling examination of the immediate and longer lasting effects on retention and consolidation. Analysis is currently underway and preliminary findings will be presented.

B14

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Memory reactivation during sleep supports qualitative changes in memories

Memory reactivations during sleep have been demonstrated to immediately stabilize newly acquired memory contents during sleep. However, it still remains unclear whether reactivation also supports qualitative changes of these memories (e.g. the extraction of a gist). Here, we investigated in children and adolescents the short- and long-term effects of memory reactivations during SWS on qualitative and quantitative changes of memories. In the evening, subjects learnt to associate ambiguous pictures of every-day life situations with either positive or negative semantically related words which thereby support a corresponding emotional interpretation of the presented pictures. Picture-word associations that had been reactivated during the post-learning night were better remembered the next morning but worse one week later when compared to non-reactivated stimuli. Valence ratings of pictures were not affected by reactivation the next morning. However, this was the case one week later as indicated by greater knowledge about the acquired emotional tone of reactivated picture-word associations. These findings suggests that memory reactivation during sleep supports the long-term extraction of a gist of memories (i.e. the valence of an acquired memory) at the expense of context information.

B15

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EEG and carbon dioxide sensitivity for early detection of panic disorder

Previous EEG experimental design yielded an inconsistence finding to dissociate between panic disorder and other psychiatry disorder. The objective of this research is to study the bio-marker of carbon dioxide hypersensitivity in panic disorder. EEG recording will be held during in a breath holding and 7% CO_2 inhalation. EEG spectral analysis will be employed for the carbon dioxide reactivity among panic disorder patient, first degree relatives and other psychiatry disorders (depression, phobia, OCD).

B16

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Does sleep after initial learning influence long-term procedural memory performance in children?

In developing song birds, an initial deterioration of song performance over night-sleep is related to better performance in the long run. The current study explored if children show similar effects when first learning a procedural memory task, the Button Box, where they have to press buttons that light up in a specific sequence. Twenty-eight children (8-12 years old) first performed the task in the evening, had a first retrieval session the following morning and a second retrieval session after a whole week of daily training on the Button Box with the same sequence. Like in previous studies, children gained high explicit knowledge of the implicitly learned sequence after the first night of sleep. Changes in implicit performance measures over the first night of sleep were, however, not related to performance at the second retrieval after a week of training. These findings indicate that – in contrast to song birds – sleep-related changes after initial learning are not related to long-term procedural memory in children.

B17

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Conditioned to sleep? - Effect of sleep on classical conditioning in Aplysia californica

Sleep appears to be conserved throughout the animal kingdom and has been postulated as having a critical role in learning and memory. Yet, sleep research has not been conducted in one of the most well-characterized models for learning and memory, the marine mollusk Aplysia californica. We investigated sleep and rest activity in Aplysia using criteria established to define invertebrate sleep including: 1) specific sleep posture, 2) preferred resting location, 3) reversible behavioral quiescence, 4) elevated arousal threshold and 5) compensatory rebound in sleep after sleep deprivation. Individual animal activity patterns were analyzed over multiple days at one min intervals to determine whether animals were actively engaged in locomotion, exhibiting stationary movements or stationary without movement (resting). We found that Aplysia exhibited robust diurnal rhythms in locomotor and rest activity with locomotion mainly during the day and sustained periods of rest during the night. Rest was separated in bouts, with the length of the rest bout declining towards the end of the dark period. Animals demonstrated a strong resting place preference spending the majority of their resting time in the upper portion of the tank close to the water surface. Differences in body posture were also apparent between wake and rest states. During rest, the body posture appears more contracted with the parapodia closed around the body and the foot firmly attached to the substrate. To determine whether differences in sensory arousal thresholds existed between the rest and wake states for individual animals, we tested behavioral responses to an appetitive (seaweed) and aversive stimulus (concentrated salt) between wake and rest states at ZT 18 and ZT 22. Individual animals were tested only once per night. Animals classified as awake had significantly shorter latencies for orientation and elicitation of biting to a seaweed stimulus compared to resting animals. Furthermore, awake animals responded with an escape step after application of a salt stimulus to the tail more than 88% of time while less than 30 % of the resting animals took an escape step. To determine if Aplysia exhibited a homeostatic drive for rebound sleep after rest deprivation, animals were deprived of rest using manual stimulation for 11 h during the night. We found that rest deprivation resulted in resting behavior during the subsequent day. This behavior was not triggered when animals were exposed to similar stimulation during the day. Thus, this research establishes Aplysia as a valid model for sleep research as Aplysia demonstrate all the characteristics of sleep including rebound sleep after rest deprivation.