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Decoding retrieval success and memory content during short-term memory maintenance

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Zusammenfassung

In his search for the physical substrate of long-term memory in the brain, Semon proposed that, apart from coding the particular content of a learning episode, an engram should enable correct memory retrieval. Using multivariate pattern classification, we tested whether electrical brain activity recorded during short-term memory maintenance satisfies these conditions, and where identified short-term memory representations reside. In our experiment, participants learned two short-term memory tasks, encoding either pictures of faces or houses, or sequences of digits or letters. Brain activity was recorded using EEG. It was possible to decode retrieval success from electrical brain activity during the delay period of both short-term memory tasks. Moreover, we could distinguish whether participants kept pictures of faces or houses in memory, and classifier performance on this problem correlated with successful memory maintenance. Using spatial as well as frequency band-based searchlight analyses, we found that distinct brain areas and frequency bands coded for the success versus the content of short-term memory. Frontal and parietal higher frequency bands and alpha activity predicted retrieval success, whereas memory content was represented in temporal and parietal higher frequency ranges, as well as theta activity. We propose that frontal cortex supports memory-related control processes, whereas temporal cortex shows a sensory reinstatement of material content and is part of the wider activated network during memory retention. Interestingly, the only overlap between electrodes coding for retrieval success and memory content was found over medial parietal regions, indicating that a dedicated short-term memory representation resides in medial posterior cortex.

Imaging memory transformation: neural signature of detailed and gist-like memories of recent and remote events

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Zusammenfassung

Over time, memories undergo a neural reorganization. Yet the exact nature of this reorganization is still debated. According to the Standard Consolidation Theory, memories are gradually consolidated from the hippocampus to the neocortex until they are ultimately independent of the hippocampus. The Memory Transformation Hypothesis, however, postulates that memories undergo a transformation from detailed, episodic to gist-like, semantic representations that can be retrieved solely from the neocortex, whereas the detailed episodic memories would always remain hippocampus-dependent. This experiment contrasted these views and tested the transformation of episodic memories as well as the neural changes associated with the temporal dynamics of memory. Participants encoded pictures and performed a recognition test in the MRI scanner either 1 day or 28 days later. Critically, the recognition test contained, in addition to the original and entirely novel pictures, similar pictures carrying the gist of the original ones, thus allowing us to assess the specificity of memory. Overall, memory performance after 28d was reduced compared to 1d but was still mainly intact. Twenty-eight day old memories, however, were characterized by a striking lack of specificity reflected in a significantly elevated false alarm rate specifically for similar pictures, thus suggesting a transformation to more gist-like memories. Imaging data showed significantly reduced hippocampus and entorhinal cortex activity after 28d (vs. 1d), whereas activity in most neocortical regions of interest did not differ. Multivariate imaging analyses targeting the hippocampal and neocortical representation

Memoria ex Machina: Real memory from virtual reality – An EEG study

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Zusammenfassung

“Real-life” autobiographical memory is characterized by self-involvement and rich associative mnemonic networks. Concerns have been raised that conventional “laboratory memory” differs from these vivid experiences. We addressed these concerns by comparing retrieval-related EEG-indices of both forms of memory. Furthermore, we aimed at bridging the gap between both types of remembrance by adding a virtual reality (VR) encoding condition. Participants took either part in a (a) real car drive, were confronted with a (b) 360° VR, or (c) a 2D video of the same ride. An unannounced recognition memory task followed 48 hours after encoding. ERPs revealed that the retrieval of real-life and VR experiences is processed similarly, whereas both differ from the retrieval of conventional laboratory-events. Within the 2D condition, we replicated a central N400 memory-related effect (hit vs. miss). Remarkably, no such effect was observed within the real or the VR condition. However, these conditions elicited comparable differences at frontal electrodes in the same latency when comparing the ERPs to old and new items. Our study provides evidence

that the central N400 effect only occurs under laboratory conditions. It might be a result of shallow, familiarity-related processes and reflect real-life cognition only to a limited extent. Conversely, the higher degree of self-involvement in the real and the VR condition allowed for an autobiographical decision. The similarity between these two conditions makes VR a promising tool for future studies with enhanced ecological validity.

Neuromodulation as a tool to induce olfactory and auditory source-monitoring deficits in healthy subjects

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Zusammenfassung

Source-monitoring describes the process of determining the source of a percept as external (e.g. a sound, or smell), or internal (an imagined self-generated sound, or smell). Source-monitoring is affected by the similarity of perceived and imagined memories, with (pre-) supplementary motor area (SMA) having a crucial role in distinguishing between the two sources. In this study, we aim to inhibit the functionality of (pre-) SMA using cathodal (and sham) transcranial direct current stimulation (tDCS) in a group of healthy participants. By tDCS-induced transient neuromodulation we hope to introduce source-monitoring deficits in a source-monitoring task involving auditory (i.e. spoken words) and olfactory (i.e. smells) stimuli that are presented to the participant. We expect to find decreased SMA BOLD activation after cathodal tDCS application as well as behavioral indicators of source-monitoring deficits (i.e. ascribing the wrong source to a stimulus). A better understanding of the role of (pre-) SMA in the source-monitoring framework may enable to explain (and treat) hallucinations experienced by clinical populations, in which source-monitoring is known to be heavily compromised (i.e. paranoid schizophrenia). Preliminary results suggest successful down-modulation of (pre-) SMA, as indicated by reduced levels of BOLD activation in participants that received 2mA of cathodal tDCS for 20min compared to a sham control group. These findings are supported by behavioral results that show a trend towards decreased source-monitoring performance of the tDCS group across both modalities. This suggests (pre-) SMA to be a promising candidate region within a sourcemonitoring network, that if impaired, leads to general source-monitoring deficits.

The time course of cognitive control: New insights under relaxed linearity assumptions.

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Zusammenfassung

Objective: The relationship between predictor variables and brain activity is often assumed to be linear. However, there exist many situations for which this assumption does not hold. To demonstrate this, we focussed on recent findings (Braver, Gray & Burgess, 2007) suggesting that cognitive control operates in two distinct modes. The first, proactive control, is resource costly and preparatory. The second, reactive control, is flexible and allows corrective behavioural adaption. We believe that these processes achieve balance in accordance to task demands and are optimised over time. Further, we believe that these processes are best represented by the magnitude of fronto-central (e.g. CNV) and fronto-parietal (e.g. P3) brain potentials (i.e. ERPs). Method: EEG from 60 participants was recorded during a Continuous Performance Task. Here, participants needed to establish stable proactive control based on the predictive value of cues. Conversely, reactive control was necessary when these predictions were violated. Further, we combine spline regression and multilevel modelling (MLM) to illustrate the relationship between ERPs and the predictors (e.g. predictability, expectancy violation, and time on task). Results: Activation patterns for the preparatory and reactive control modes differed significantly, as well as their (curvilinear) modulations through time. Discussion: Results indicate that non-linear MLM offers new insights into the modelling of EEG-data. We discuss its advantages in terms of incremental validity, goodness of fit and statistical power.

I want to sleep better: Effects of voluntary control on objective sleep parameters

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Zusammenfassung

Sleep is mainly regulated by homeostatic and circadian factors, and sleep disturbances are typically treated by pharmacological interventions. However, a large portion of non-organic sleep disturbances are caused by psychological factors including worrying, perceived prospective threats and negative recurrent thoughts, suggesting that sleep is strongly influenced by cognitive and affective mechanisms. In support of this notion, we have recently shown the duration of objectively measured slow-wave sleep (SWS) can be extended by using hypnotic suggestions to

sleep deeper. Here we aim at testing whether healthy participants are capable of voluntarily influencing objective sleep parameters even without hypnosis. We predict that participants can voluntarily worsen but not improve their sleep as compared to a normal sleep condition. 18 healthy young volunteers participated in one adaptation night and three experimental nights. All nights were done on the same weekday with an interval of one week. Polysomnography and subjective sleep quality was measured during all four nights. In the three experimental nights, participants either had to sleep "normal", worse than normal or better than normal, in a balanced order. The results show that the subjective and objective sleep onset latency as well as the time spent awake after sleep onset could be significantly altered. In a same direction changed the parameters slow wave sleep and total sleep time, which showed a significant increase. The results demonstrate that it is possible to influence sleep voluntarily. Findings show a first answer to the question if sleep is influenceable within one´s mean.

Behavioral and neuronal determinants of negative reciprocity in the ultimatum game

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Zusammenfassung

The rejection of unfair offers in the ultimatum game (UG) indicates negative reciprocity. The model of strong reciprocity claims that negative reciprocity reflects prosociality since the rejecting individual is sacrificing resources in order to punish unfair behavior. However, a recent study found that the rejection rate of unfair offers is linked to assertiveness (status defense model). To pursue the question what drives negative reciprocity, the present study investigated individual differences in the rejection of unfair offers along with their behavioral and neuronal determinants. We measured fairness preferences and event-related potentials (ERP) in 200 healthy participants playing a computerized version of the UG with pictures of unfair and fair proposers. Structural equation modeling (SEM) on the behavioral data corroborated both the strong reciprocity and the status defense models of human cooperation: More prosocial but also more assertive individuals were more likely to show negative reciprocity by rejecting unfair offers. Experimental ERP results confirmed the feedback negativity (FN) as a neural signature of fairness processing. Multilevel SEM of brainbehavior relationships revealed that negative reciprocity was significantly associated with individual differences in FN amplitudes in response to proposers. Our results confirm stable individual differences in fairness processing at the behavioral and neuronal level.

The Verbal Interaction Stress Task: a new paradigm implementing verbal, interactive and social components for investigating the effects of social rejection on psychosocial stress.

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Zusammenfassung

In recent years, digital communication and social media have taken an indispensable role in human society. Social interactions are no longer bound to real-life encounters, but more often happen from behind a screen. In this behavioral study we developed and validated a new, MRI compatible, social stress paradigm in which we mimicked an online communication platform. During the Verbal Interaction Stress Task (VISTA) participants initiate 30 short conversations by selecting one of the four predefined opening sentences. Two computerized interlocutors respond to the opening sentence with mostly negative comments and rejections towards the participant. This approach induces feelings of social rejection and thereby social stress in the participants. The stress response is measured during and after the social stressor in 30 male and female first year students. Validation took place via multiple cortisol assays acquired via saliva samples, heart rate measurements and questionnaires for subjective measures of stress. We hypothesized that the VISTA leads to elevated release of cortisol, an increase in heart rate as well as increased level of experienced stress and that these effects are larger in women than in men. During the VISTA heart rate was increased and positive mood decreased over time for both genders. Cortisol assays are currently assessed in the laboratory. With a realistic implementation of verbal, interactive and social components, the MRI compatible VISTA will fill an open niche in social stress research.

NRSN1 associated grey matter volume of the visual word form area reveals dyslexia before school

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Zusammenfassung

Learning how to read and spell requires the brain to reorganize in response to environmental influences. At the same time, literacy skills are heritable and thus to some degree genetically

predetermined. Here we related 19 literacy-associated genes to gray and white matter volumes derived by voxel-based morphometry in a cohort of 141 children ranging from 3 to 12 years of age. Subsequently, a sample of 34 children attending grades 4 to 8, and another sample of 20 children, longitudinally followed from kindergarten to first grade, was separated into dyslexics and controls using linear binary support vector machines. Age, gender, handedness, non-verbal IQ and parental education were included as covariates of no interest in the models. The gray matter volume of the "visual word form area" (VWFA) was found to be related to NRSN1, a gene assumed to regulate neurite growth. Moreover, the NRSN1-associated cluster in the VWFA distinguished dyslexics and controls not only after several years of schooling (classification accuracy: 73.53%, p = 0.031, family-wise error-corrected), but also already at a kindergarten age before literacy instruction had actually begun (classification accuracy: 75%, p = 0.035, family-wise error-corrected). These findings (published in the journal Brain) shed new light on the "nature and nurture" of literacy acquisition. We have shown that there seems to be a genetic limit to the neuroplastic adaptivity of the VWFA. These results could pave the way for identifying and treating dyslexia (the most common learning disorder) before it manifests itself in school.

Dermatomal Organization of SI Leg Representation in Humans: Revising the Somatosensory Homunculus

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Zusammenfassung

Penfield and Rasmussen’s homunculus is the valid map of the neural body representation of nearly each textbook of biology, physiology, and neuroscience. The somatosensory homunculus places the foot representation on the mesial surface of the postcentral gyrus followed by the representations of the lower leg and the thigh in superio-lateral direction. However, this strong homuncular organization contradicts the dermatomal organization of spinal nerves. We used somatosensory evoked magnetic fields and source analysis to study the leg’s neural representation in the primary somatosensory cortex (SI) in 18 healthy subjects. We show that the representation of the back of the thigh is located inferior to the foot’s representation in SI whereas the front of the thigh is located laterally to the foot’s representation. This observation indicates that the localization of the leg in SI rather follows the dermatomal organization of spinal nerves than the typical map of neighboring body parts as depicted in Penfield and Rasmussen’s

illustration of the somatosensory homunculus. Therefore, there is a need to revise the Penfield maps with respect to specific aspects of the leg's representation.