Functional connectivity in the human brain

Peter Fransson, professor, Karolinska Institutet, Stockholm

During recent years, resting-state fMRI has become a versatile tool to investigate the large-scale functional network architecture of the human brain. It has been shown that synchronous BOLD fMRI signal fluctuations are ubiquitously present in the brain and that it is sensitive to the experienced degree of awareness. Hence, resting-state fMRI shows the potential to be able to contribute valuable information on the state changes that our brain undergoes during the decent to sleep as well as sleep-related disorders. In this talk, I will give a historical account and short introduction to resting-state fMRI and its potential usage in brain connectivity research.

Sleep deprivation and the brain: focus on emotion

Gustav Nilsonne, PhD, Karolinska Institutet & Stockholm University, Stockholm

Sleep deprivation causes impaired attention and performance. Effects of sleepiness on brain mechanisms for emotional processing are however not well studied. We have performed a study of partial sleep deprivation using functional magnetic resonance imaging (fMRI). In a within-group design, participants have been scanned after a full night of sleep and after partial sleep deprivation where they were allowed to sleep for 3 hours. Sleepiness was investigated with the psychomotor vigilance task (PVT) and the Karolinska Sleepiness Scale (KSS). Emotional mimicry was investigated using electromyography (EMG) during fMRI scanning by showing participants pictures of angry, happy, and neutral facial expressions. Emotional empathy was investigated using a well-established paradigm based on pictures of hands being pain stimulated with needles. Resting state functional data were acquired. Sleep deprivation caused increased ratings of sleepiness, but not significantly slower response times in the PVT. Participants rated their emotional state as less happy and more angry, and stimuli of others in pain were perceived as more unpleasant. EMG data showed less happy and more angry expressions after sleep deprivation regardless of stimulus type. Both facial expressions and others in pain gave rise to expected patterns of activation in the brain, but with no strong effects of sleep deprivation. These results indicate that changes in emotional processing in the brain are an early effect of sleep deprivation, preceding performance impairments in a reaction time task. Furthermore, they highlight the potential use of sleep interventions as an intervention to affect emotional processes in order to experimentally investigate their brain correlates.

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Symposium:

IMAGING THE SLEEPY BRAIN

Abstracts

Cerebral functional network correlates of NREM sleep studied by fMRI

Philipp G. Sämann, MD, MPI of Psychiatry, Neuroimaging Core Unit, Munich

Functional MRI with its mesoscopic spatial scale and when combined with techniques of functional connectivity analysis is a formidable tool to study the brain's reorganization during falling asleep. I will mainly present results from a series of studies based on combined fMRI/EEG recordings during wakefulness and NREM sleep in a total of about 45 subjects. More specifically, different techniques including independent component analysis, seed based analysis, dynamic version of these latter approaches, cross correlation analysis, graph theory analysis, hierarchical clustering, psychophysiological interaction analysis and functional connectivity density mapping are presented in the context of sleep fMRI. Both analysis of specific networks such as the default mode network and explorative whole brain analysis were used to capture connectivity changes. Multivariate techniques can in turn be used to predict the current vigilance state from fMRI data. The large effect size of vigilance associated FC changes renders vigilance fluctuations a major potential confound in clinical studies. When integrated with other NREM fMRI studies, these results can serve as reference for comparisons with effects of sleep deprivation or vigilance disturbances in pathological states such as coma, and effects of anesthesia.

Spontaneous brain activity fluctuations: insights from states of diminished conscious awareness

Enzo Tagliazucchi, PhD, University of Kiel, Kiel

In recent years we have seen a flood of papers studying intrinsic brain activity during wakeful rest ("resting state") and its use as a tool to understand brain function, as well as to develop biomarkers for different diseases. In spite of many interesting results, there is little consensus about the answer to very basic questions regarding these spontaneous, intrinsic brain activity fluctuations. What is their origin? What is their function? How are they related to unrestrained ongoing cognition? In this talk, we will first present many different plausible answers to these questions, and we will then show what we can learn about them by the study of brain activity during the different states of awareness we experience as we fall into deep sleep. As a result of these studies, we expect to gain insights not only on resting state brain activity during wakefulness, but also on the mechanisms which underlie loss of consciousness in the descent to deep sleep. Furthermore, taking into account the possibility of sleep during resting state experiments will lead to redefine the brain state associated with spontaneous activity, prompting a major re-evaluation of a number of already published results.

The Effects of Sleep Deprivation on Brain Function and Cognition

Sean P.A. Drummond, PhD, UCSD, San Diego

The impact of sleep deprivation on brain function and cognitive performance varies among individuals and as a function of task demands. Broadly speaking, there are two basic types of cerebral responses to cognitive challenges during sleep deprivation: a) one characterized by deficits in cerebral activation and impaired performance; and b) one characterized compensatory brain responses and relatively intact performance. Nonetheless, there are several aspects of nuance to these generalizations. For example, the response of the default mode network during cognition (also termed negative task-related activation) following sleep deprivation may vary depending on whether an individual has insomnia or is a healthy sleeper. This lecture will present an overview of findings from early functional MRI studies with healthy controls of cognition during sleep deprivation to illustrate the major patterns of results. Then, we will discuss functional MRI findings examining the response of the default mode network during cognitive performance in healthy controls and patients with insomnia to highlight the more subtle nature of changes in brain function with sleep loss.

Large-scale internet assessment and brain imaging reveal different subtypes of insomnia

Eus JW Van Someren, Assoc. Prof., Dept. Sleep & Cognition, Netherlands Institute for Neuroscience and VU University & Medical Center, Amsterdam

Insomnia is the most common health complaint and has serious consequences. Our understanding of underlying brain mechanisms is limited. We hypothesized that the lack of robust findings may be due heterogeneity of underlying causes of insomnia. The presentation will illustrate the hypothesis and support found up till now. First, it will be shown that a data-driven clustering approach to a large database of multivariate psychometric profiles assessed in volunteers of www.sleepregistry.org suggests four different subtypes of insomnia. Interestingly, subtypes differentiated hardly on sleep constructs. Second, it will be shown that the use of MRI tools in careful selections of homogeneous sets of participants can reveal neural correlates of sound sleep and insomnia severity. Notably, these correlates can be different depending on psychiatric phenotype.

Further reading: Altena et al., Biol Psychiatry 2010;67:182; Piantoni et al., J Neurosci 2013;33:227; Stoffers et al., Front Neurol 2012;3:105; Stoffers et al., Brain 2014;137:610; Van Der Werf et al., Biol Psychiatry 2010;68:950