Rhythms of attention: The functional and causal role of neural oscillations in selective attention.

Attention is the focal point of our mental world and one of the pillars of our cognition. To successfully perform any goal-oriented action, we need to focus on information that is relevant for preparing the action and monitoring its accuracy and results. Similarly, if we want to remember given information, we need to pay attention to it. Selective attention enables us to single out the relevant information from all irrelevant distractions. In fact, as William James - the father of modern psychology - wrote over a hundred years ago, "e*veryone knows what attention is*" because everyone has one. However, no one *really* knows how exactly the brain gives rise to attention. **What are the underlying neural mechanisms through which the attentional focus emerges in our subjective *stream of consciousness*?** To answer this question, we study oscillatory rhythms of electrophysiological brain activity. Specifically, we investigate what are the specific functional and causal contributions of so-called alpha and theta rhythms in the brain mechanisms of attention.

Neural oscillations are a fundamental functional feature of the brain. They have been called the neurobiological root of cognition. Probably most neural computations underlying our cognition are oscillatory. This means that both local groups of neurons and large-scale brain networks work in rhythmic tempos, just like all songs have rhythm. So, also selective attention appeared to be intrinsically rhythmic. Alpha and theta waves are two dominant, slow brain rhythms, pulsating in about 10 and 6 cycles per second, respectively (measured in hertz or Hz). They have been characterized as traveling waves spreading throughout the brain like a wave across the water, and synchronizing neuronal activity in distant specialized areas like visual and motor cortices. This may be the biophysiological apparatus of focusing selective attention. Such an inter-regional brain synchronization enables us to perform complex actions, like learning to drive a car or playing a musical instrument. We investigate how are these *local* and *inter-regional* alpha and theta rhythms involved in four basic aspects of attention: (A) signal enhancement and distractor suppression; (B) stages of anticipation, selection, and maintenance of selected information; (C) implementations of selective processing in sensory cortices, and top-down control of this implementations; and finally (D) in two types of selection: location-based spatial selection, and feature-based non-spatial selection.

We have planned six experiments in which we employ the well-established experimental procedure called *attentional cueing*. The goal is to direct participants' attention in a particular way by providing cues on what is going to happen in the upcoming trial of the experimental task. Then, we will measure the initiated this way attentional process by recording participants' behavioral responses and electrical brain activity, that is, the **electroencephalograph or EEG**. To examine how the oscillatory rhythms are related to each of the particular aspect of attention, and how different brain areas are "talking" to each other when we pay attention to a given visual stimulus, the obtained EEG data will be decomposed by means of a so-called time-frequency spectral analysis. To this end, we will use several advanced computational and statistical techniques. We expect that the results of EEG analysis will reveal the specific functional roles of the oscillatory rhythms. In the last four of the six experiments, we will investigate the causal role of these rhythms in modulations of distant brain areas and, thereby, our attention. To this end, we will use the method called **transcranial magnetic stimulation or TMS**. We will apply TMS in two ways: *First*, to induce *local* transient "lesions" that are expected to *impair* the functioning of the entire *connected network* and related *attentional processes*. This will allow to examine the causality of functional connections within the attentional network. *Second*, TMS will be applied to *entrain* (boost) specific brain oscillations, aimed to *improve* the frequency-specific functions of the entire network and related attentional processes. Here, we expect the results to demonstrate specific differences in the functional and causal roles of *particular oscillations* in controlling our attention.