Wakefulness

Wakefulness is a daily recurring brain state and state of consciousness in which an individual is conscious and engages in coherent cognitive and behavioral responses to the external world such as communication, ambulation, eating, and sex. Being awake is the opposite of the state of being asleep in which most external inputs to the brain are excluded from neural processing.

By simultaneously recording intracranial and non-invasive scalp EEG (10-20 system) in epileptic patients who were candidates for neurosurgery, Muñoz-Torres et al. explored synchronous activity among the amygdala, hippocampus, and neocortex during wakefulness (W), Non- Rapid eye movement sleep (NREM), and Rapid eye movement sleep (REM).

The findings reveal that hippocampal-cortical synchrony in the sleep spindle frequencies was spread across the cortex and was higher during NREM vs. W and REM, whereas the amygdala showed punctual higher synchronization with the temporal lobe. Contrary to expectations, delta synchrony between the amygdala and frontal lobe and between the hippocampus and temporal lobe was higher during REM than NREM. Gamma and alpha showed higher synchrony between limbic structures and the neocortex during wakefulness vs. sleep, while synchrony among deep structures showed a mixed pattern. On the one hand, amygdala-hippocampal synchrony resembled cortical activity (i.e., higher gamma and alpha synchrony in W); on the other, it showed its own pattern in slow frequency oscillations.

This is the first study to depict diverse patterns of synchronic interaction among the frequency bands during distinct vigilance states in a broad human brain neural circuit with direct anatomical and functional connections that play a crucial role in emotional processes and memory [1].

The spatiotemporal dynamics of interaction between slow (delta or infraslow) waves and fast (gamma) activities during wakefulness and sleep are yet to be elucidated in human electrocorticography (ECoG). Togawa et al. evaluated phase-amplitude coupling (PAC), which reflects neuronal coding in information processing, using ECoG in 11 patients with intractable focal epilepsy. PAC was observed between slow waves of 0.5-0.6 Hz and gamma activities, not only during light sleep and slow-wave sleep (SWS) but even during wakefulness and rapid eye movement (REM) sleep. While PAC was high over a large region during SWS, it was stronger in the posterior cortical region around the temporoparietal junction than in the frontal cortical region during REM sleep. PAC tended to be higher in the posterior cortical region than in the frontal cortical region even during wakefulness. Our findings suggest that the posterior cortical region has a functional role in REM sleep and may contribute to the maintenance of the dreaming experience [2].

Impaired wakefulness (IW) in normal pressure hydrocephalus (NPH) is associated with reduced relative regional cerebral blood flow (rrCBF) in the anterior cingulate cortex. Improved wakefulness following surgery corresponds to rrCBF increments in the frontal association cortex [3].

1)
Muñoz-Torres Z, Corsi-Cabrera M, Velasco F, Velasco AL. Amygdala and hippocampus dialogue with

neocortex during human sleep and wakefulness. Sleep. 2022 Sep 17:zsac224. doi: 10.1093/sleep/zsac224. Epub ahead of print. PMID: 36124713.
2)
Togawa J, Matsumoto R, Usami K, Matsuhashi M, Inouchi M, Kobayashi K, Hitomi T, Nakae T, Shimotake A, Yamao Y, Kikuchi T, Yoshida K, Kunieda T, Miyamoto S, Takahashi R, Ikeda A. Enhanced phase-amplitude coupling of human electrocorticography selectively in the posterior cortical region during rapid eye movement sleep. Cereb Cortex. 2022 Mar 15:bhac079. doi: 10.1093/cercor/bhac079. Epub ahead of print. PMID: 35288751.
3)
Tullberg M, Hellström P, Piechnik SK, Starmark JE, Wikkelsö C. Impaired wakefulness is associated with reduced anterior cingulate CBF in patients with normal pressure hydrocephalus. Acta Neurol Scand. 2004 Nov;110(5):322-30. PubMed PMID: 15476461.