Gamma-band (~40 Hz) information flow dynamics in cat EEG during wakefulness and sleep

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Cognitive processes rely on extensive thalamocortical and corticocortical recurrent interactions. Oscillations within the gamma frequency band (30-45 Hz) of the electroencephalogram (EEG) are associated whit these interactions and play a role in cognitive functions. These oscillations have been implicated in the integration of spatially separated yet temporally correlated neural events, leading to a cohesive perceptual experience. On the other hand, it is recognized that top-down processing refers to the brain's ability to use expectations, attentional focus, and other cognitive factors to influence bottom-up sensory processing. However, the precise directionality of the information flow (bottom up or top down) encoded by gamma band oscillations remains unknown. Therefore, the primary objective of our study is to investigate the direction of information flow in the gamma band during both wakefulness and sleep. To achieve this, 6 cats were chronically prepared for polysomnographic recordings, with electrodes placed in various cortical regions. To examine the directionality of information flow in the gamma band, we employed two approaches. First, we quantified the time lag of amplitude envelopes of gamma oscillations between pairs of EEG channels. Second, we analyzed Granger causality for the same channel pairs.

During quiet wakefulness, the predominant direction of information flow in the gamma band was from the dorsolateral prefrontal cortex (Pfdl) to the posterior parietal cortex (Pp), as well as from Pfdl to the primary somatosensory cortex (S1), primary visual cortex (V1), and primary auditory cortex (A1). Furthermore, there was a significant flow from Pp toward the primary cortices (S1, A1, and V1). Furthermore, when examining late gamma oscillations induced 0.5 to 1.5 seconds after a simple auditory stimulus, such as clicks, we observed a predominant bottom-up directionality from the Pp to the Pfdl, as well as from A1 to Pfdl. In contrast, late gamma oscillations induced by complex stimuli, produced a predominant top-down directionality from Pfdl to Pp, A1, and V1 cortex.

Hence, during wakefulness, different patterns of information flow emerge depending on the nature of the stimuli. Specifically, bottom-up processing was found to predominate for simple repetitive sound stimuli, while top-down processing prevailed for complex and variable sounds, as well as in the baseline condition (in the absence of stimuli). In addition, no specific directionality in

information flow was observed during NREM and REM sleep, suggesting a different mode of cognitive processing during sleep.

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