Idling With the $\mu$ Rhythm? Focus on “7 to 12 Hz Activity in Rat Gustatory Cortex Reflects Disengagement From a Fluid Self-Administration Task”

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Large-amplitude oscillations in a frequency range of 7–12 Hz are among the most prominent within the somatosensory cortex of rodents but the function of these oscillations is currently controversial. Such oscillations develop during quiet immobility and appear analogous to the human $\mu$ rhythm (Gastaut 1952). In rodents, this 7- to 12-Hz oscillation has a spike and wave appearance not dissimilar to those of sleep spindles or absence seizures, and, not surprisingly, many have argued that the $\mu$ rhythm in rodents reflects a pathological/epileptic condition (Shaw 2004). On the other hand, others have advanced that the $\mu$ rhythm reflects a task oriented state of sensory “readiness” (Fanselow et al. 1999; Nicolelis et al. 1995). The study by Fontanini and Katz in this issue of Journal of Neurophysiology (p. 2832–2840) tested whether the 7- to 12-Hz rhythm recorded in gustatory cortex (gustatory $\mu$ rhythm) is more closely associated with a sensory stimulus-elicited task or with disengagement from the same task. Rats were trained to press a lever to receive a fluid reward $\geq30$ s after the previous reward. The rats clearly learned to anticipate the reward as their lever presses clustered just before the end of the required 30-s inter-reward period. However, after more than an hour at this task, rats became “disengaged” in that they “stopped” anticipating the arrival of the reward period by a cluster of lever presses. Strikingly, the gustatory $\mu$ rhythm appeared only during the disengagement phase when rats switched to a low-frequency random pattern of lever pressings. During tasting or lever pressing the $\mu$ rhythm was always absent indicating that this rhythm has nothing to do with sensory processing per se.

The idea that the $\mu$ rhythm in the somatosensory system may encode sensory information and set temporal processing domains (Nicolelis et al. 1995) is attractive. But do the 5- to 12-Hz rhythms in somatosensory and gustatory cortices really have disparate functions? It seems more reasonable that the somatosensory $\mu$ rhythm may also reflect an “idling” state during quiet immobility and, as in the gustatory cortex, that this network oscillation is not directly involved in sensory processing but is permissive to sensory activation. In fact, rats respond as rapidly and reliably to vibrissal stimulation during periods dominated by $\mu$ rhythm as during non-oscillatory periods (Wiest and Nicolelis 2003). This observation suggests that the somatosensory $\mu$ rhythm does not reflect an epileptic state because its presence does not impair perception. Similarly, the fact that in the Fontanini and Katz (2005) experiments, rats licked and swallowed tastants delivered during gustatory cortex 5- to 12-Hz oscillatory periods distinguishes these events from epileptic episodes. So, if the 5- to 12-Hz oscillations recorded in gustatory cortex resemble spike and wave oscillations characteristic of absence seizures but are not absence seizures, then what are they? Fontanini and Katz (2005) favor the idea that the $\mu$ rhythm represents an “idling” state and propose that absence seizures represent a condition of protracted and extreme disengagement.

$\mu$ oscillations, like spindles, are associated with bursting of thalamic neurons (Fanselow et al. 2001) and may represent an attractor state for thalamo-cortical networks in the absence of focused attention. At the macroscopic level, a particular neuronal network may generate similar patterns even if the underlying contribution by the network cell’s intrinsic and synaptic properties are quite diverse (Prinz et al. 2004). While it is possible that there is no particular functional meaning to the $\mu$ rhythm beyond idling, it seems more reasonable that perhaps bursting of thalamo-cortical neurons during $\mu$ oscillations represents a self-maintenance or homeostatic phase of cortical networks so that they are ready when sensory processing is actively needed. In hippocampal networks, quiet immobility is also associated with periods of high-frequency oscillations (termed hippocampal “ripples”) (Buzsáki et al. 1992) that resemble epileptiform events but that are normal network phenomena (Bragin et al. 1999). Hippocampal ripples may play a very important role in synaptic plasticity and the transfer of hippocampal memory signals to the cortical mantle (Buzsáki 1996). Interestingly, it has recently been shown that hippocampal ripples and sleep-spindles in the somatosensory cortex are highly correlated events (Sirota et al. 2003) likely reflecting temporal windows with a high degree of hippocampal-neocortical intercommunication. It would thus be interesting to know the potential relationship between the gustatory $\mu$ rhythm and hippocampal oscillatory activities.

REFERENCES


