Cortical network plasticity to communication sounds in awake mice

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Understanding the representation of natural stimuli is one of the main goals of sensory systems research. In audition, such stimuli range from naturally-occurring environmental sounds to those generated by organisms themselves, like species-specific vocalizations. Studies on the encoding of such calls in mammals have suggested that the neural response may be better synchronized across neurons tuned to different sound frequencies than expected from the spectral-temporal structure of the sounds, particularly if the calls are behaviorally-relevant [1,2,3]. However, these conclusions were based on data taken from anesthetized animals, and how awake mammals respond to communication sounds is not well explored.

We investigate this by recording from auditory cortical neurons in awake, head-restrained mice while playing back natural vocalizations. The mouse is developing into a promising model for this purpose. It features a well-characterized ultrasound communication system between pups and adult females, thus providing an ethological context. Only mothers and pup-experienced adults recognize the significance of pup calls, thus making virgin females a natural control for the effects of behavioral relevance on neural coding. Moreover, mice hold the potential for genetic dissection of underlying mechanisms, thus offering new research opportunities. Finally, as we demonstrate, high-quality, single-unit (SU) electrophysiology in awake mouse auditory cortex is feasible.

Our study recorded both SU’s as well as local field potentials (LFP) from the high-frequency area of the left mouse auditory cortex using high-impedance tungsten electrodes. We employed the relatively new concept of LFP ‘phase reliability’ (PR) as a useful method to differentiate neural network activity. We observed significant differences in the short-latency PR between mothers and virgins at recording sites whose best frequencies (BF) are ~25 kHz below the typical frequency of the ultrasound calls. Moreover, the percentage of tone-excited SU’s that can also be excited by pup calls is significantly increased in mothers, regardless of whether the BF is near or far from the call frequency. We discuss the possibility that our results demonstrate plasticity in either the high frequency synaptic input to mid-frequency BF sites, and/or the synchronization of spiking activity within the local neural population.

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References