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SENSORY PROCESSING

A gate for sensory responses

> spikes evoked in individual neurons by the sustained tone … did not happen randomly throughout the tone presentation, but were time-locked to the spontaneously occurring activity packets

The function of spontaneous cortical activity is much debated. In a new study, Harris and colleagues show that one role for irregular spontaneous activity may be to allow higher-order structures to control the representation of sensory stimuli.

The onset of a sensory stimulus evokes a brief but reliable increase in the firing of populations of neighbouring neurons in sensory cortex, which the authors termed an 'activity packet'. Similar activity packets also occur spontaneously in sensory cortex in awake, quiescent animals. To establish what role these spontaneous activity packets might have in sensory coding, the authors performed multisite neuronal recordings in primary auditory cortex of awake rats while exposing them to extended (1-second-long) tone stimuli.

As expected, analyses of individual neurons averaged over multiple trials showed that tone onsets reliably evoked transient increases in activity ('onset responses'), after which the mean firing rate of some neurons remained increased throughout the tone duration ('sustained responses'). At the population level, onset responses were reflected by 50–100-ms-long activity packets at tone onset. Surprisingly, however, population activity during the sustained period was not continuous but showed the same pattern of sporadic activity packets and silence as observed during silence. The activity packets occurring at tone onset, during silence and in sustained periods were very similar. Further analysis revealed that the onset of a tone increased the probability of an activity packet occurring, but not their size, compared with sustained tone presentation or silence.

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The authors showed that spikes evoked in individual neurons by the sustained tone (as reflected by the increased mean firing rate during tone presentation) did not happen randomly throughout the tone presentation but were time-locked to the spontaneously occurring activity packets. In addition, as had been shown before, the size of the sustained responses depended on tone frequency, with each neuron having a 'preferred' frequency.

Activity packets had a stable temporal structure — the timing of firing of any particular neuron relative to the rest of the population that contributed to the activity packet remained the same between trials using the same tone, but, like spike amplitude, it varied with tone frequency.

The authors next established how population responses to tone stimuli differed between cortical states, specifically between synchronized states (associated with quiescence) and desynchronized states (associated with higher levels of alertness). Population activity fluctuations were strong in synchronized states — that is, there were clear activity packets — whereas population activity seemed more evenly distributed in desynchronized states. This was the case both during silent periods and during sustained tone presentation, suggesting that cortical state influences the structure of activity packets more than does an auditory stimulus.

On the basis of these findings, and combined with evidence that activity packets are triggered by corticocortical rather than thalamocortical connections, the authors propose that activity packets in primary auditory cortex reflect the top-down opening of a 'gate' that allows input from lower auditory regions to be processed by primary auditory cortex.

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ORIGINAL RESEARCH PAPER Luczak, A., Bartho, P. & Harris, K. D. Gating of sensory input by spontaneous cortical activity. *J. Neurosci.* **33**, 1684–1695 (2013)
FURTHER READING Harris, K. D. & Thiele, A. Cortical state and attention. *Nature Rev. Neurosci.* **12**, 509–523 (2011)