Journal Club

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A Spotlight on the Searchlight

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Review of McAlonan et al. (<http://www.jneurosci.org/cgi/content/full/26/16/4444>)

Visual and auditory information must pass through the thalamus before being processed by the cerebral cortex. In vision, a canonical thalamic circuit comprises the lateral geniculate nucleus (LGN), thalamic reticular nucleus (TRN), and V1. LGN relay cells project to the striate cortex, and en route to the cortex they emit collaterals within the TRN. The cortex sends a feedback projection to the LGN, which also provides collaterals to the TRN. Although these thalamocortical feedforward and corticothalamic feedback connections to the TRN are excitatory, the projection from the TRN to the LGN provides the major extrinsic inhibitory input to the LGN. Many proposed mechanisms of the emergence of early attention within the thalamocortical circuit involve rhythmic burst firing in LGN cells. The encoding of a stimulus becomes distorted during burst firing, but the background noise significantly decreases, which leads to better signal detectability (Guido et al., 1995). Consequently, bursts have been hypothesized to function as a “wake-up” call signaling environmental changes to the cortex (Sherman, 2001), possibly providing better target detection or initial discrimination of an unattended object. Because the activation of low-threshold bursts requires removal of inactivation by membrane hyperpolarization, the TRN seems ideal for providing the in-

hibition necessary to modulate the responses of LGN cells during attentional processing (Crick, 1984). However, little is known about the way TRN activity changes with attention.

A recent article by McAlonan et al. (2006) in *The Journal of Neuroscience* addressed this issue by examining the activity of TRN neurons during a cross-modal attention task. The authors recorded from single neurons in two macaque monkeys trained to shift attention between two stimuli. The monkeys were required to direct attention to the appropriate sensory stimulus, an auditory tone or a visual spot, cued by the color of a central fixation point. A green fixation point signaled a visual trial, whereas a red fixation point indicated an auditory trial. After both stimuli were presented simultaneously for 500–1000 ms, either the auditory or visual stimulus was decreased in intensity independently of the other. The monkey was required to maintain its gaze until two blue spots appeared below and above the central fixation point and then make a saccade to one of the targets only if the intensity of the attended stimulus changed. Therefore, a green fixation point instructed the monkey to attend to a visual stimulus and saccade to the upper target if the spot dimmed during the trial. Conversely, a red fixation point indicated an auditory trial and that a saccade should be made to the bottom target if the volume of the tone decreased.

Although the authors did not observe burst firing with or without attention in TRN cells, they reported high background activity and a transient response of in-

creased neuronal discharge to the stimulus onset [McAlonan et al. (2006), their Fig. 2 (<http://www.jneurosci.org/cgi/content/full/26/16/4444/F2>)]. The transient response occurred when attention was directed to either stimulus [McAlonan et al. (2006), their Fig. 4A (<http://www.jneurosci.org/cgi/content/full/26/16/4444/F4>)]. However, the amplitude of the response was greater when attention was shifted to the visual spot compared with the auditory tone [McAlonan et al. (2006), their Figs. 4B (<http://www.jneurosci.org/cgi/content/full/26/16/4444/F4>) and 5A (<http://www.jneurosci.org/cgi/content/full/26/16/4444/F5>)] with no change in response latency or duration. On average, the peak response was 10% greater for the attended visual stimulus, and the majority of TRN cells exhibited higher neuronal responses during visual trials compared with auditory trials [McAlonan et al. (2006), their Fig. 5C (<http://www.jneurosci.org/cgi/content/full/26/16/4444/F5>)].

To ensure that the monkeys were selectively attending to the appropriate stimuli, two indices were used to determine their level of performance. The results suggest that attention was directed to only one stimulus during each trial. A bias for the visual stimulus was expected because of the highly visual nature of monkeys. Therefore, it seems important to examine effects of attention within a single modality, and additional investigations focusing on the modulation of a visual stimulus are warranted. Figure 1 illustrates such a visual attention task using intramodal spatial cues in which the auditory sensory stimulus has been eliminated, thereby re-

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moving any biases between competing sensory modalities and enabling investigators to provide a clear interpretation of the effects of attentional modulation.

Moreover, the core of Crick's (1984) hypothesis is based on the spatial specificity of synaptic inputs and suggests that TRN activity results in spatially organized positive feedback. Because of the topographic arrangement of inputs within the thalamocortical circuit, an active patch of cortex may stimulate similar spatial regions of the TRN and LGN, resulting in vertical assemblies. According to Crick (1984), the TRN may effectively intensify activity by producing rapid firing of bursts within a subset of thalamic neurons and suppressing the remaining neurons. This may play out as a "push-pull" system, in which cortical feedback from layer VI plays a defining role in setting up the spatial organization of attentional modulation (Tsumoto et al., 1978) and directs the searchlight to the attended target.

In summary, McAlonan et al. (2006) performed the first study examining the neuronal mechanisms of attentional modulation in TRN neurons of nonhuman primates. The TRN neurons showed increased activity in response to a visual stimulus with attention. Ultimately, the increased activity could play a role in attentional processing by facilitating visual

Figure 1. Visual attention task using spatial cues. A green fixation point indicates that attention should be directed to the circle on the right, whereas the red fixation point instructs the monkey to attend to the left circle. During the trials, either spot could dim or remain constant independently of the other. If the appropriate stimulus decreases in intensity, the monkey should saccade to the corresponding target when the blue dots appear. [Figure adapted from McAlonan et al. (2006).]

detection and discrimination through the initiation of burst firing in LGN cells. Such increases in TRN activity may also underlie selective firing reductions in regions of the LGN outside of the attentional spotlight, or in other sensory modalities by interactions occurring through intrathalamic projections (Crabtree, 1999).

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