Discrete photoentrainment of the mammalian central clock is regulated by a bimodal network in the suprachiasmatic nucleus

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Objective

Creatures on the earth have to adapt and predict the periodic changes of day and night to facilitate their survival and fitness, which endogenous circadian clocks that can be entrained by the environmental light changes are critical. The clocks can harmonize with the environment by shifting their circadian phase delay or advance depending on the circadian time receiving stimuli. The circadian time-dependent response function is described as the phase response curve (PRC). In mammals, the suprachiasmatic nucleus (SCN) located in the bottom of the hypothalamus is in charge of the master circadian oscillator and integrating environmental light signals transmitted through the retinohypothalamic tract that trigger photoentrainment of circadian rhythms. However, how the SCN computes PRC remains unclear.

Methods

To elucidate it, we observe acute light responses of SCN in unanesthetized mice using fluorescent genetically encoded calcium indicators relayed through gradient-index endoscopes, enabling repeated observation of the same set of neurons in the SCN under various conditions. Additionally, by chemogenetically modulating select regions of the SCN, we successfully isolated the delay portion of the PRC.

Results

The results showed distinct neuron activity patterns at different circadian time zones, including phase delay zone, phase advance zone, and the behaviorally irresponsive dead zone. Moreover, the correlation between neuron activities and the composition of light-responsive neurons is changed between circadian time zones.

Conclusion

Instead of conventional simple hierarchical models of SCN information flow, our findings suggest that SCN employed a bimodal network to process light signals separately in the early and late subjective night.

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