

Neuronal ensemble bursting in the basal forebrain encodes salience irrespective of valence

Shih-Chieh Lin^{1,2}, Miguel A.L. Nicolelis¹⁻⁵

1 Dept. of Neurobiology, Duke University Medical Center, Durham, NC, USA

2 Center for Neuroengineering, Duke University, Durham, NC, USA

3 Dept. of Biomedical Engineering, Duke University, Durham, NC, USA

4 Dept. of Psychological and Brain Sciences, Duke University, Durham, NC, USA

5 Edmond and Lily Safra International Institute of Neuroscience of Natal, Natal RN, Brazil

The main goal of animal behavior is to maximize reward and avoid punishment. To achieve this goal, animals similarly attend to both types of motivationally salient events despite their opposite hedonic valence. Recent evidence suggests that the opposite hedonic valence of reward and punishment are processed by different and possibly opposing neural systems. However, it remains unknown whether motivational saliency of reward and punishment is processed by the same valence-specific neural systems, or alternatively, is encoded separately as a distinct and valid neurobiological construct.

Here we show that motivational saliency is encoded by ensemble bursting of basal forebrain (BF) neurons in behaving rats. We observed that motivationally salient sensory cues that predicted either sucrose or quinine delivery in a Go/Nogo task elicited a similar brief bursting response in many BF neurons. This bursting response occurred irrespective of the cue's sensory modality, the associated motor response and the hedonic valence of the expected outcome. BF ensemble bursting emerged as cues acquired motivational saliency and predictive ability through associative learning and diminished after the cue-outcome associations underwent extinction. The same BF neurons also responded to both primary reward (sucrose) and punishment (quinine) with highly similar bursting patterns. These salience-encoding BF neurons represented a homogeneous subset of BF *non-cholinergic* neurons because they did not change their average firing rate across wake-sleep states [1] and their firing properties were consistent with in vitro characterizations of BF non-cholinergic neurons [2]. Finally, the relationship between BF ensemble bursting and behavioral performance was documented by showing that BF bursting responses predicted successful detection of near-threshold tones in a tone detection task.

Our results point to the existence of an independent salience-encoding system, mediated by ensemble bursting of BF neurons. This discovery suggests that the valence and salience of attended stimuli are encoded by two major neuromodulatory systems – the midbrain dopaminergic neurons and BF non-cholinergic neurons – using similar bursting responses. Contrary to the traditional view that BF functions are mediated mostly via cholinergic neurons, our findings provide the first evidence regarding the in vivo functions of the poorly understood BF non-cholinergic neurons in behavioral contexts. The encoding of motivational saliency by BF ensemble bursting may improve behavioral performance by transiently enhancing cortical gamma oscillation power [3] and, therefore, mediating the influences of attention on cortical processing. Together, our results support the hypothesis that BF ensemble bursting represents a novel candidate mechanism for attention.

- [1] Lee, M.G., et al., *Cholinergic Basal Forebrain Neurons Burst with Theta during Waking and Paradoxical Sleep*. J. Neurosci., 2005. **25**(17): p. 4365-4369.
- [2] Alonso, A., et al., *Differential oscillatory properties of cholinergic and noncholinergic nucleus basalis neurons in guinea pig brain slice*. Eur J Neurosci, 1996. **8**(1): p. 169-82.
- [3] Lin, S.C., D. Gervasoni, and M.A. Nicolelis, *Fast modulation of prefrontal cortex activity by basal forebrain noncholinergic neuronal ensembles*. J Neurophysiol, 2006. **96**(6): p. 3209-19.