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Opinion

Times for the Neuroscience: Patch-Clamp Recordings and Optogenetics in Decoding Neural Circuits

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Deciphering neural circuits is crucial to understanding brain function and dysfunctions. Multiple patch-clamp recordings assisted with optogenetics makes it more convenient for the dissection of neural circuits [1], and the combination of these two techniques provides deeper clarification for the synaptic contributions of specific neurons or nuclei in different brain areas. On the one hand, traditional patch-clamp recordings provides the possibility of decoding cortical neural microcircuit mechanisms underlying some neurological disorders using animal models [2-4]. Compared with traditional patch-clamp recordings on cultured cells and acute brain slices, the development of *in vivo* patch-clamp recordings fulfills a direct measure of neuronal activity and delineates synaptic inputs from neural circuits in living animals [5]. However, on the other hand, it is relatively a little difficult to investigate properties of neural circuits in freely behaving live animals. In contrast, optogenetics compensates the disadvantage of patch-clamp recordings by investigating synaptic dynamics in freely moving animals [6]. Moreover, due to the precise spatiotemporal control of delivered stimulation on defined cells and circuits, optogenetics has contributed greatly in tremendous research areas including the learning and memory processes [7-10], the olfactory pathway [11], the dissection of neural circuits underlying mood disorders [12,13], psychiatric diseases [14-16] (references therein) and neurodegenerative diseases [17]. Actually, based on the great precision in non-invasive optical control of specific neural circuits, optogenetics has also been widely used for the treatment of some neurological diseases such as epilepsy [18,19] and stroke [20]. Besides the crucial role of optogenetics in deciphering neural circuits, its application in investigating non-neuronal cells such as astrocytes and gliotransmitters [21], the drug discovery [22] and some non-neurological diseases [23,24] has been gradually increasing. Last but not the least, optogenetics also shows promise for the restoration of functional vision in patients with outer retinal degenerations [25]. Though limitations of patch-clamp recordings [26-28] and optogenetics [29], these two approaches as important research tools are continuing growing in many laboratories around the world, indicating that times for the neuroscience in patch-clamp recordings and optogenetics will be definitely prosperous now and also in the future. It will be great interest to unravel mechanisms underlying abnormal behaviors of neurological diseases (e.g. depression and epilepsy) at cellular, neural circuit network and behavioral levels using a combination of electrophysiological, optogenetics, morphological and behavioral techniques. Taking advantage of patch-clamp recordings and optogenetics to explore neural circuits in animal models will certainly open new landscapes and shed some light on the pathogenesis of some neurological and non-neurological diseases in human beings.

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