Spatio-Temporal Structure of Cerebellar Responses to ‘Tidal-Wave’ Stimuli

A. Brandt, D. Heck, A. Aertsen, U. Egert

Neurobiol. & Biophys., Inst. Biol. III, Univ. Freiburg, Schänzlestr. 1, 79104 Freiburg, Germany
bradt@biologie.uni-freiburg.de, http://www.brainworks.uni-freiburg.de

Parallel fibers (PF) of the cerebellum have been linked to movement control in the tidal wave theory\(^1\). It states that the spatio-temporal structure of the incoming activity is crucial for PF driven Purkinje cell (PC) responses. Experimental support for this model has been found \textit{in-vitro} using horizontal cerebellar slices. These experiments showed direction-dependent induction of PF and PC field potential and single unit responses by specific spatiotemporal stimulation patterns delivered to granule cells.

To investigate the spatial structure of field potential responses in this slice model in more detail we have applied a recently introduced recording technique using planar microelectrode arrays (MEAs)\(^2\), allowing us to monitor the spatiotemporal extent of the response.

Results are in agreement with the observations of Heck\(^3\). Successions of current pulses delivered to the PF with a stimulus electrode array at delays simulating action potential spreading along the fibers were particularly efficient. Such volleys induced postsynaptic responses when their sequence was timed to maximize spatiotemporal summation. Stimuli placed with short delays at \textit{progressively more distant} (antidromic) or random positions with respect to the recording sites elicited shallow responses fading at short distances from the site of stimulation. Volleys of \textit{progressively closer} (orthodromic) stimuli, however, elicited a sharp wave of excitation spreading along PF, away from the stimulus position.

This type of response was observed on all electrodes beneath the PF layer (i.e. across a stretch of max. 1.4 mm) after orthodromic stimulation. Secondary, \textit{Ca}\(^{2+}\) dependent responses indicated successful transmission across PF/PC synapses with orthodromic stimulation.

References:

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