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Chaotic mossy fiber stimulation efficiently increases the frequency of epileptiform bursts in rat CA3 hippocampal slices

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Abstract. We investigated effects of different temporal pattern stimuli on induction of epileptiform bursts in rat CA3 hippocampal slices. Average frequencies of stimuli are the same and are in the theta frequency range. Chaotic mossy fiber stimulation efficiently increases the frequency of epileptiform bursts in rat CA3 hippocampal slices. This is because the chaotic signal is an effective temporal pattern to increase the synaptic efficacy in the hippocampal CA3 region.

Keywords: Chaos; Temporal pattern; CA3; Hippocampus; Epileptiform burst; Theta rhythm; Slice; Mossy fiber

1. Introduction

It has been reported that chaotic activity exists in the central nervous system [1,2]. However, functional roles of the chaotic activity in the brain are still unclear. In the hippocampus, the dentate gyrus was found to work as a band-pass filter for theta rhythm in vivo experiments [3]. It has also been reported that the dentate gyrus has properties of a band-pass filter for theta rhythm in vitro experiments [4]. Signals at the theta frequency are therefore transmitted to the hippocampal CA3 region from the dentate gyrus through mossy fibers. It is believed that realistic signals in the hippocampus is not periodic but fluctuates.

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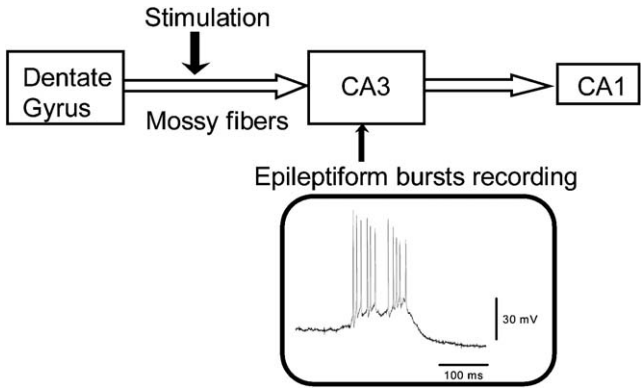

Fig. 1. Experimental setup. A recording electrode was placed on the pyramidal cell layer in CA3 and mossy fibers were stimulated by a fine bipolar electrode. The lower panel shows epileptiform bursts induced in CA3 by chaotic or tetanic mossy fiber stimulation.

Our objective is to determine the effects of chaotic stimulation on induction of epileptiform bursts in rat CA3 hippocampal slices.

2. Materials and methods

Sagittal hippocampal slices, 400 μm thick, were obtained from male Wistar rats, 3–5 weeks of age (60–130 g). The slices were placed on the liquid/gas interface chamber maintained at $34 \pm 0.5\,^{\circ}C$. ACSF bubbled with 95% O_2, and 5% CO_2 was perfused. Field potential was recorded by a glass microelectrode (tip diameter: 20–30 μm) placed on the pyramidal cell layer in the CA3 region and the mossy fibers were stimulated by a fine bipolar electrode (Fig. 1). Gaussian and chaotic patterns were used for stimulation. The chaotic pattern was generated by an iteration map which is a spiky convex function.

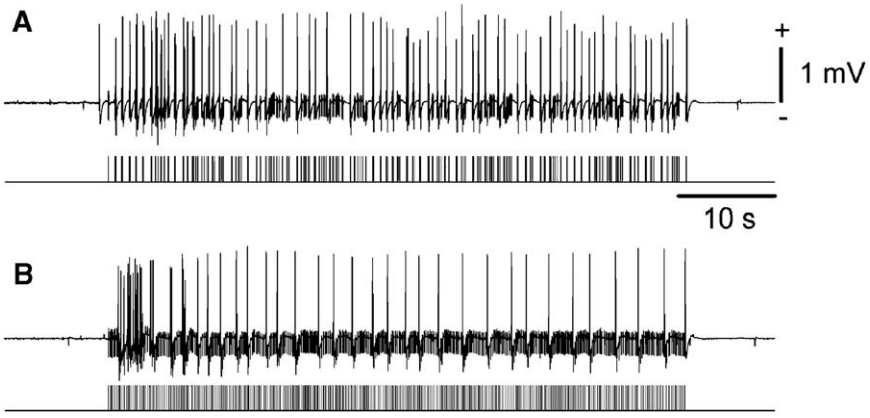

Fig. 2. Epileptiform bursts induced in CA3 by mossy fiber stimulation. (A) Chaotic pattern stimulation. (B) Gaussian pattern stimulation. The mean frequency of the two stimulus patterns is 6.7 Hz.