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SHORT COMMUNICATION
Attention-dependent coupling between beta activities recorded in the cat's thalamic and cortical representations of the central visual field

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Abstract

We have previously proposed that enhanced 16–24 Hz (beta) local field potential activity in the primary visual cortex and lateral geniculate nucleus may be an electrophysiological correlate of the attentional mechanism that increases the gain of afferent visual information flow to the cortex. In this study, we measured coupling between beta signals recorded in the thalamic (i.e. lateral geniculate or perigeniculate) and cortical representations of the central visual field (within 5° from *area centralis*), during visual and auditory attentive situations. Signal coupling was calculated in two ways: (i) by means of crosscorrelation between raw beta activities, which depends primarily on phase coherence, and (ii) by phase-independent crosscorrelation between amplitude envelopes of beta activities. Mean amplitudes of raw signal crosscorrelations obtained for thalamo-cortical recording pairs were not significantly different when calculated during behavioural demands for either visual or auditory attention. In contrast, amplitudes of envelope crosscorrelations obtained during behaviour requiring visual attention were, on average, two times higher than those calculated during the auditory task. This attention-related coupling emerged from synchronized amplitude modulation of beta oscillatory activity that occurs within the cortico-thalamic circuit involved in central vision.

Introduction

In the mammalian visual system, the most numerous synapses on principal cells in the lateral geniculate nucleus (LGN) and on their recurrent inhibitory interneurons in the perigeniculate nucleus (PGN) are formed by corticofugal fibers of pyramidal cells in layer VI (Ide, 1982; Montero & Singer, 1984; Wilson *et al*., 1984; Montero, 1991). Synapses formed by this rich cortico-thalamic projection show a prominent frequency potentiation mechanism, which was postulated to increase the gain of the retino-cortical flow of information during visual attention (Lindström & Wróbel, 1990). The attentional role of the cortico-thalamic pathway was supported by observations of attention-dependent increase of activity in the LGN of the cat (Bekisz & Wróbel, 1993; Wróbel *et al*., 1994) and in the LGN and thalamic reticular nucleus of the rat (Montero, 1997; McAlonan *et al.,* 2000; Montero, 2000). Attention-related changes of activity were also found in the LGN of the monkey (Vanduffel *et al.,* 2000).

In our previous experiments, cats' attention was shifted between visual and auditory systems in a spatial differentiation task, which involved stimuli of either modality (Bekisz & Wróbel, 1993; Wróbel *et al*., 1994). It appeared that local field potentials (LFPs), recorded in the LGN and primary visual cortex (VCx), contained more beta (16–24 Hz) activity when cats attentively expected visual rather than auditory cue stimuli. Moreover, such enhancements of beta power were not found prior to erroneous behavioural responses of the animal. We have therefore proposed that enhanced beta activity within the VCx and LGN might be an electrophysiological correlate of the attentional mechanism that increases the gain of afferent visual information flow to the cortex.

The visual task in our experiments required a cat to react to the visual cue stimulus. This process should involve central vision. In order to investigate the functional relationship between the thalamus and visual cortex in visually and auditory attentive situations, we measured coupling between 16 - 24 Hz beta signals recorded in the representations of central visual space in both these structures.

Materials and methods

The experimental procedures described below were approved by the Ethics Commission at the Nencki Institute.

Behavioural paradigm

Data presented in this paper were obtained from three cats with electrodes chronically implanted at various sites of the cortico-geniculate visual system. Cats were trained to solve a spatial differentiation test. They were placed in a small ($20 \times 45 \times 45$ cm) wooden cage facing two translucent doors 5 cm apart. The animal was kept away from the doors by a movable transparent screen.

The differentiation paradigm has been described in detail previously (Wróbel *et al*., 1995; Bekisz & Wróbel, 1999). Two animals (Cats 4 and 5) had to notice the site of disappearance of either a visual or auditory stimulus (being a cue at the end of the presentation period), moving continuously back and forth in a horizontal direction during 10–25 s long trials. The trials of the third animal (Cat 6) started with a 1-s long preparatory visual or auditory stimulus: a diffuse light on the

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