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The contribution of glial cells to spontaneous and evoked potentials

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Abstract

The mechanism by which brain cells generate alpha and other rhythms remains obscure, and the possible participation of glial cells in the process continues to be debated. We will present data obtained from freely moving rats in which flashes produced by a light emitting diode implanted under the skin of the scalp evoke retinal and cortical responses recorded through electrodes implanted behind the eye and over visual cortex. In the retina, which is a brain-like structure isolated in the periphery during embryology, the b-wave evoked response is thought to be produced by the Müller glial cells as they maintain potassium ion homeostasis in the extracellular space during the synaptic events initiated by rod and cone activation. We will report on the results of a search in this retinal analogue of the brain for spontaneous activity in the EEG spectrum. © 1997 Elsevier Science B.V.

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1. Introduction

During this conference Riitta Hari said 'to make sense of alpha events we should proceed from single cell dynamics to population dynamics'. We heartily agree, and offer for your consideration the neuropile visualized in any good electron micrograph of mammalian cortex as the brain cell population whose dynamics are most worthy of analysis. Neuropile is an intimately intertwined collection of microscopic membranes within which

interactions such as glia–glial, glia–neuronal, and neuro–neuronal are constantly taking place across the fluid-filled extracellular space. Neuropile is ubiquitous, and understanding its population dynamics will surely help unravel some of the mysteries of brain function. The first author of this paper began thinking this way in 1961, when he declared an interest in the physiology of glial cells (Galambos, 1961), and has speculated further on the matter since then (Galambos, 1989). Very recently, after 35 years of searching, we have at last discovered a way to study normal glia in situ, and have begun to use the preparation for testing the idea that dynamic interactions between astro-

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cytes and neurons contribute to the electrical activities recorded through scalp electrodes. We recently published the first report of these experiments (Galambos et al., 1994); they deal with evoked potentials, not alpha rhythms, but perhaps after considering these earliest results you may agree the method could uncover useful new facts about the electrogenesis of rhythmic brain oscillations as well.

2. The method

Our preparation exploits the rat visual system, a typical mammalian collection of retinas, optic nerves, a chiasm, and bilateral central pathways that end in visual cortex. We implant stainless steel electrodes behind each eyeball and on each visual cortex, and reference these during recording to a stainless steel screw turned into the bone over the cerebellum. We also implant a small red-light emitting diode (LED) under the skin over the left eye. Wires from the implants are soldered to a plug glued to the skull through which connections to the diode stimulus generator and EEG amplifiers can be made at any time.

This preparation enjoys three advantages over similar ones others have described. First, the LED illuminates the entire head, and the light that reaches the retina (apparently through the scleral covering of the eyeball) appears to remain constant regardless of eyelid position, pupil size, eyeball rotation, or behavioral state. Second, ERG electrodes placed permanently behind each eyeball instead of temporarily on the sensitive cornea permits constant 24-h recording, if desired, of simultaneous retinal and cortical responses to the same visual stimulus. Finally, our rats tolerate these implants well, and have delivered data for as long as 4 months, which is a substantial fraction of the average rat lifetime.

3. The main result

We test our rats during the day, which is when they tend to sleep. They move freely about inside a small box whose plexiglass walls allow us to observe their behavior, and we continuously monitor the ongoing EEG. Fig. 1 shows typical EEG samples collected from a rat judged by both behavioral and EEG criteria to be AWAKE, or in

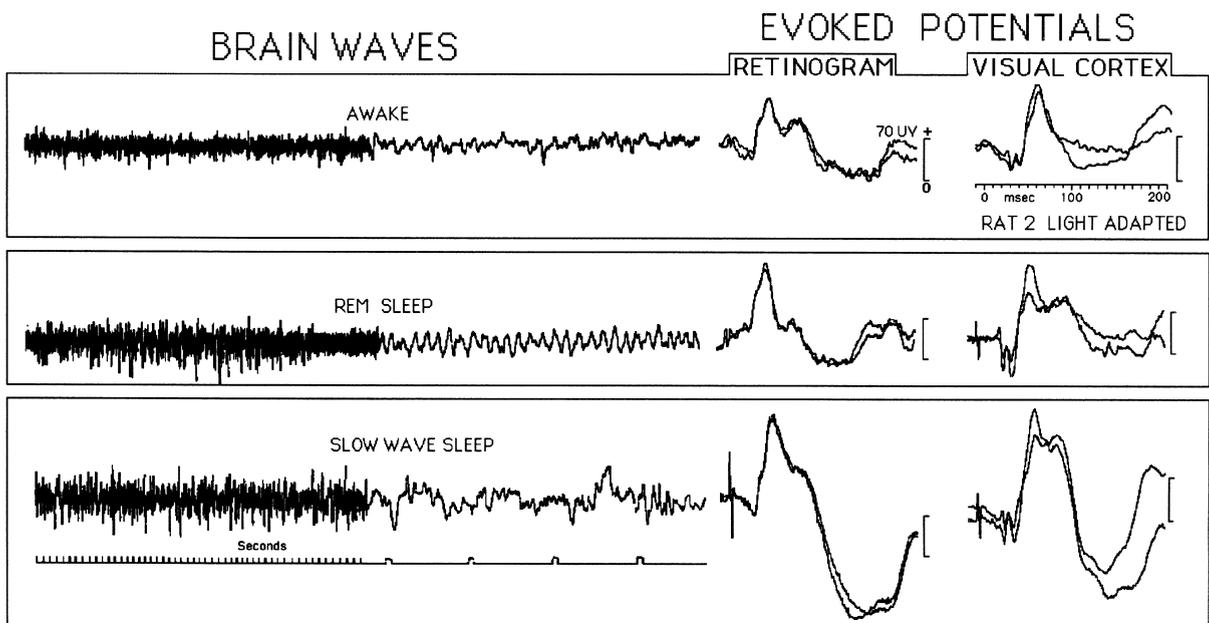


Fig. 1. Retinal and cortical flash responses evoked during three stages of sleep. See text for details.

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