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Phase dynamics of Brain Waves in Frequency Locking to Repetitive Flicker Stimuli

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Spatiotemporal phase dynamics of response of brain wave to flicker stimuli are investigated to compare nonlinear property of the alpha wave with that of steady-state visually evoked potentials (SSVEPs). Brain waves at rest and under the stimuli were recorded from 16 healthy subjects aged 21-25 (3 females and 13 males). Flicker stimuli consisting of flushes of 14 red light emitting diodes were applied to the subjects with their eyes closed for 20 s per trial. The stimulus frequency is randomly set at an integer from 5 to 20 Hz each trial. Under flicker stimuli the frequency of which is outside the range of the alpha wave (8-13 Hz) , the response of the brain wave which mainly consists of the SSVEPs, forms the phase reversal between the frontal and occipital lobes for most of the subjects. Under the flicker stimuli the frequency 8-13 Hz, the response of the brain wave, including the entrained alpha wave as well as the SSVEP, also shows the phase reversal. Such a phase reversal is also seen in the spontaneous alpha wave although the phase difference between the frontal and occipital lobes is varied complicatedly with time. Spatial phase gradient of the SSVEPs is uniform from the frontal to occipital regions, which is similar to that of the spontaneous alpha wave. These results suggest that the spatiotemporal dynamics of the SSVEPs and alpha wave are closely related to each other under the flicker stimuli. The underlying mechanism of the SSVEPs may be considered in the context of the entrainment of nonlinear oscillators.

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Synthesis of a robust pace making network by oscillatory electrode assemblies

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Spatiotemporal patterns emerging through coupling of relaxation oscillatory electrode pairs are studied. Each pair, consisting of an iron anode and a copper cathode, oscillates periodically under fixed applied potential difference. Controlling the applied potential, the pair also behaves as a chaotic oscillator and/or an excitatory oscillator. The relationship describing the dynamic profiles of the single pair is mathematically similar to the Hodgkin-Huxley equations. The behavior of the network made of 10-40 pairs is compared with the response of coupled relaxation cells of neurophysiological interest. The network consisting of almost identical self-sustained relaxation oscillators synchronizes rapidly (within few oscillatory cycles) and differences of individual natural frequencies as well as boundary effects are compensated. When oscillators are coupled through neighboring electrodes, the response is synchronized by a simultaneous segregation of groups due to enhancement or inhibition of the oscillations depends on the relative position of interacting anodes and cathodes. The robust pace making network is synthesized by the heterogeneous combination of oscillatory and excitatory pairs. When the primary pace making oscillator is damaged, this system has a self-repairing function; the secondary and tertiary oscillator is able to relay the task with enlarging the pulse intervals of the network. This is reasonably identical to the spatiotemporal motion in the biological system such as upper urinary tract.

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Transitions between characteristic oscillation patterns in the plasmodium of Physarum polycephalum

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Synchrony in the rhythmic contraction has long been regarded as a single characteristic of the Physarum plasmodium. We found that the plasmodium actually exhibits various contraction patterns such as standing wave like pattern, chaotic pattern with plural rotating waves, a rotating spiral wave, and synchronous pattern, and transitions between these patterns took place spontaneously. An endoplasmic drop (about 1 mm in diameter) prepared from a large plasmodium developed rhythmic contraction within 10 min by forming actin-myosin filaments as found by Bottermann about 40 years ago. The first mode is characterized as standing wave. At a certain moment, the contraction waves start to propagate accompanying decrease in the amplitude, resulting in chaotic mode with plural rotating waves. Disappearance of the spiral cores accompanying acceleration of wave propagation occurs, and a single rotating spiral eventually governs the entire organism, and this mode continues about 60 min or less. At the last stage of this mode, drift and disappearance of the spiral core takes place, and then it turns into the synchronous pattern.

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Model of collective motion of motors in muscle oscillation

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In general, the contractile unit of muscle takes one of two states, relaxation or contraction. The contraction results from relative sliding of the thick (myosin) and thin (actin) filaments in sarcomere, which is the contractile unit of striated muscle. In the state of SPontaneous Oscillatory Contraction (SPOC), sarcomeres repeat slow shortening and quick extension spontaneously [Okamura,N. and Ishiwata,S., J.Muscle Res.Cell Motil. 9, 111-119(1988).]. How does such a regular oscillation occur when many molecular motors, which function as a stochastic nano-machine, are assembled? It seems to be difficult to explain SPOC in the conventional framework of muscle contraction. Recently, a new advance in non-equilibrium statistical mechanics has been made on describing fluctuations in systems at and out of equilibrium. These results have been applied to the modeling of biological molecular motors such as rotary F1-ATPase motor and linear myosin-actin motors [Gaspard, P., Prog. Theor. Phys. Supp. in press (2006)]. In this model, the stochastic process is formulated by a set of coupled Fokker-Planck equations containing biased diffusion and random jumps between some chemical states. To understand the SPOC mechanism, we modify this model. Here we take into account the experimental observations of SPOC and single-molecular behavior under external load to this modified model and try to explain the collective mode of motion observed in an assembly of myosin motors.