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Somatosensory evoked potentials during a rubber-hand illusion in schizophrenia

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Abstract

The rubber-hand illusion (RHI), an illusion in which tactile sensations are referred to a synthetic alien limb, is enhanced in schizophrenia patients. Somatosensory evoked responses of the illusion were compared between schizophrenia patients and normal control subjects. Schizophrenia patients had significant alterations in long latency evoked responses during the illusion. These findings support the hypothesis of alterations in associative higher-level neuronal activity in schizophrenia. The findings support previous results pointing to alterations in associative brain regions in schizophrenia.

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1. Introduction

Evoked potentials (EPs) are the brain's transient response to externally applied stimuli—such as light flashes, auditory clicks and mild electrical shocks. These stimuli respectively form the visual evoked response or potential (VEP), auditory EP (AEP) and somatosensory EP (SEP). Since the EEG has much higher amplitude than the EP, it is necessary to apply a stimulus repetitively at random times and average the results to effectively remove the random background EEG and visualize the EP. This computerized

technique is often referred to as signal averaging. Classic neurophysiology employs a few EP channels and evaluates the short latency response (e.g., under 30 ms). When obtained, these signals are seen to arise from specific deep brain structures and allow for assessment of structures within the brain stem and thalamus. When longer latencies (longer times from stimulation, e.g., 300 ms) are evaluated, signals appear to be coming from the cortical mantle. In short, EPs roughly reflect the organization of neuronal circuitry in the millisecond range of electrical activity.

Schizophrenia is a complex disorder with many cognitive deficits. According to Bleuler (1969), schizophrenia is the splitting of mental functions. Such “splitting” is probably correlated with disturbances of neural brain organizations, for example, disconnection

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syndromes (Friston and Frith, 1995; Friston, 1998) and other deregulations (Peled, 1999) of the neural networks spread in the brain. The effort to correlate schizophrenia deficits with underlying disturbances of brain organization is the subject of intensive investigations (for review Andreasen, 1997, 1999). The revelation of correlates of brain deficits to schizophrenia symptoms would shed light on the etiology of this debilitating disease.

We investigated the EPs of an illusion effect differentiating schizophrenia patients from normal controls (the rubber-hand illusion; Botvinick and Cohen, 1998; Peled et al., 2000). We assumed that the differences in the illusion effect between patients and normal controls are correlated with a significant deviation of the relevant EPs in patients compared to normal controls, thus reflecting aberrant millisecond range organization of neuronal circuitry in schizophrenia.

The rubber-hand illusion (RHI) is an illusion in which tactile sensations are referred to a synthetic alien limb (Botvinick and Cohen, 1998). In this procedure, subjects are seated with the left arm resting upon a small table. A standing screen is positioned beside the arm to hide it from the subject's view and a life-sized rubber model of a left hand and arm is placed on the table directly in front of the subject (Fig. 1). The subject sits with eyes fixed on the artificial hand while two small paintbrushes are used to stroke (synchronous brushing) the rubber hand and the subject's hidden hand. Strokes are delivered at a frequency of 1 s intervals, approximately 900 strokes for each experiment (lasting 15 min). Perceptual effects of the RHI were recorded on a questionnaire designed for that purpose.

In a previous study (Peled et al., 2000), we found that schizophrenia patients experienced enhanced RHI compared to controls. This was evident both by the shorter periods needed to evoke the illusion and the ratings of illusory intensity as registered with the questionnaire. We assumed that enhanced illusion supports the idea of spurious reconciliation between brain processes (vision, touch and proprioception) as a mechanism of brain pathology in schizophrenia. In this study, hypothesis altered somatosensory evoked potentials (SEPs) that correlate with the differences of the RHI in patients compared to normal controls. Based on the disconnection approach to schizophre-

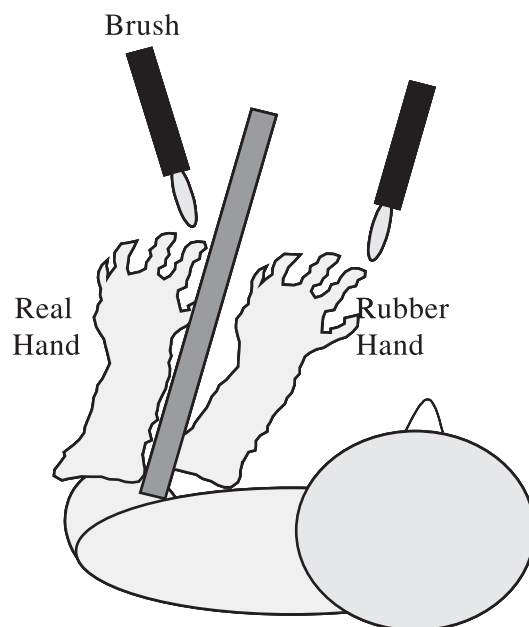


Fig. 1. Experimental setting involved subjects seated with their left arm resting upon a small table. A standing screen was positioned beside the arm to hide it from the subject's view and a life-sized rubber model of a left hand and arm was placed on the table directly in front of the subject. The subject sat with eyes fixed on the artificial hand while two small paintbrushes were used to stroke (synchronous brushing) the rubber hand and the subject's hidden hand.

nia, we assume involvement of associative cortices in these SEP alterations.

2. Methods and materials

2.1. Subjects

Written informed consent was obtained from all subjects participating in the study following a complete explanation of the study and procedures. The study was approved by the Institutional Review Board. A total of 38 right-handed adult subjects participated in the study (19 schizophrenia inpatients and 19 healthy controls). Subjects with past history of neurologic disorders or drug abuse were excluded. Schizophrenia patients and healthy controls were matched for age (mean 32, S.D. ± 10 ; mean 25, S.D. ± 8.7 , respectively, $t=0.87$, $P>0.38$), gender (M16/F3; M17/F2, respectively) and education meas-

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