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Relationship between resting alpha activity and the ERPs obtained during a highly demanding selective attention task

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Abstract

In spite of previous reports on the relationship between ongoing EEG and ERPs, there remains a lack of agreement on the nature of their nexuses. The aim of the present study was to evaluate the relationship between resting EEG and the ERP components in two groups of healthy subjects with different levels of performance in a highly demanding selective visual attention task. Young adults were classified according to the amount of their correct responses in the task, into high (HP; averaged hits (AH): 86%) and low performance groups (LP; AH: 59%). EEG was recorded during rest, prior to task performance and absolute (AP) and relative power (RP), as well as inter- (rTER) and intrahemispheric (rTRA) correlation were calculated. ERPs during task performance were also obtained and their amplitude and latency measures were assessed. Results showed that individuals with better behavioral performance had a higher synchronization between both hemispheres during rest as well as higher amplitude and shorter latencies of N2 and P3. Principal Component Analysis revealed that alpha2 AP and RP were inversely related to P2 and N2 latency. Higher values of alpha1 and alpha2 rTER were clustered with higher P3 amplitude and shorter reaction time. In conclusion, the differences in the cortical organization of HP and LP at rest (EEG) seem to be associated to the way the brain reacts during information processing (ERPs).

Keywords: Alpha; Attention; Cognitive performance; Coherent activity; ERPs; EEG

1. Introduction

It is usually assumed that resting brain electrical activity could reflect a functional steady state which might represent the brain latent processing capabilities. In spite of several reports that seem to confirm a relationship between resting EEG and cognitive performance their nexuses for highly demanding cognitive tasks remain unclear.

Nevertheless, spontaneous (EEG) and event-related (ERPs) brain electrical activity recording has been a very useful tool for studying brain functioning during cognitive processes in humans. With regard to EEG, within and between individuals comparisons have generated descriptors of the association between different EEG states and specific cognitive processes (Başar et al., 1997; Klimesch, 1997).

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In general, changes in the EEG parameters during task performance have been mainly related to the intrinsic attributes of the task (duration, physical characteristics of the stimuli, cognitive demand, etc.) or to cognitive strategies used by the subjects (Rappelsberger and Petsche, 1988). The alpha frequency is probably one of the most studied bands of the EEG prior or during the performance of behavioral tasks. Early observations of task-related alpha suppression or "alpha blocking" interpreted its variation as an index of change in the attentional source. However, a wider range of functional significance had been suggested for this measure as a result of its correlation with primary sensory, cognitive and motor processing (Andrew and Pfurtscheller, 1997; Başar et al., 1997; Petsche et al., 1997).

Spencer and Polich (1999) reported that, as attentional requirements increased through different tasks, alpha1 and alpha2 power and mean frequency also increased. Similar results were described by Shaw (1996) in goal directed concentration tasks. Furthermore, a positive correlation between alpha frequency and intelligence test scores have been described, where higher alpha frequency and alpha peak frequency were found in subjects with higher intelligence scores (Kiroi et al., 1995; Jausovec et al., 2001).

The capability to reorganize the ongoing EEG and to lock in phase the alpha waves after stimulus presentation could change with age (Yordanova and Kolev, 1997), which also seems to increase the complexity of brain internal relationships (Anokhin et al., 1996, 1999). It may be possible that the capability to reorganize the EEG could be more developed in some individuals than in others and that it could be reflected in their performance of attention tasks. Furthermore, when EEG responses on a visual task are analyzed, slow and fast frontal alpha responses seem to be affected differentially by the age, which might suggest activation of functionally distinct alpha networks (Kolev et al., 2002).

Actually, slow and fast alpha frequencies seem to respond differently during information processing. Pfurtscheller and Klimesch (1992) proposed that differences in cognitive task demands are mainly reflected in fast alpha band, while slow alpha seems to have a more unspecific relationship with attention. In this sense, Klimesch (1997) quoted that the lower alpha band may reflect attentional processes while upper alpha levels are related to semantic memory processes.

In fact, the alpha band had also been correlated with memory performance. It was reported that the alpha frequency on good memory performers was higher than that found in bad ones (Klimesch, 1999). The author suggested that this could be because good performers are faster in retrieving information from memory and these data could indicate that alpha frequency is related to the speed of information processing or reaction time. It could not be set up, however, that smarter brains ought to process faster (Posthuma et al., 2001).

Başar (1992) proposed that EEG emerges from the activity of an ensemble of generators producing rhythmic activities in several frequency ranges. Usually, these generators are randomly active, but when sensory stimulation occurs, generators become coupled and act together in a coherent way. He proposed that the superimposition of this coherent activity in particular frequency ranges could, at least partially, determine ERP components. In this context, he postulated that if a brain structure is able to generate intrinsic activity in a given frequency, it possibly has the ability to respond to sensory stimulation in the same frequency. In this regard, a relationship between pre-stimulus theta and alpha activities and ERPs amplitudes has been reported (Başar et al., 2001b).

ERPs have shown their usefulness for studying attention, and there are several ERP components associated with selective attention processing such as N100, P200, N200 and P300 (Mangun and Hillyard, 1988). Specifically, P300-correlated ERP activity has been postulated to be involved in new information processing when attention is engaged to update memory representations (Donchin and Coles, 1988) and it has been reported as functionally associated with event-related alpha oscillations (Yordanova and Kolev, 1998).

Regarding the attention processes, a higher level of pre-stimulus alpha activity correlates with higher ERP amplitude in auditory attention and memory tasks, confirming the intimate relationship between spontaneous EEG in the pre-stimulus period and the resulting ERP from stimulus presentation (Barry et al., 2000; Fingelkurts et al., 2002).

Exploring the association between individual variability in the EEG and ERP component variation in an auditory oddball task, Intriligator and Polich