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Research Report

# Brain oscillations evoked by the face of a loved person

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ABSTRACT

Previous studies have shown a close interrelation between emotional processing and memory processes using facial stimuli and applying the concept of oscillatory brain dynamics. Amending prior findings the influence of neural correlates related to the emotional state termed "*romantic love*" was investigated. Specifically, the effect of feelings of love on face perception was of interest. Pictures of a "*loved person*" were presented to female subjects and the elicited responses were compared with responses to pictures showing faces of a "*known and appreciated person*" or an "*unknown person*" during EEG recordings ($n=20$ females). As a control condition *light stimulation* was employed. The sequence of faces shown was presented in random and block-design. EEG data was analyzed considering maximum amplitudes and topographical differences within the conventional frequency bands of delta, theta, alpha, beta and gamma. Differences between light and face stimuli were found in the delta and theta bands and differences between the face types and the two designs were found in the delta band. The delta response to the picture of the "loved person" showed significantly higher amplitude values, not only in comparison with the "unknown person", but also with the picture of the "appreciated person". Frontal lobes appear to react to different types of facial stimuli with specific increases in delta responses. The difference between the response to the "loved person" and of the "known and appreciated person" reflects the component of the emotion denoted as love. The findings and their interpretations are discussed within the framework of event-related oscillations and complex stimulus processing emphasizing the concept of dynamic localization.



## 1. Introduction

### 1.1. *Emotional processes and their interrelation with perception and memory*

Emotion is akin to a sensory modality, an internally directed sensory modality that provides information about the current state of the body itself (Solms and Turnbull, 2002). Further, according to the authors emotion adds a "sixth sense" to our conscious experience. This kind of a sixth sense experience embodies the aspect of consciousness that is left if all the externally derived contents are removed. James (1890) conceived emotion in terms of a sequence of events that starts with the occurrence of an arousing stimulus and ends with a passionate feeling, a conscious emotional experience. Le Doux (1999) states that a major goal of emotion research is, still, to

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elucidate this “stimulus-to-feeling” mechanism to figure out, what kind of processes take place between the stimulus and the feeling.

The role of memory in emotional processes is fundamental; therefore, it is essential to add some important views on “memory”, to the previous approaches investigating the “stimulus-to-feeling” mechanism. According to Fuster (1997), memory reflects a distributed property of cortical systems. An important part of the higher nervous function, such as perception, recognition, language, planning, problem solving and decision-making, is interwoven with memory. It is a property of the neurobiological systems; it serves them and is inseparable from their functions. It has been hypothesized that neuronal mechanisms described as selectively distributed oscillatory systems (or networks) may provide a general communication framework and that they can be a useful concept for functional mapping of brain oscillations (Mesulam, 1994). In past decades an increasing number of reports and reviews on “electrical oscillations in the brain” have emerged in the neuroscience literature and Mountcastle (1992) and Freeman (1999) stated that neuroscience is ripe for change. The functional importance of distributed multiple oscillations in the brain was emphasized for the first time in a series of reports in the 1970s (Başar, 1992; Başar et al., 1975a,b,c; Başar and Ungan, 1973). Selectively distributed and selectively coherent oscillatory activities in neural populations describe integration over the spatial axis (Başar, 1980). Consequently, integrative activity is a function of the coherences among spatial locations of the brain; these coherences vary according to the type of sensory and/or cognitive event and possibly the state of consciousness of the species (Başar, 1999 and 2004). The publications by Bressler and Kelso (2001), von Stein and Sarnthein (2000) and Varela et al. (2001) describe the trend of concerted activity of alpha, theta, delta and beta oscillations in distributed structures such as the reticular formation (RF), the hippocampus (HI), the thalamus and sensory cortices. The experimental work of Klimesch and co-workers show the possibility of differentiating the role of alpha and theta oscillatory activity during memory tasks. The results of this group support the hypothesis that ERPs can be understood and described in terms of the superpositions of several event-related oscillations recorded in various structures (Doppelmayr et al., 2000; Klimesch, 1999; Klimesch et al., 1999; Klimesch et al., 2000a; Klimesch et al., 2004; Klimesch et al., 2006). Moreover, these author’s experiments include memory tasks that differentiate between the oscillatory responses of good and bad memory performers.

### 1.2. Experiments with pictures of familiar versus unknown faces and happy versus angry faces

Returning to the actual scope of the current study, the investigation of a “stimulus-to-feeling” mechanism — the authors have recently included two paradigms with emotional components in their studies that are interrelated with perception and memory: the following were presented a) pictures of known faces, such as pictures of the subjects’ *own grandmother* (Başar et al., 2006, 2007) and b) pictures of *faces with happy and angry expressions* (Başar et al., 2006; Güntekin and Başar, 2007). The results using this approach indicate that differences in emotional expression and familiarity with the persons face are associated with the activity of different oscillatory networks. The brain response following presentation of percepts can be described as a construct in a multi-dimensional state manifested by changes in the amplitude of oscillatory responses within topological coordinates, and changes within the time axis, including delays and prolongations and coherence between locations. Given facial stimuli, a specific location can show a specific activation pattern, however, the formation of percepts is manifested by multiple oscillations with differentiated weight in large neural populations (Başar et al., 2006). Our results show that multiple brain oscillations clearly differentiate the known and unknown faces with varying degrees of selective-responsiveness in a short time window between 0 and 800 ms, with a broad distribution over the cortex. Mechanisms leading to the perception of the subject’s own grandmother are associated with parallel activations of neural assemblies in different cortical locations, which are detectable as a superposition of *delta*, *theta*, *alpha*, *beta*, and *gamma* oscillations. Thus, such percepts cannot be localized in a given specific region. Moreover, the differentiation of facial expression induces significant change, mainly, in *alpha* and *theta* oscillations (Güntekin and Başar, 2007; Başar et al., 2006, 2007). The presented evidence of *selectively distributed multiple oscillations* for differentiation of facial percepts is in conceptual accordance with conclusions about the selectively distributed processing in neurocognitive networks in the work of Goldman-Rakic (1988), Fuster (1997), and Mesulam (1990, 1994).

In the analysis of the electrophysiology of a facial percept, the experimenter is confronted with the process of face processing, which comprises (i) perceptual and memory processes required for the recognition of complex stimulation — such as a face, (ii) the identification of the particular face in view, and (iii) the analysis of facial expression (McCarthy, 2000), ,and (iv), since emotions are also a cognitive and memory related aspect, therefore, emotional involvement during the presentation of faces and different facial expressions should be taken into account.

Accordingly, extended studies should be developed and analyzed in order to find common and/or separate electrophysiological responses during face perception, face expression perception and the perception of other emotional stimuli. So far our studies equate emotional states with facial expressions, and therefore, it can be argued that emotions cannot be exhaustively comprehended only by using facial expressions. Nevertheless, our results and the results of others using similar approaches, represent initial steps in the attempt to describe the emotions elicited in this way. Since “emotion” is a general expression applied to all emotional states, such as anger, happiness, sadness and disgust, it can be assumed that all these emotions have separate and/ or common processes.

### 1.3. Experiments with pictures of a “loved person” versus unknown faces and simple light stimuli

From the information presented above, it can be seen that the current study should extend our recent experiments to the investigation of emotional processing and its interrelation with memory processes using facial stimuli and applying the