

Decoding emotional awareness

Cornelia Herbert^a, Beate Maria Herbert^b, Andrea Kübler^a, Paul Pauli^a

^aDepartment of Psychology I, University of Würzburg, Würzburg, Germany

^bDepartment of Psychosomatic Medicine and Psychotherapy, University Hospital Tübingen, Eberhard-Karls-University Tübingen, Germany

Correspondence: Cornelia Herbert, Department of Psychology I, University of Würzburg, Marcusstr. 9-11, 97070 Würzburg, Germany. E-mail: cornelia.herbert@psychology.uni-wuerzburg.de, phone +49 (0) 931 31 81981, fax +49 (0) 931 31 82424

Abstract. This research investigated the neural correlates associated with the processing of verbal stimuli describing participants' own emotions to explore whether neural responses to such stimulation could be used for the detection of emotional states in disorders of consciousness (DOC) and for basic communication by means of a BCI. In healthy participants silent reading of self-related emotional expressions spontaneously enhanced amplitudes of a late positive potential (LPP) in the EEG and activity in brain structures essential for reflecting upon one's own emotional state. Our paradigm could thus be used for the detection of consciousness in DOC and might be adapted for simple yes/no communication by means of BCI.

Keywords: emotion, self-consciousness, emotional awareness, communication

1. Introduction

Ever since William James, researchers have sought answers to the question what constitutes emotions and the self. Although no clear theoretical consensus has yet been reached, contemporary empirical research converges on the view that emotional and self-related stimuli (e.g., the subject's own name) capture attention quite automatically and effortlessly even in patients in whom and in situations in which conscious processing is severely compromised [Kotchoubey et al., 2009; Laureys, Perrin & Brédart, 2007]. Here, we present results from a series of EEG-ERP [Herbert, Herbert, Ethofer & Pauli, in press] and functional imaging studies [Herbert et al., in prep.] that investigated in healthy participants if emotional stimuli describing participants' own emotions would lead to similar enhanced and automatic processing as has been shown for emotional and personally relevant stimuli alone or whether this type of self-referential emotional stimuli leads to higher-order, cognitive processing that may involve activation within the brain's default network essential for reflecting about one's own mental and emotional state. Specific ERP and hemodynamic signal patterns as response to such stimulation could be used for (1) the detection of emotional states and (2) for basic communication by means of a BCI [Kübler and Kotchoubey, 2007].

2. Material and Methods

Twenty-three subjects (10 males, 13 females) participated in the EEG-study and fifteen subjects (6 males, 9 females) participated in the imaging experiment. Participants were all right-handed, healthy native speakers of German (mean age: 24 years) with no history of drug abuse, chronic physical conditions, neurological diseases, and with normal sense of hearing and normal or corrected to normal vision. Stimuli comprised unpleasant, pleasant and neutral verbal expressions. Expressions were either directly related to the participant, to another person or had no self-other reference. Stimuli were presented event-related, for either 600 ms (in the EEG-ERP study) or 1000 ms (imaging study). Participants' task was to read the words silently while EEG was recorded from 28 scalp electrodes or brain activity was scanned by means of functional imaging methods (fMRI).

3. Results

Silent reading of emotional expressions elicited an enhanced early negativity potential over parieto-occipital electrodes as early as 200 ms after stimulus presentation regardless of the words' relatedness. In the same time window, self- and other-related expressions elicited significantly larger cortical negativity relative to the processing of expressions which had no self-other reference at particularly left posterior electrodes. However, there was no interaction between the stimulus' emotionality and its relatedness at this early perceptual processing stage. Later ERPs (> 300 ms) such as the late positive potential (LPP) were significantly enhanced during processing of words describing participants' own emotions (pleasant ones in particular). Source localization techniques (LORETA) revealed major neural sources in the brain's default network including the medial prefrontal cortex, the posterior cingulate cortex and the precuneus. Imaging data from second-level, whole brain, voxel-wise analysis (significance threshold $P < .005$, uncorrected) confirmed enhanced activity in the brain's default network in addition to significant changes in the insula and the amygdala during reading of emotional words related to the self.

4. Discussion

Our results unraveled the neuronal dynamics underlying the processing of self-related emotional stimuli under natural processing conditions of silent reading. In particular, our results demonstrate that processing of stimuli describing one's own emotions involves higher-order, cognitive processing and therefore may be a suitable means for the detection of residual cognitive functions in non-responsive patients with disorders of consciousness. In operant or classical conditioning approaches these ERP and hemodynamic signal responses might be used for simple yes/no communication by means of a BCI.

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