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Emotion processing in Parkinson's disease: Dissociation between early neuronal processing and explicit ratings

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Abstract

Objective: Patients suffering from Parkinson's disease (PD) have a diminished ability to discriminate facial expressions of emotion. We investigated early emotion discrimination deficits in PD by means of event-related potentials (ERPs).

Methods: Emotional pictures were presented to 14 PD patients and 14 healthy controls in a rapid serial visual presentation paradigm (three frames per second) while EEG was recorded. In addition, valence and arousal ratings were obtained for a representative subsample of 54 pictures.

Results: PD patients rated pictures of highly arousing content as less exciting than did healthy controls. Pictures of high compared to low emotional arousal were associated with a pronounced relative negative shift in the ERP waveform over parietal and occipital sites developing about 220 ms after picture onset. This early posterior negativity (EPN) did not differ between PD and control group.

Conclusions: This dissociation of affective ratings and early ERP components supports the view that PD is associated with blunted emotional responses, but there is no evidence for a deteriorated early visual processing of emotional stimuli.

Significance: Frequently reported deficits in emotion discrimination are likely not due to deficits in early emotion processing.

Keywords: Parkinson's disease; Emotion processing; Early affective discrimination; ERPs

1. Introduction

Parkinson's disease (PD) is caused by an irreversible degeneration of dopaminergic neurons in the substantia nigra pars compacta, which leads to dysfunction of the striatal structures innervated by those neurons (e.g., Parent, 1990). Research on PD mostly focused on the characteristic motor symptoms (Hoehn and Yahr, 1967) and cognitive impairments such as disturbed executive functioning (e.g., Pillon et al., 1996). In recent years, the observation that emotional processing can be affected in PD has received growing attention. Both spontaneous and posed facial expressions have been shown to be disturbed and reduced in PD patients (Jacobs et al., 1995; Madeley et al., 1995; Smith et al., 1996; Simons et al., 2003). PD patients showed fewer and less expressive spontaneous facial expressions in response to emotional video clips (Smith et al., 1996) as well as in response to unpleasant odors (Simons et al., 2003). PD is also associated with a reduced ability to pose facial expressions voluntarily (Jacobs et al., 1995; Madeley et al., 1995). While these findings suggest an association of PD with reduced emotional behavioral outputs, few studies focused on emotion perception. Guided by clinical observations PD-related deficits were examined with respect to affective prosody (Pell, 1996; Benke et al., 1998; Breitenstein et al., 2001) and facial expression (Scott et al., 1984; Dewick et al., 1991; Jacobs et al., 1995) which are the most relevant cues on emotional communication.

In Pell's study (1996), PD patients completed a battery of emotional prosody tasks which included sentences with both

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semantically congruent and nonsense content. PD patients' performance in the identification tasks was significantly less accurate than that of control participants. Breitenstein et al. (2001) also found a considerably diminished ability to recognize affective prosody in PD patients. Similar findings are reported by Benke et al. (1998) who examined affective prosody, emotional speech detection, and humor recognition. PD patients without cognitive impairments showed deficits only in their performance of producing affective prosody, whereas patients with mild cognitive impairments showed significantly inferior performances in all three tasks compared to a healthy control group.

In a facial affect recognition task Blonder et al. (1989) demonstrated that PD patients were impaired in processing emotional features of facial expressions compared to healthy controls. Other studies revealed that PD patients have difficulties discriminating emotional facial expression and imagining emotional facial expressions compared to controls, although their performance in object imagery was not affected (Scott et al., 1984; Dewick et al., 1991; Jacobs et al., 1995). Recently, Sprengelmeyer et al. (2003) reported that the poor performance in identifying emotion in facial expressions can be improved by adequate medication. In sum, these findings suggest an impairment of processing emotional stimuli in PD, but impairments in emotion recognition were not always found (Adolphs et al., 1998).

The underlying neurological cause of these problems in processing of emotional information in PD may be the degeneration of the basal ganglia. Cancelliere and Kertesz (1990) reported that patients with cortical lesions who had additional damage to the basal ganglia showed the most pronounced deficits in emotional judgements. Moreover, Tessitore et al. (2002) showed in a fMRI-study that the amygdala is also affected in PD, and it is well documented that the amygdala is involved in processing of emotional, especially fearful stimuli like negative facial expressions (e.g., Davidson and Irwin, 1999; Davis and Whalen, 2001). Tessitore et al. (2002) investigated the activation of the amygdala in PD patients during an emotion task (matching emotional facial expressions), while they were in a hypodopaminergic state (i.e., more than 12 h after the last medication) and while they were in a dopaminergic state. In both states PD patients exhibited weaker amygdala activation in response to facial stimuli than healthy controls. In addition, the activation of the amygdala was stronger in the dopaminergic state than in the hypodopaminergic state. This influence of hypodopaminergic state on the amygdala might provide an explanation for the observed deficits in the recognition of emotional facial expressions and in emotion processing in PD.

All the studies on emotion recognition mentioned above except for the latter one dealt with behavioral responses (e.g., recognition tasks) to emotional stimuli. Because behavioral output tasks require participants to fully process and evaluate the stimuli, these studies did not differentiate between stages of processing. It is well documented however, that emotional processing involves a multitude of processes in several brain circuits. One example is the somatic marker hypothesis by Damasio, which states that emotions result from an interpretation of somatic states (e.g., Bechara et al., 2000). To our knowledge, affective responses at the early (sensory) rather than the later (postperceptual and decision) stages of stimulus processing have not been examined separately. This is necessary to identify the pathological underpinnings of the observed deficits. Besides, motor responses as required in the emotion recognition studies may be affected in PD per se and should therefore be regarded very carefully.

Event-related brain potentials (ERP) in response to affective visual stimuli are regarded as an appropriate research tool for investigating the attentional processes at early stages of stimulus encoding. Recent ERP studies have clearly demonstrated that affective cues automatically capture attention (Junghoefer et al., 2001; Schupp et al., 2003). Even when the pictures were presented rapidly, i.e., in a rapid serial visual presentation paradigm (RSVP), the brain discriminates affective from neutral stimuli (Junghoefer et al., 2001). At fast presentation rates (3 or 5 Hz), early emotion discrimination is reflected in an early posterior negativity (EPN) developing about 200 ms after picture onset. Pictures of high compared to low emotional arousal caused a pronounced relative negative shift in the ERP waveform on temporo-occipital sites compared to low arousing pictures. The main neural sources of this early emotion discrimination seem to be located in primary and secondary visual processing areas of the brain. The automatic processing of emotionally arousing pictures is observable even when attention is explicitly directed to other features of the stimuli. Schupp et al. (2003) investigated this by instructing healthy participants to detect specific checkerboard images (targets) which were presented at random positions in the stream of emotional and neutral pictures. Most participants succeeded in the non-emotional detection task (as reflected by behavioral data and in the P3 amplitude), but pictures of high emotional arousal still elicited an augmented EPN, regardless of whether participants viewed the picture under free viewing conditions or under the non-emotional attention task. In sum, the EPN associated with highly emotional pictures provides an early cortical index of selective emotional processing in the human brain. Because the RSVP paradigm allows for short durations of experiments it seems to be particularly well suited for studies with neurological patients. One further advantage of that paradigm is the large number of presented trials and therefore an improved signal-to-noise ratio.

The main purpose of the present study was to replicate reports of diminished emotional responses of PD patients as reflected in diminished arousal ratings for pictures, which are normally rated as highly arousing and emotionally salient. Most important we also wanted to examine whether the reported deficits in emotion discrimination in PD