Biological Psychology 119 (2016) 141–155

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Alterations in neural processing of emotional faces in adolescent anorexia nervosa patients – an event-related potential study

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ARTICLE INFO

Article history:
Received 30 December 2015
Received in revised form 17 June 2016
Accepted 19 June 2016
Available online 23 June 2016

Keywords:
Anorexia nervosa
Adolescence
Event-related potentials (ERPs)
Emotion recognition
Face processing
Early posterior negativity (EPN)
Late positive potential (LPP)

ABSTRACT

The present study explored the neurophysiological correlates of perception and recognition of emotional facial expressions in adolescent anorexia nervosa (AN) patients using event-related potentials (ERPs). We included 20 adolescent girls with AN and 24 healthy girls and recorded ERPs during a passive viewing task and three active tasks requiring processing of emotional faces in varying processing depths; one of the tasks also assessed emotion recognition abilities behaviourally. Despite the absence of behavioural differences, we found that across all tasks AN patients exhibited a less pronounced early posterior negativity (EPN) in response to all facial expressions compared to controls. The EPN is an ERP component reflecting an automatic, perceptual processing stage which is modulated by the intrinsic salience of a stimulus. Hence, the less pronounced EPN in anorexic girls suggests that they might perceive other people's faces as less intrinsically relevant, i.e. as less "important" than do healthy girls.

1. Introduction

Anorexia nervosa (AN) is a mental disorder characterised by significantly low body weight, intense fear of gaining weight and body image disturbance (American Psychiatric Association, 2013). Most patients are female and lifetime prevalence rates for women range from 0.9% to 2.2% (Preti et al., 2009; Smink, van Hoeken, & Hoek, 2012). Adolescent and young adult women are most frequently affected, with approximately 40% of patients being 15–19 years old (Smink et al., 2012). AN is a severe and highly debilitating disorder with the highest mortality rate of all mental disorders (Arcelus, Mitchell, Wales, & Nielsen, 2011; Harris & Barraclough, 1998) and a relatively poor long-term prognosis: less than half of patients recover fully and approximately 20% of cases take a chronic course (Fichter, Quadflieg, & Hedlund, 2006; Steinhausen, 2002).

Several prominent models have proposed difficulties in social and emotional functioning to play a major role in the development and maintenance of eating disorders (e.g. Arcelus, Haslam, Farrow, & Meyer, 2013; Connan, Campbell, Katzman, Lightman, & Treasure, 2003; Oldershaw et al., 2011; Schmidt & Treasure, 2006; Treasure & Schmidt, 2013). Moreover, socio-emotional impairments and alterations in underlying neural mechanisms have been found to predict less favourable treatment outcomes (Schulte-Rüther, Mainz, Fink, Herpertz-Dahlmann, & Konrad, 2012; Speranza, Loas, Wallier, & Corcos, 2007). It is therefore crucial to gain insight in the way emotions are processed in AN patients and to identify specific impairments.

One important socio-emotional skill that is potentially impaired in AN patients is the ability to correctly recognise and interpret other people's emotions. The *face* is a particularly important means for communicating emotions and the ability to perceive

Abbreviations: AN, anorexia nervosa; ANOVA, analysis of variance; BDI-II, Beck Depression Inventory-II; BMI, body mass index; EDI-2, Eating Disorder Inventory 2; EEG, electroencephalography; EM task, emotion discrimination task; EPN, early posterior negativity; ERP, event-related potential; FW task, face-word discrimination task; GE task, gender discrimination task; HC, healthy control; IAPS, international affective picture system; IQ, intelligence quotient; LPP, late positive potential; PV task, passive viewing task; ROI, region of interest; RT, reaction time (for correct answers); STAI, State Trait Anxiety Inventory; STAIC, State Trait Anxiety Inventory for Children.

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http://dx.doi.org/10.1016/j.biopsycho.2016.06.006
0301-0511/

and understand emotions in the faces of others is essential to successful human communication and interaction (e.g. Knapp, Hall, & Horgan, 2013). Various experimental paradigms have been used to assess difficulties in facial emotion recognition in AN patients, most of them requiring categorisation of either basic (e.g. Kucharska-Pietura, Nikolaou, Masiak, & Treasure, 2004) or more complex (assessed via the Reading the Mind in the Eyes task; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; e.g. Russell, Schmidt, Doherty, Young, & Tchanturia, 2009) facially expressed emotions. Studies of adult samples have yielded ambiguous results: some have found behavioural deficits in AN patients compared to healthy controls (HCs; Harrison, Sullivan, Tchanturia, & Treasure, 2009; Harrison, Sullivan, Tchanturia, & Treasure, 2010; Jänsch, Harmer, & Cooper, 2009; Kucharska-Pietura et al., 2004; Pollatos, Herbert, Schandry, & Gramann, 2008; Russell et al., 2009; Tapajóz Pereira de Sampaio, Soneira, Aulicino, & Allegri, 2013) whereas others have not found AN patients to perform inferior to controls (Adenzato, Todisco, & Ardito, 2012; Calvo Sagardoy et al., 2014; Goddard & Treasure, 2013; Kessler, Schwarze, Filipic, Traue, & von Wietersheim, 2006). One reason for this heterogeneity of results might be the age and illness duration of the studied samples: studies finding no behavioural emotion recognition deficits in AN patients are predominantly those studying young adults (e.g. Goddard & Treasure, 2013; Kessler et al., 2006; Mendlewicz, Linkowski, Bazelmans, & Philippot, 2005) while studies finding deficits tend to comprise older samples with long mean illness durations of up to nine years (e.g. Harrison et al., 2010; Jänsch et al., 2009; Russell et al., 2009). This emphasises the importance of differentiating between age groups and taking into account illness duration when studying facial emotion recognition in AN.

As recognising facially expressed emotions is still subject to developmental change during adolescence (e.g. Thomas, De Bellis, Graham, & LaBar, 2007), potential impairments in the processing of emotional faces, or alterations in the underlying brain mechanisms, could be particularly detrimental if already present in adolescent patients as they might interfere with the normal development of socio-emotional skills. Considering this and keeping in mind that the incidence of AN is highest during adolescence (Smink et al., 2012), it seems of particular importance to study facial emotion recognition in adolescent AN patients. Surprisingly, to date only few studies have addressed this age group and their behavioural results have been mixed: while some have found deficits in adolescents with AN compared to healthy adolescents (Zonnevylle-Bender, van Goozen, Cohen-Kettenis, van Elburg, & van Engeland, 2002), others have not (Hatch et al., 2010; Lulé et al., 2014). Thus, there is still a lack of knowledge concerning facial emotion recognition in adolescent AN patients and the extent of impairments at this early age needs to be further clarified.

It is not only important to study AN patients' difficulties in emotion processing on the behavioural level, but also to understand their neural underpinnings. Neurophysiological methods like event-related potentials (ERPs) recorded via electroencephalography (EEG) can help to gain insight into *when* and *how* emotional stimuli are processed in the patients' brains. EEG records neural brain activity with a high temporal resolution, therefore allowing the time course of different stages of emotional processing to be studied and providing a way to capture alterations in early and automatic processing stages which may be too subtle to be accompanied by behavioural impairments. Four ERP components that are thought to reflect successive stages of visual attention and emotional face processing (e.g. Holmes, Nielsen, & Green, 2008; Rellecke, Sommer, & Schacht, 2012) are of major interest in the investigation of the processing of emotional faces: the P100, the N170, the early posterior negativity (EPN) and the late positive potential (LPP). The P100 peaks approximately 100 ms after stimulus onset at occipital electrode sites (e.g. Rellecke et al., 2012). It reflects automatic perceptive processing of visual stimuli and is sensitive to visuospatial attention (e.g. Luck, Woodman, & Vogel, 2000). The N170 is a negative peak recorded around 170 ms after stimulus onset at parieto-occipital electrodes and has been interpreted as reflecting face-specific stages of structural encoding (e.g. Bentin, Allison, Puce, Perez, & McCarthy, 1996; Eimer, 2000). Evidence on the sensitivity of the P100 and the N170 to the emotional expression of a face are mixed: some studies have reported higher amplitudes for emotional compared to neutral faces (e.g. Batty & Taylor, 2003; Holmes et al., 2008; Rellecke et al., 2012), whereas other studies have not found emotion effects in those very early ERP components (e.g. Ashley, Vuilleumier, & Swick, 2004; Batty & Taylor, 2006; Holmes, Vuilleumier, & Eimer, 2003; Leppänen, Moulson, Vogel-Farley, & Nelson, 2007). The EPN is a relative negativity over temporo-occipital electrode sites which is reliably found for both positive and negative emotional stimuli when compared to neutral stimuli (e.g. Herbert, Junghofer, & Kissler, 2008; Kujawa, Weinberg, Hajcak, & Klein, 2013; Pincham, Bryce, & Pasco Fearon, 2014; Rellecke et al., 2012; Schupp, Flaisch, Stockburger, & Junghöfer, 2006). It is usually most pronounced between 200 and 300 ms post-stimulus and is thought to be a result of 'natural selective attention' (Schupp et al., 2006) in perceptual processing: intrinsically salient stimuli capture more visual attention which leads to enhanced perceptual encoding indicated by a more pronounced EPN. Subsequent to perceptual encoding, a modulation of the LPP by emotional stimuli is consistently observed. The LPP is a relative increase in positivity over centro-parietal electrodes that emerges around 300 ms after stimulus onset and lasts for several hundred ms (e.g. Mühlberger et al., 2009; Rellecke et al., 2012; Schupp et al., 2006). It is thought to index stimulus representation in working memory (e.g. Schupp et al., 2006) and modulation by emotional stimuli presumably results from facilitated automatic perception (e.g. Mühlberger et al., 2009) as well as heightened post-perceptual cognitive processing of salient emotional material (e.g. Moratti, Saugar, & Strange, 2011; Rellecke et al., 2012). Similar to the EPN, the LPP is found to be enhanced in response to various kinds of emotional stimuli and for positive as well as negative compared to neutral stimuli (e.g. Herbert et al., 2008; Kujawa, Klein, & Hajcak, 2012; Rellecke et al., 2012; Schupp et al., 2006; Solomon, DeCicco, & Dennis, 2012; Zhang et al., 2012). Studying all four components allows differentiation between alterations in very early attentional (P100) or structural (N170) stages of perceptive processing and alterations in early (EPN) or late (LPP) emotionally modulated processing stages.

To our knowledge, only two ERP studies have addressed the neurophysiological correlates of emotional face processing and recognition in AN. The first study investigated the recognition of emotional facial expressions in adult AN patients and matched HCs and recorded ERPs during the emotion recognition task (Pollatos et al., 2008). In addition to the behavioural result of a reduced ability to correctly identify neutral, sad and disgusted facial expressions in AN patients compared to controls, the investigators also found alterations at the neural level in terms of higher N200 amplitudes for all face categories and lower P300 amplitudes for afraid, angry and disgusted faces in the AN group. The authors interpreted the increased N200 amplitudes as reflecting increased attentional demands AN patients have to meet when performing the task, and the reduced P300 amplitudes as an indicator for impaired processing of faces displaying negative emotions. The only study investigating ERPs in adolescent AN patients was conducted by Hatchet al. (2010). They examined an adolescent AN sample longitudinally at admission to hospital and after weight restoration and recorded ERPs (P120, N170, P300) during viewing of emotional faces under overt (supraliminal) and covert (subliminal) conditions. Emotion recognition abilities were assessed in a separate, behavioural task. No behavioural group differences were found