Psychiatry Research 239 (2016) 72–78

Contents lists available at ScienceDirect

Psychiatry Research

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

The perception of affective touch in anorexia nervosa

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ARTICLE INFO

Article history:
Received 25 September 2015
Received in revised form
18 December 2015
Accepted 17 January 2016
Available online 3 March 2016

Keywords:
Body representation
CT system
Interoception
Interpersonal touch
Facial expressions
Social modulation

ABSTRACT

Anorexia nervosa (AN) is a disorder characterized by restricted eating, fears of gaining weight, and body image distortions. The etiology remains unknown; however impairments in social cognition and reward circuits contribute to the onset and maintenance of the disorder. One possibility is that AN is associated with reduced perceived pleasantness during social interactions. We therefore examined the perception of interpersonal, 'affective touch' and its social modulation in AN. We measured the perceived pleasantness of light, dynamic stroking touches applied to the forearm of 25 AN patients and 30 healthy controls using C Tactile (CT) afferents-optimal (3 cm/s) and non-optimal (18 cm/s) velocities, while simultaneously displaying images of faces showing rejecting, neutral and accepting expressions. CT-optimal touch, but not CT non-optimal touch, elicited significantly lower pleasantness ratings in AN patients compared with healthy controls. Pleasantness ratings were modulated by facial expressions in both groups in a similar fashion; namely, presenting socially accepting faces increased the perception of touch pleasantness more than neutral and rejecting faces. Our findings suggest that individuals with AN have a disordered, CT-based affective touch system. This impairment may be linked to their weakened interoceptive perception and distorted body representation.

1. Introduction

Anorexia nervosa (AN) is a psychiatric disorder characterized by: (a) the persistent restriction of energy intake leading to significantly low body weight relatively to health norms, (b) fear of gaining weight and related behaviors, and (c) a disturbance in body weight or shape perception, including unawareness of such perceptual disturbances (DSM-V, 2013). In addition, patients with AN may show other deficits, such as hyperactivity (Kron et al., 1978), repetitive and stereotypic behaviors (Anderluh et al., 2003, Cassin and von Ranson, 2005), disturbances in mood (Blinder et al., 2006) as well as social cognition and attachment difficulties (see Caglar-Nazali et al. (2014) for a systematic review).

The etiology of AN remains unknown. One proposal is that decreased serotonin neurotransmission as a consequence of malnutrition is thought to play a role in the hyperactivity, depression and behavioral impulsivity observed in this population (Haleem, 2012; Kaye et al., 2009). Another line of research including animal models and human neuroimaging studies suggests that a dysfunctional dopamine-based reward system is associated with the disorder (Avena and Bocarsly, 2012; Kaye et al., 2013). It is unclear whether these abnormalities are the cause or the result of chronic dysfunctions in eating behavior; nevertheless, AN patients show low novelty seeking and seem to be more anhedonic than those with bulimia nervosa (Davis and Woodside, 2002) and other eating disorders (Tchanturia et al., 2012). Some researchers propose that restricting food intake and exercising have become aberrantly rewarding in AN patients, in a fashion similar to the pathological processes seen in addiction (Scheurink et al., 2010). Other theorists claim that AN is associated with a reduced experience of pleasure associated with food (food anhedonia) and a hyporesponsive striatal dopamine system (Zink and Weinberger, 2010). In the present paper, we focus mainly on the latter aspects of the disorder.

More generally, it has been proposed that impaired social cognition and interpersonal relating play a key role in the onset and maintenance of anorexia nervosa (Zucker et al., 2007; Castro et al., 2010; Arcelus et al., 2013). Individuals with AN are typically reserved, have limited social networks, and self-report poorer quality and quantity of relationships (Tchanturia et al., 2013; Tiller et al., 1997). Furthermore, experimental studies have shown that patients with AN have impairments in emotion recognition, as

Abbreviations: AN, anorexia nervosa; HC, healthy controls

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http://dx.doi.org/10.1016/j.psychres.2016.01.078
0165-1781/

well as cognitive and affective 'theory of mind' (i.e. inferring other people's mental states; see Zucker et al. (2013), Caglar-Nazali et al. (2014), for reviews). For example, people with AN may show attentional biases when processing social stimuli, paying more attention to angry, negative (Harrison et al., 2010), or 'rejecting' human faces (Cardi et al., 2012). Moreover, some of these attentional biases are correlated with early adverse social experiences (e.g. early separation from parents, unwanted sexual experiences) (Cardi et al., 2012).

Despite the above evidence and theories, few studies have attempted to understand the possible relationship between social cognition and reward abnormalities in AN. One possibility is that some of the social difficulties patients with AN show may be associated with the lack of pleasant feelings coming from social interactions; a disturbance termed social anhedonia (Tchanturia et al., 2012). To examine this further, we focused on the perception of interpersonal, 'affective touch' and its social modulation. Affective touch is associated with a distinct class of slow-conducting, unmyelinated tactile C (CT) afferents, present only in the hairy skin of mammals and responding specifically to gentle stroking delivered at slow speeds (between 1 and 10 cm/s) (Löken et al., 2009). Microneurography studies in humans have found that CT firing rates are correlated with subjective pleasantness ratings (Löken et al., 2009). Moreover, neuroimaging evidence suggests that CT afferents take a distinct ascending pathway from the periphery to the posterior insular cortex (Morrison et al., 2011; Olausson et al., 2002). This pathway is thought to serve the convergence of interoceptive signals from the body, i.e. signals that monitor the homeostatic state of the organism (Craig, 2009). Further re-mappings of such signals in anterior cortical areas are thought to allow integration of such signals with other information about the body, as well as with other cognitive and social factors, ultimately serving body awareness and its modulation by dispositional and contextual factors (Craig, 2009; Critchley et al., 2004).

Given the aforementioned role of the anterior insula in bodily self-awareness, and the altered neural activity in this area in individuals with AN as shown by a functional neuroimaging study (Kerr et al., 2015), it has been argued that this population might suffer from a physiologically distorted sense of self (Pollatos et al., 2008; Kaye et al., 2009).

Interoceptive perception in individuals with AN has been associated with altered activity in the insular cortex (Strigo et al., 2013; Wagner et al., 2008; Vocks et al., 2011; Kerr et al., 2015). Indeed many of the symptoms observed in AN could be related to deficits in interoceptive perception, such as altered subjective responses to food (Bruch, 1962), pain and heart beat awareness (Raymond et al. 1999; Pollatos et al., 2008; Strigo et al., 2013). There is also a more general, increasing interest in somatosensory disturbances in AN, and their potential role in body image distortions (Zucker et al., 2013; Keizer et al., 2011). Keizer et al. (2014) reported that patients with AN do not differ from healthy controls in the amount of pleasantness they report from interpersonal, 'neutral' touch, delivered as part of a body perception task (Keizer et al., 2014). However, in order to specifically assess the perception of CT-based, 'affective touch' in patients with AN, the perceived pleasantness of gentle, dynamic touch applied at CT-optimal versus non-optimal speeds must be tested, as in the present study.

Given the aforementioned social difficulties in AN, studying the CT afferent system in AN is important, not only because affective touch is a distinct interoceptive modality, but also because the CT afferent system is considered specialized for detecting the velocities of interpersonal touch that may have social relevance (Olausson et al., 2008), and for promoting social bonding and affiliation between individuals (Morrison et al., 2010). Indeed, more recent neuroimaging studies (e.g. Gordon et al., 2011; Voos et al., 2013), have shown that in addition to the insular cortex, the processing of affective, CT-based touch involves several key nodes of a neural network previously implicated in social perception and social cognition (for reviews see Gallagher and Firth (2003), Koster-Hale and Saxe (2013)). These regions involve the posterior superior temporal sulcus (pSTS), medial prefrontal cortex (mPFC), the orbitofrontal cortex (OFC) and the amygdala (Gordon et al., 2011; Voos et al., 2013). Thus, it would be of interest to investigate how this socio-affective modality can be influenced by both bottom-up factors (sensory properties of the tactile stimulation) and top-down factors (concomitant manipulations of social context) in individuals with AN.

Accordingly, in this study we aimed to examined 1) whether the perception of affective touch (as operationalized by responses to a pleasantness rating scale) is reduced in patients with AN compared to healthy controls, 2) whether this effect could be linked to the CT fibers system, and 3) whether the perception of tactile stimulation is differentially affected in AN and healthy controls by the concomitant presentation of emotional facial expressions. We predicted that the perception of touch pleasantness would be reduced in people with AN, given their general anhedonia. However, we expected this effect to be specific to the CT afferent system, in the sense that it would be driven by the perception of tactile stimulation at CT-optimal speeds. Furthermore, we predicted that simultaneously presenting socially accepting vs. neutral faces would increase the perception of touch pleasantness, while rejecting vs. neutral faces should have the opposite results. Finally, we expected this effect to be stronger in patients with AN compared to controls, given the selective biases of the former towards rejecting faces (Cardi et al., 2012).

2. Methods

2.1. Participants

Twenty-five female participants with AN were recruited from clinics associated with the Maudsley NHS Trust in London over a one year period. All patients met the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV; American Psychiatric Association, 2013) criteria for AN, as assessed using the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID). Thirty, gender and age matched healthy controls (HC) were also recruited from University College London. Exclusion criteria for both groups included being left handed, any skin condition (e.g. psoriasis, eczema, etc.) and any substance abuse (i.e. drug and alcohol). Exclusion criteria specific for the HC group included a known history of any other axis I clinical disorder, a body mass index (BMI) out of the normal range (18.5–25) and any indications on psychometric assessments of clinical depression, or anxiety disorders. A total of one AN and five HC participants were later excluded from the data analysis; one AN patient and one HC did not comply with the experimenter instructions, two HC had a body mass index below the normal range, and two HC showed a depression score outside the normal range as assessed using the Depression Anxiety Stress Scale (DASS, Lovibond and Lovibond, 1995; a 21-item, three-scale self-reported measure of depression, anxiety and stress. where higher scores are related to a higher level of depression, anxiety and stress).

2.2. Design and data analysis

We used a 2 (Group: AN vs. HC) × 2 (Stroking Velocity: slow vs. fast) × 3 (Facial Expression: accepting vs. rejecting vs. neutral) mixed factorial design, with repeated measures on the latter two factors. The dependent variable was the perceived pleasantness of touch, measured using a pleasantness rating scale ranging from 0 (not at all pleasant) to 100 (extremely pleasant), presented visually, to which participants responded verbally by choosing a number between the two specified anchors.

Statistical analyses were conducted with SPSS version 21.0. The data were tested for normality by means of the Shapiro-Wilk test and found to be non-normal ($p < .05$). Subsequent Log, Square Root and Reciprocal transformations did not correct for the normality violations, therefore appropriate non-parametric tests were used to analyze the data (described below). Bonferroni-corrected planned contrasts ($\alpha = 0.025$) were used to follow up significant interactions between group and the two within-subject factors. Thus, to assess whether reduced pleasantness in AN relates specifically to impairment in the CT afferents system we compared between groups the responses to CT optimal speeds, and separately the non-