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Aberrant somatosensory perception in Anorexia Nervosa

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ABSTRACT

Anorexia Nervosa (AN) patients have a disturbed experience of body size and shape. Previously it has been shown that these body representation disturbances extend to enlarged perception of tactile distances. Here we investigated whether misperception of tactile size could be related to inaccurate elementary somatosensory perception. Tactile size perception was measured with the Tactile Estimation Task (TET) (see Keizer et al., 2011). Elementary somatosensory perception was assessed with a pressure detection task and two point discrimination (TPD). Compared to controls ($n=28$), AN patients ($n=25$) overestimated tactile size, this effect was strongest for the abdomen. Elementary tactile perception deviated in AN as well: Patients had a lower threshold for detecting pressure on their abdomen, and a higher threshold for TPD on both the arm and abdomen. Regression results implied that group membership predicted tactile size estimation on the arm. Both group membership and TPD predicted tactile size estimation on the abdomen. Our results show that AN patients have a disturbance in the metric properties of the mental representation of their body as they overestimate the size of tactile stimuli compared to controls. Interestingly, AN patients and controls differ in elementary somatosensory perception as well. However, this could not solely explain misperception of tactile distances, suggesting that both bottom-up and top-down processes are involved.

1. Introduction

Central symptoms of Anorexia Nervosa (AN) are denial of low body weight, an intense fear of gaining weight or becoming fat while being underweight, and an unrealistically fat experience of the own body (American Psychiatric Association, 2002). These symptoms have been linked to the development and maintenance of AN (Killen et al., 1996; Stice, 2002; Stice and Shaw, 2002), unsuccessful treatment (Carter et al., 2004; Exterkate et al., 2009) and relapse (Stice and Shaw, 2002). Further, the disturbed experience of the body implies that AN patients have an inaccurate internal representation and experience of the shape and size of their body. More specifically, metric aspects of the mental representation of their body could be disturbed (see e.g., Guardia et al., 2010 and Nico et al., 2010 on how body representation disturbances may affect body scaled action in AN).

In the literature often a distinction between different body representations is made. Particularly, the idea of two separate representations, body image, which is mainly cognitive perceptual, and body schema, subserving sensorimotor action, is made (e.g., Gallagher, 2005). However, there is no real consensus on how many separate body presentations can be identified, and what exactly each representation would entail (for a review see De Vignemont, 2010). Therefore, in the current article we adopt the more neutral term mental body representation.

Mental body representations are believed to store information on body part size and shape, the position of the body parts in space, and the integration of multiple parts into a whole (Dijkerman and De Haan, 2007; Gallagher, 2005; Paillard, 1999; Serino and Haggard, 2010). They are invoked in both perception and action, and are crucial in a wide variety of behaviors, such as imagining how the own body looks, reaching towards objects (Dijkerman and De Haan, 2007; Kammers, 2009; Serino and Haggard, 2010), and spatial orientation constancy (Funk et al., 2010). Spatial orientation constancy has already been found to be impaired in AN patients (Grunwald et al., 2002; Guardia et al., 2011). It is suggested that different body representations play different roles, and that encoding of bodily information in the brain depends on how bodily information is used in a given situation (De Vignemont, 2010).

Mental body representation in the context of metric characteristics of the body refers to an abstract, multimodal representation of

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the own body (Dijkerman and De Haan, 2007). Both bottom-up sensory input, such as vision and touch, and top-down cognitive input, for example related to semantic and affective information, are supposedly used to construct the mental body representation (De Vignemont, 2010; Serino and Haggard, 2010). Although the information used to construct a (metric) mental body representation comes in various formats and frames of reference, the brain selects and integrates relevant information for the given context or task (see e.g., De Vignemont, 2010).

Previous research on body representation disturbances in AN has mainly focused on aberrant visual images of the body (e.g., Cash and Deagle, 1997). These studies have shown that AN patients overestimate their body size in visual and visual imagery tasks (e.g., Cash and Deagle, 1997; Farrell et al., 2005; Keizer et al., 2011.; Smeets, 1997; Skrzypek et al., 2001). It has been suggested that conceptual information can influence and distort visual (mental) processing (Kosslyn, 1987; Lupyan et al., 2010). In the context of AN, this could imply that inaccurate metric information regarding the body is retrieved from memory when creating a visual mental image of the body, possibly due to inappropriate concepts or beliefs (i.e. "I am fat", Mohr et al., 2007; Smeets and Kosslyn, 2001). In other words the mental representation of the body in AN patients does not resemble their actual body size, consequently impairing size judgments related to the body.

Given the multimodal character of body representations (De Vignemont, 2010; Serino and Haggard, 2010), it is possible that disturbances in size judgments in AN patients are not limited to the visual modality, but extend to the tactile modality. Surprisingly, hardly any research has been conducted on somatosensory aspects of body representation in AN. Studies of healthy participants showed that a mental body representation related to metric properties of body(part) size is accessed when participants were asked to make judgments of the size of external stimuli touching the skin surface (De Vignemont et al., 2005; Spitoni et al., 2010). Since skin receptors do not directly convey information regarding metric characteristics of body parts (Serino and Haggard, 2010), information about what is felt on the skin has to be compared to, and integrated with, a stored higher order representation of body part size, which is mainly based on visual input (De Vignemont et al., 2005; Spitoni et al., 2010).

In a recent study, we investigated tactile size perception in AN by asking blindfolded participants to estimate the distance between two stimuli that were simultaneously pressed to their skin. Interestingly, we found that AN patients overestimated tactile stimuli size compared to controls (Keizer et al., 2011). These results seem to indicate that in AN tactile disturbances related to mental body representation can be identified as well. Similar to studies that show correlations between visual size estimation and body attitudes (Cash and Deagle, 1997), overestimation of tactile distances in AN patients correlated with negative attitudes and cognitions towards the body (Keizer et al., 2011).

Previous studies with healthy participants demonstrated that top-down processes, such as experimentally inducing a distorted experience of body size, influenced subsequent tactile size estimation (De Vignemont et al., 2005; Ehrsson et al., 2005; Spitoni et al., 2010; Taylor-Clarke et al., 2004). Accordingly, top-down processes related to for example body dissatisfaction may play a causal role in overestimation of tactile body size in AN (see also Keizer et al., 2011). However, we cannot rule out that AN patients overestimated tactile distances due to more elementary deficits in somatosensory perception. Such bottom-up influences have been found in healthy participants as a result of for example anesthesia, where reduced afferent inputs resulted in an altered experience of the size of the thumb (Gandevia and Phegan, 1999).

It is clear that elementary and higher order somatosensory perception involve partially different neural processes. Elementary tactile perception such as the detection of pressure, mainly depends on processes early in the cortical hierarchy, in the contralateral primary somatosensory cortex, particularly Brodmann area 3B (Dijkerman and de Haan, 2007; Friedman et al., 2004). Neurons further away from the thalamic input in the primary somatosensory cortex, such as Brodmann area 1, display more complex response properties (Gardner, 1988). Somatosensory input is further processed in the second somatosensory area (SII) and in the posterior parietal cortex. Particularly the posterior parietal cortex has been related to higher order body representations (Berlucchi and Aglioti, 2010; Dijkerman and de Haan, 2007). Functional imaging studies show some overlap but also important differences in the neural processes underlying elementary somatosensory perception (pressure sensitivity) and higher order somatosensory perception (tactile distance judgments). Overlap occurs bilaterally in the anterior portion of the intraparietal sulcus, the inferior parietal lobule, the superior parietal lobule and the superior postcentral gyrus (Spitoni et al., 2010). For the higher order somatosensory task, activation in these areas was stronger than for the elementary task. In addition, for higher order somatosensory perception (such as tactile distance estimation), additional processing in the right parieto–occipito–temporal junction (POTJ) was identified, which suggests that the POTJ is involved in (processing of) the representation of actual body size required for tasks focusing on e.g. tactile distance estimation (Spitoni et al., 2010). These higher order multimodal representations of the body may influence lower levels of somatosensory processing through top-down connections (Taylor-Clarke et al., 2004), which may allow body size scaling of tactile distances.

A few studies have been conducted on elementary tactile perception in eating disordered populations, and the results are somewhat contradictive. It has been found that Bulimia Nervosa (BN) patients have a lower pressure sensitivity than controls on both the finger tip and abdomen (Florin et al., 1988), but these results were not replicated (Faris et al., 1992). Further, elevated nociceptive thresholds for heat stimuli have been identified in BN patients (Faris et al., 1992; Lautenbacher et al., 1990; Papežová et al., 2005). Elevated pain thresholds have been found in AN patients as well (Papežová et al., 2005; Pauls et al., 1991), although not consistently (Lautenbacher et al., 1990).

In the current study we aimed to investigate whether AN patients would show deficits in elementary somatosensory perception. We included two measures of elementary tactile perception, one focusing on the detection of pressure provided by a single stimulus applied to the skin, and one focusing on spatial acuity, e.g. the minimum distance at which two stimuli applied simultaneously to the skin surface can be discriminated. In addition we employed the tactile size estimation task (Keizer et al., 2011). This task arguably operates a higher cognitive level (Spitoni et al., 2010). In order to make a size estimate it is necessary to first detect pressure on the skin at the site of stimulation, discriminate between the two pressure points, and then integrate what was felt on the skin with a mental representation of the distance between the pressure points on the skin. To investigate whether concerns about fatness of certain body parts might show specific differences between or within the patient and control group two body parts were tested in each tactile task: The abdomen, as this may be regarded as a high-concern body part (i.e., subject to high concerns of fatness in females), and the forearm, which may be seen as an neutral body part (i.e., not subject to high concerns of fatness).

2. Method

2.1. Participants

The current study was approved by the local medical ethical committees of the involved institutions. In total 55 females participated. The patient group consisted of 25 patients (11 AN patients and 14 Eating Disorder Not Otherwise