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Review

Show me how you walk and I tell you how you feel — A functional near-infrared spectroscopy study on emotion perception based on human gait

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ABSTRACT

The ability to recognize and adequately interpret emotional states in others plays a fundamental role in regulating social interaction. Body language presents an essential element of nonverbal communication which is often perceived prior to mimic expression. However, the neural networks that underlie the processing of emotionally expressive body movement and body posture are poorly understood.

33 healthy subjects have been investigated using the optically based imaging method functional near-infrared spectroscopy (fNIRS) during the performance of a newly developed emotion discrimination paradigm consisting of faceless avatars expressing fearful, angry, sad, happy or neutral gait patterns. Participants were instructed to judge (a) the presented emotional state (emotion task) and (b) the observed walking speed of the respective avatar (speed task).

We measured increases in cortical oxygenated haemoglobin (O_2HB) in response to visual stimulation during emotion discrimination. These O_2HB concentration changes were enhanced for negative emotions in contrast to neutral gait sequences in right occipito-temporal and left temporal and temporo-parietal brain regions. Moreover, fearful and angry bodies elicited higher activation increases during the emotion task compared to the speed task. Haemodynamic responses were correlated with a number of behavioural measures, whereby a positive relationship between emotion regulation strategy preference and O_2HB concentration increases after sad walks was mediated by the ability to accurately categorize sad walks.

Our results support the idea of a distributed brain network involved in the recognition of bodily emotion expression that comprises visual association areas as well as body/movement perception specific cortical regions that are also sensitive to emotion. This network is activated less when the emotion is not intentionally processed (i.e. during the speed task). Furthermore, activity of this perceptive network is, mediated by the ability to correctly recognize emotions, indirectly connected to active emotion regulation processes. We conclude that a full understanding of emotion perception and its neural substrate requires the investigation of dynamic representations and means of expression other than the face.

Contents

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Introduction

The ability to correctly detect and recognize emotional states in others represents a fundamental requirement for adequate social interaction. It enables us to appropriately interpret social situations and to adapt our own behaviour to given conditions. Impaired emotion recognition is thus related to prominent deficits in social functioning. Accordingly, emotion recognition deficits have been observed in a variety of psychiatric syndromes, such as affective diseases (Gur et al., 1992; Mandal and Bhattacharya, 1985; Milders et al., 2010; Schaefer et al., 2010), eating disorders (Ridout et al., 2012), and different types of personality disorders (Dickey et al., 2011; Levine et al., 1997; Marissen et al., 2012). They are also central in schizophrenia (Chan et al., 2010; Edwards et al., 2002; Hellewell and Whittaker, 1998), and in the case of autism, they even represent the core deficit (Hobson et al., 1988; Philip et al., 2010).

Over a period of several decades, emotion recognition was investigated predominantly by means of facial stimuli. Neurobiological research on facial emotion perception revealed that emotion related activation increases in brain areas associated with face perception, such as the fusiform face area (FFA; Ganel et al., 2005; Jacob et al., 2012; Vuilleumier and Pourtois, 2007; Vuilleumier et al., 2001), superior temporal sulcus (Haxby et al., 2000; Winston et al., 2004), and inferior occipital gyrus (Fusar-Poli et al., 2009). Moreover, emotional face expressions have been reported to trigger neural activation within a distributed network, including the amygdala, the insula, the cerebellum, and prefrontal as well as orbitofrontal brain regions, (see Fusar-Poli et al., 2009), whereupon regional activation increases partly depend on the respective emotion perceived.

Although facial expression plays – without question – a crucial role in human social function, there are good reasons to broaden emotion recognition research by additionally studying body language expressions. First, in a number of daily situations body language is more accessible than facial expressions, e.g. if the face is averted or a person is observed from a distance. It has further been shown that the perception of facially expressed emotions is significantly affected by whole-body expressions (Meeren et al., 2005; Van den Stock et al., 2007). Moreover, although traditional and widely accepted approaches assume separate processing of facial identity and emotion following an initial stage of structural encoding (Breen et al., 2000; Bruce and Young, 1986), there is some evidence that the recognition of facial expression and identity is not entirely independent (Atkinson et al., 2005; Ellamil et al., 2008; Schweinberger and Soukup, 1998). While to our knowledge no studies have so far investigated interaction effects of emotion and identity for body movements, there are some studies showing that identity recognition and discrimination from moving bodies is, though possible, associated with very poor performance (Kozlowski and Cutting, 1977; Westhoff and Troje, 2007), indicating that identity is unlikely to strongly affect emotion processing from body language. Considering that facial emotion recognition, in contrast, may indeed be affected by identity, a holistic view of neural and cognitive mechanisms underlying emotion perception from body language appears even more reasonable.

Against this background, an increasing number of functional brain imaging studies have addressed the anatomical and functional substrates of emotion perception based on body expressions. Beyond face selective areas, circumscribed brain regions have been reported that are specialized in processing human body posture, body movements and/or body expressions, partially overlapping with those areas associated with the recognition of facial expressions: ventral parts of the fusiform gyrus (fusiform body area, FBA; Peelen and Downing, 2005, 2007; Schwarzlose et al., 2005), a region within the lateral occipitotemporal cortex (extrastriate body area, EBA; Downing et al., 2001), and the superior temporal sulcus (STS; Grossman et al., 2000; Krakowski et al., 2011). Using anatomical landmarks, a recent study further identified the inferior temporal gyrus (ITG), which is directly neighboured to the lateral fusiform cortex, as a relevant region for the perception of human bodies and limbs (Weiner and Grill-Spector, 2011). Recent studies explicitly assessing the neural processing of body expressions indicate that emotions indeed modulate brain activity within these brain regions. In addition to enhanced amygdala activity (Hadjikhani and de Gelder, 2003; Peelen et al., 2007), emotion-related increases in brain activation after the presentation of body expressions have been observed in the FBA (Hadjikhani and de Gelder, 2003; Kret et al., 2011; Pichon et al., 2008; van de Riet et al., 2009), the ITG (De Gelder et al., 2004b; Prochnow et al., 2013), the EBA (Atkinson et al., 2012; see de Gelder et al., 2010 for an overview; Grèzes et al., 2007; Kret et al., 2011; Peelen et al., 2007; Pichon et al., 2008), the STS (Grèzes et al., 2007; Kret et al., 2011; Peelen et al., 2010; Van den Stock et al., 2011), the temporo-parietal junction (TPJ; Grèzes et al., 2007; Pichon et al., 2009; Sinke et al., 2009) and frontal brain regions (de Gelder et al., 2004a; Peelen et al., 2010; van de Riet et al., 2009; Van den Stock et al., 2011). It has to be noted, that these effects strongly depend on whether the affective state was presented by means of static vs. dynamic body expressions. Recent research indicates that activation in the STS, a region that is known for its crucial role in social information perception (Kreifelts et al., 2009, 2010), is enhanced by emotional compared to neutral body expressions only if dynamic stimuli are presented (Grèzes et al., 2007). Moreover, emotional modulation of the EBA, in particular, is only evident in studies using dynamic, but not static, body expressions (de Gelder et al., 2010).

Human gait reflects a specific type of dynamic body motion which provides sufficient information for the perception of expressed motivational or emotional states (Karg et al., 2010; Montepare et al., 1987, 1999; Roether et al., 2009a,b). Using biological motion stimuli in terms of animated point-light displays, previous studies showed that emotions from point-light walkers can be reliably discriminated (Atkinson et al., 2004; Clarke et al., 2005; Dittrich et al., 1996) and, moreover, it has been demonstrated that emotional content facilitates gait identification (Chouchourelou et al., 2006; Ikeda and Watanabe, 2009). Until now, only very few brain imaging studies on the neurofunctional substrates of the perception of dynamic body expressions from gait patterns exist. Heberlein et al. (2004) used dynamic point-light stimuli that were based on walking actors expressing four different emotions (happiness, anger, fear, and sadness) to determine cortical regions that are involved in emotion recognition in healthy subjects and patients with brain damage. Their findings suggest a crucial role of the

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